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A Journey to the Green Future; Biodiesel from Jatropha

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Introduction

Jatropha Curcas, which is popularly called "Bita da zugu" in hausa, is a drought resistant shrub or tree belonging to the family Euphorbiaceae, which is cultivated in the central and south America, south Asia, India and Africa (Openshaw, 2000). As a second- generation (non-food supply) biofuel crop, it can affordably and sustainably help to provide a portion of the current fuel supply with minimal environmental impact. The goal of second-generation biofuel is to increase the biofuel supply with crops such as Jatropha, castor (Ricinus communis), and Camelina (Camelina sativa).

Jatropha yields a considerable amount of inedible oil that can be converted to biodiesel. The oil can be used as a direct replacement for fuel in engines and machines, and it has other industrial and commercial uses as well (Cerrate *et al*. 2006; Ndong *et al*. 2009). Additionally, different parts of Jatropha have medicinal value, such as anticancer properties (Duke, 1983). Roots and leaves can be used to make antibiotics and products for the treatment of skin diseases (Henning, 2002). Being rich in nitrogen (N), the seed cake can be an excellent plant nutrient source if detoxified (Makkar *et al*. 1998).

Presently, some countries are producing Jatropha oil to supplement the fuel requirements for lamps, cooking, and small diesel engines. Jatropha is being cultivated in 32 countries around the world, including India, Mali, Mexico, Sri Lanka, Nepal, Cambodia, South Africa, Tunisia, China, Bangladesh, Egypt, and the United States. Jatropha oil has successfully been used in small diesel engines in India, Brazil, Madagascar, Thailand, Vietnam, China, Indonesia, and Myanmar (Heller 1996). South Florida soils are suitable for cultivation of Jatropha, but the tree's susceptibility to occasional freezing temperatures makes south Florida unsuitable for commercial cultivation. However, if freeze protection is provided, plants can be preserved.

Plant Morphology

Jatropha is a small tree with smooth gray bark. The bark discharges a white, watery latex when cut. Generally, the tree can grow between 6.0 and 18.0 (1.8–5.5 m) in height, but it can grow to 30.0 (9.2 m) given favorable conditions.

Leaves

There is tremendous variability in morphology. In general, Jatropha leaves are green to pale green, alternate to subopposite, and three- to five-lobed with a spiral phyllotaxis.

Flowers

The petiole length ranges from 0.24 to 0.90 inches (6.1–23.1 mm). The inflorescence can be formed in the leaf axil. Flowers are formed terminally and individually, and female flowers are slightly larger during the warmer months. However, there is variation here as well. Furthermore, it is important to note the ratio of male to female flowers. The plant is monoecious and also presents hermaphroditic flowers occasionally.

Fruits

In the winter, plants lose their leaves and do not produce fruits; most fruit production is concentrated from mid- summer to late fall with variations in production peaks. Some plants have two or three harvests and some produce continuously through the season. In Florida, there is variability in fruit production.

Three bivalved cocci are formed after the seeds mature and the fleshy exocarp dries. Fruits are produced continuously from midsummer to late fall, which may be an obstacle to mechanical harvest and increase harvest costs because of the need for multiple harvests.

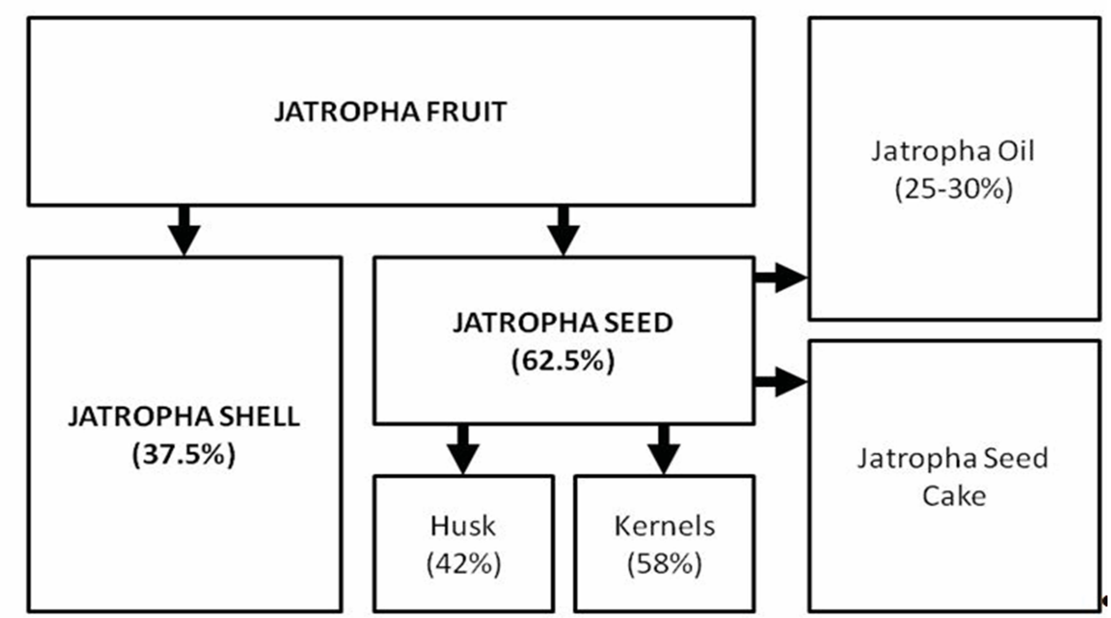


Fig 1. Fruit composition percentage of Jatropha curcas. Credits: Abreu 2008

Seeds

The seeds become mature when the capsule changes from green to yellow after 2–4 months. The seeds contain 21% saturated fatty acids and 79% unsaturated fatty acids (Gubitz *et al*. 1999), and they yield 25%–40% oil by weight (Deng *et al*. 2010; Heller 1996). Additionally, the seeds contain other chemical compounds, such as saccharose, raffinose, stachyose, glucose, fructose, galactose, and protein. The oil is largely made up of oleic and linoleic acids (List and Horhammer, 1979). Jatropha also contains curcasin, arachidic, linoleic, myristic, oleic, palmitic, and stearic acids and curcin (Perry, 1980). Curcin and phorbol ester are toxic compounds contained in the Jatropha meal. However, the meal can be suitable for animal feed after a detoxification process (Gaur et al. 2011).

Crop Adaptability Climate

Jatropha is a highly adaptable species and is especially tolerant of severe heat, ACCREC have established this fact by cultivating jatropha in Borno state (accrec website). This plant thrives in warmer weather. The plant is susceptible to freeze damage but can tolerate a light frost of relatively short duration. Jatropha can survive light freezes using overhead high-volume irrigation. The plant drops its leaves when cold. Older trees can withstand lower temperatures than younger trees. Black frost (internal freezing of vegetation) can kill young plants and severely damage older plants. The tree can survive in occasional flooding. In past flooding instances in Florida, heavy rains and water-logged soils caused defoliation and promoted the development of Pythium root rot, which severely injured or killed many plants.

Soil Type and Quality

The plant thrives on different soil types, including infertile, gravelly, sandy, and/or saline soils (Dagar et al. 2006). Jatropha can also thrive on the poorest stony soil. The plant does not require arable land and can be grown in marginal dry soils, such as along railway lines, roads and highways, river embankments, canals, streams, crop boundaries, and coastal lines, as well as in hilly areas, but yield will be lower than crops grown in arable land. It can grow in pH ranging from 5.5 to 9.0 (Foidl et al. 1996). Once the root penetrates deeper into the soil, Jatropha can tolerate even more acidic or alkaline soil, but yield will be lower than at optimal pH ranges. In projects around the world, Jatropha plantations have failed because plants were planted in poor soil conditions and returned very low or no yields. It is important to understand that plants can adapt to and grow under poor soil conditions, but for commercial yields, proper crop management, such as irrigation and fertilization, is needed.

Propagation Method

Several propagation methods can be used, such as direct seeding, transplanting, direct planting (cutting), or tissue culture (Freitas and Barjona 1906). Direct planting by cutting decreased the time of production as compared to direct seeding or transplanting. However, it does not produce a good tap root, which is why this is not the method used by most growers. Propagation through seed (sexual propagation) leads to genetic variability in terms of growth, biomass, seed yield, and oil content. This is because there is no certified seed production in Jatropha. Low seed viability and poor germination also limit seed propagation. Vegetative propagation has been achieved by stem cutting, grafting, and budding as well as by air layering techniques. The cuttings should be taken preferably from juvenile plants and treated with 200 mcg/l of rooting hormone indole butyric acid (IBA) to ensure the highest level of rooting for the cutting (Noor Camellia et al. 2009). The optimal stem for cutting is 0.08 inches (2.0 mm) in diameter and 1.0 (30.4 cm) in length. The stem pieces can be cut from the mother plant and planted at any time of the year. If it is planted during a dry period, irrigation is required.

Plant Population

Plant spacing of 5.9 by 5.9 or 8.8 by 8.8 (1.8 by 1.8 m or 2.7 by 2.7 m, respectively) is acceptable with plant densities of 1,012 plants/acre (2,500 plants/ha). Distance of 8.8 by 8.8 (2.7 by 2.7 m) may be more desirable for commercial cultivation because wider spacing is reported to increase crop yield by increasing fruit size (De Avila 1949). However, spacing depends on the harvest method; mechanical harvest in large-scale commercial plantations may require more open spacing. Manual harvesting, which is applicable to smaller plantations (Central and South America, Africa and Asia), is the best method for sustainable production and generating jobs in developing countries.

Irrigation

The plant is adapted to dry soils. Jatropha plants can survive from air humidity when rainfall is as low as 10.0 inches (254 mm) per year. In Florida, unirrigated Jatropha failed to reach 2.5 (75 cm) after 1 year. Rainfall of 12.0–40.0 inches (305–1,016 mm) produces optimal yields. Jatropha can also stand for long periods without water (as long as 2 years) and regrow when rains return. The average water consumption rate of Jatropha is 1 L/plant/day throughout the growing season with high-quality seeds (Ahad et al. 2014).

Biophysical Limits

Jatropha mainly grows at altitudes of 0–6,000 (0–2,000 m) where optimal temperature ranges from 68°F to 104°F (20°C–40°C); however, temperatures lower than 50°F (10°C) and higher than 122°F (50°C) are acceptable for short periods of time (Misra and Misra 2010).

Cultural Practices Germination

Germination normally takes 7–10 days with optimum moisture conditions. In Maiduguri, jatropha germinates faster than usual 5-8 days (ACCREC). The shell splits, the radicula emerges, and four peripheral roots are formed.

Fertilization

Jatropha is adapted to low soil fertility. In general, fertilized Jatropha trees provide higher yields than trees without fertilizer (Mohapatra and Panda 2011; Moore et al. 2011). Higher yields can be obtained on poor-quality soils if fertilizers are applied containing N, phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S). After transplant and establishment, cow manure and N-P-K fertilizer can be applied annually (Ahad et al. 2014).

Weed Control

Depending on the field conditions and season, weeding can be performed four times per year by soil surface plowing or by applying herbicides, such as oxy fluorfen or pendimeth- alin (Rocha 2010).

Crop Yield

None of the Jatropha species have been properly domesticated. Therefore, the productivity of individual trees can be variable, and the long-term impact on large-scale production and uses is currently unknown. Estimates of Jatropha seed yield vary widely because of a lack of research, genetic diversity, and the range of environmental conditions in which the crop can be grown. The tree can begin production 9–12 months after germination, but optimal yields can be obtained after 4–5 years. Seed production ranges from about 0.13 to 4.86 t/acre (0.3–10.9 t/ha) per year (Openshaw 2000). Heller (1996) reported yield variability of 0.09–7.2 t/acre (0.2–16.1 t/ha) per year, probably because of low and high rainfall areas. However, 4.4–5.5 t/acre (9.8–12.3 t/ha) of dry seed is a reasonable yield estimate for an adequately managed plantation with favorable environmental conditions (Achten et al. 2008). Jatropha can be a competitive feedstock when compared to soybeans and rape seed, which produce lower oil yields than Jatropha Fig 2. The seed kernel contains predominantly crude fat (oil) and protein, while the seed coat contains mainly ber (Brittaine and Lutaladio 2010).

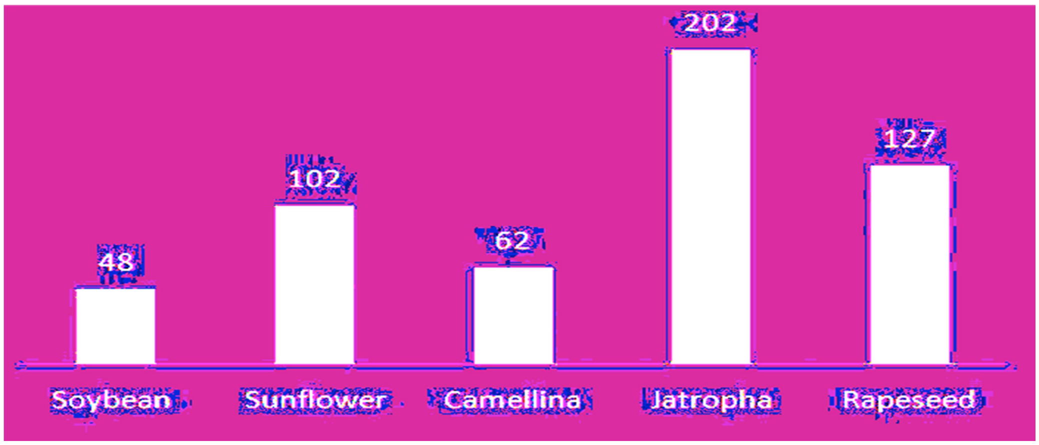


Fig 2. Comparison of oil yields from different biomass feedstock. Credits: U.S. DOE 2010

Crop Uses

The oil is mainly used as biodiesel for energy. The cake can be used for fish or animal feed (if detoxified), biomass feedstock to power electricity plants, or as biogas or high- quality organic fertilizer (Achten et al. 2008; Ghosh et al. 2007; Patolia et al. 2007; Wani et al. 2006). It can also be used as a bio-pesticide and for medicinal purposes (Heller 1996).

Pruning

Plants should be pruned once a year. The tree needs side shoots for maximum sprouting, flowers, and seed production. From December to January, the top of the plants at 0.80 (25 cm) tall or higher need to be topped while keeping 8–12 side branches for more fruit production (Gour 2006). To facilitate harvesting, it is suggested to keep the tree to a height of approximately 6.6 (2 m) (Reddy and Naole 2009). In South Florida, the trees were never pruned and produced sufficient branches, although this may seem contrary to what literature reports. Trees were pruned after 2 years only to maintain a manageable size.

Intercropping

According to the topography, soil profile, and prevailing agro-climatic conditions in an area, Jatropha trees can be combined with other suitable species, such as with agricultural, horticultural, herbal, pastoral, and/or silvicultural cropping systems. Without cutting the lateral roots of Jatropha, intercropping with crops such as maize (Zea mays L.), indigo (Indigofera tinctoria L.), lentil (Lens culinaris M.), wheat (Triticum aestivum L.), coffee (Co ea arabica L.), sugarcane (Saccharum o cinarum L.), castor oil (Ricinus communis L.), medicinal plants, fruits, grasses, tubers, and vegetables can be a source of extra earnings for farmers (Singh et al. 2007).

Harvesting

Jatropha takes 4–5 years to be highly productive. Flowering depends on location and agro-climatic conditions. Generally, cloned Jatropha seedlings produce flowers in the first 4 months. By cloning the strongest and highest- yielding plants, the clones inherit the characteristics of the parent plants. When Jatropha fruits are mature, they can be mechanically harvested using equipment such as the Korvan 9240. Mechanical harvesting provides several benefits, such as selective and continuous harvesting, cost control, labor reduction, efficiency and reliability, and the ability to harvest on demand. However, it can damage flowers that are still in the plant and harvests both mature and immature fruits. Flower and fruit synchronicity is an issue that is being addressed to solve some of these problems.

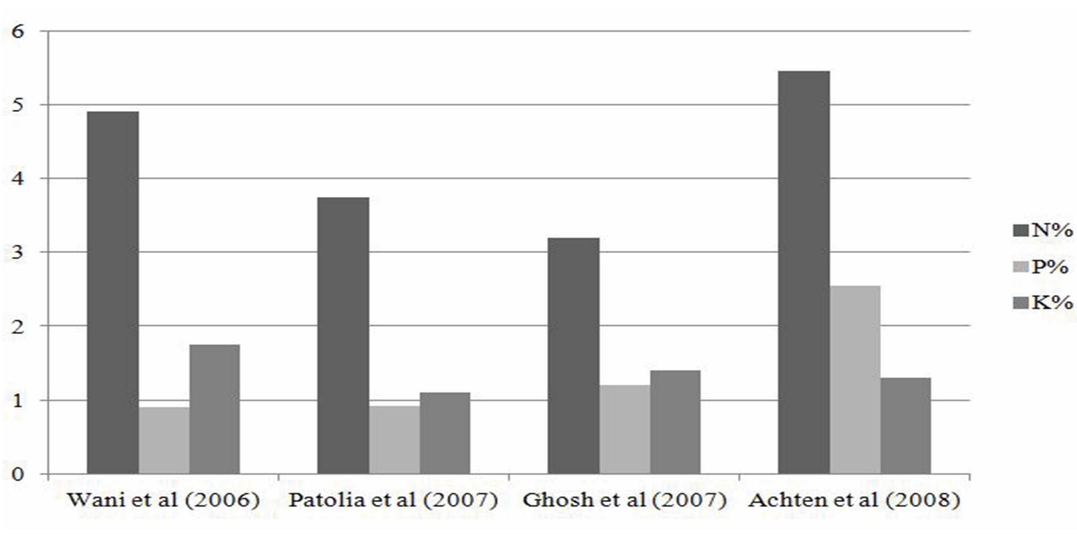


Fig 3. Percentage of nitrogen, phosphorus, and potassium in Jatropha curcas seed cake

Biodiesel

Biodiesel is a renewable fuel source that can replace petroleum diesel in compression ignition engines without any changes to the engine. Biodiesel offer an alternative energy source in placing petroleum diesel that is renewable and more environmentally favorable. Biodiesel can be produced from a number of different feedstocks such as corn, soya, palm, coconut or sunflower oil. Additionally, it can be produced from other oil-bearing plants that are not consumed as food substances such as jojoba, karanja and jatropha.

Advantages of Biodiesel

1. Provide a domestic, renewable energy supply
2. Biodiesel is a carbon neutral because the balance between the amount of CO2 emission and the amount of CO2 absorbed by the plant producing vegetables oil is equal.
3. Biodiesel can be used directly in compression, ignition engines without any substantial modification of the engine
4. Blending of biodiesel with diesel fuel increases engine efficiency
5. The higher flash point of biodiesel makes it safer
6. Biodiesel is non toxic
7. Biodiesel degrade four time faster than diesel
8. It is biodegradable

Disadvantage of Biodiesel

1. More expensive due to less production of vegetable oil
2. It’s prepared and so Consumes more time and energy
3. Required other chemicals such as catalyst which include KOH, NaOH
4. Blend of biodiesel above 20% can cause engine maintenance problems and even sometimes damage the engine

Oil extraction method

1. Traditional method
2. Manual presses
3. Ghanis

4. Expeller
5. Solvent extraction

Traditional Method

Oil is extracted from fresh coconut, olive, palm fruit and shea nut by separating the flesh and boiling it in water, salt is added to break any emulsion which is commonly formed and the oil skimmed from the surface.

Manual Method

Oil can be extracted by pressing softer oil seed and nut such as groundnut and shea nut where as harder, more fibrous materials such as copra and sunflower seed can be processed using ghanis pilped or grand materials is loaded into a manual or hydraulic press to squeeze out the oil, water emulsion. This is more efficient at removing oil than traditional hand method allowing higher production rate.

Ghanis

Are widely used in Asia but less so in other areas. A heavy wooden or metal pestle is driven inside a large metal or wooden mortal. The batch of raw materials is ground and pressed and oil is drained out. They have relatively high capital and maintenance cost and need skilled operators to achieve high oil yield.

Expeller

An expeller consists of helical threat which revolves concentrically within a perforated cylinder, the barrel is usually formed by a series of axially placed binning bars contained within a robust frame.

Solvent Extraction

Plant uses hexane as a solvent to extract oil from oil seed cake. When large amounts of oil seed cake are available, solvent extraction becomes a commercially viable option to extract the residual oil left in the cake and leaves almost oil free powder known as oil seed meal. Solvent extraction is the best method for extraction in the laboratory because it leaves behind no oil residue in the seed of the plant.

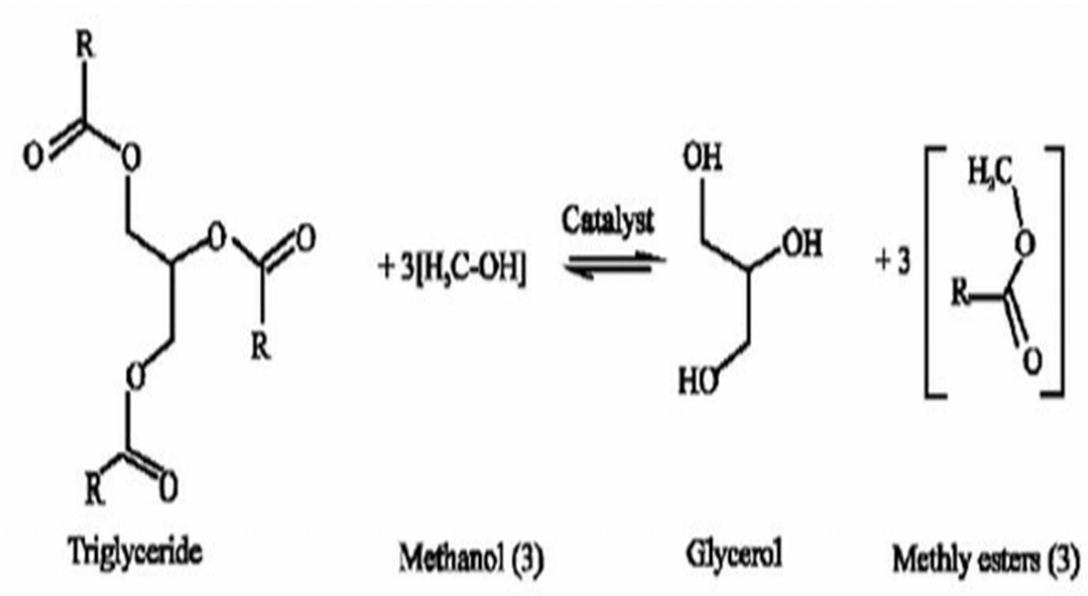
Jatropha Biodiesel Production

When Jatropha seeds are crushed, the resulting oil can be processed to produce a high-quality biodiesel that can be used in a standard diesel engine. Oil extracting and refining equipment is available in the international market at a price of approximately $30,000. An old mustard (Brassica juncea L. Czern) expeller, which is a machine to extract oil from oil seed plants, can be modified and used for Jatropha oil extraction. Small-scale hand-operated expellers can extract 0.26 gal (1 L) of oil per 11.0–12.1 lb (5.0–5.50 kg) of seed, while engine-driven screw presses can produce 0.26 gal (1.0 L) of oil from 4.0 lb (1.8 kg) dried seed (Henning 2002; Jongschaap et al. 2007). Manually operated small units that can be manufactured locally are also available. Additionally, various alternative methods, such as ram, hole cylinder, and strainer type presses, can be used for processing seed.

There are several forms of biofuel, often manufactured using sedimentation, centrifugation, and filtration. The fats and oils are turned into esters while separating the glycerin. At the end of the process, the glycerin settles and the biofuel oats. The process through which the glycerin is separated from the biodiesel is known as transesterification. Glycerin is another by-product from Jatropha oil processing that can add value to the crop. Transesterification is a simple chemical reaction that neutralizes the free fatty acids present in any fatty substances in Jatropha. A chemical exchange takes place between the alkoxy groups of an ester compound by an alcohol. Usually, methanol and ethanol alcohol are used for the purpose. The reaction occurs by the presence of a catalyst, usually sodium hydroxide (NaOH) or caustic soda and potassium hydroxide (KOH), which forms fatty esters (e.g., methyl or ethyl esters), commonly known as biodiesel. It takes approximately 10% of methyl alcohol by weight of the fatty substance to start the transesterification process (Ibeto et al. 2011). The production schematic is illustrated in Figure 9 (Nahar and Sunny 2011). The transesterification process using methanol can be expressed by the simplified equation shown below:

Oil or Fat (Triglycerides) + Methanol = Methyl Ester + Glycerol

3.52 oz + 0.37 oz = 3.54 oz + 0.36 oz 100 g + 10.75 g = 100.45 g + 10.3 g



Some of the chemicals that are used in the manufacturing of biodiesel are ethanol or methanol that bring into use methyl esters. Methanol is derived from fossil fuels, and ethanol is derived from plants. In the transesterification stage, the by-product is glycerol, which is approximately 10% of the raw oil by weight. Glycerol yield can be less than 10% of the raw oil, and a greater conversion to glycerol means greater revenue, assuming that the price of the glycerol remains constant. Revenues generated from coproducts like glycerol can reduce the net marginal cost of biodiesel production (Brittaine and Lutaladio 2010).

The Benefits of Biodiesel

Diesel substitutes from renewable sources such as biodiesel have similar properties to diesel fuel. These substitute fuels contain less sulfur (S) content and may be used in diesel engines without major engine modifications (Ramesh et al. 2006). The comparison between Jatropha biodiesel, petroleum-based diesel, and a mixture of the two is shown in Table 1.

Table 1. Comparison of *Jatropha curcas* biodiesel with petroleum-based diesel

Properties	*Jatropha* biodiesel	Mixture*	Petroleum diesel
Fuel Consumption, g/kw/h	629.7	1,298.0	784.0
Mass of fuel, lb/h	1.36	0.97	1.56
Brake thermal efficiency, %	24.09	10.80	11.76
Mass of air, lb/h	12.17	18.71	17.50
Air fuel ratio	8.90	19.30	31.15
Exhaust % of CO_2	1.33	5.00	9.00
Exhaust % of O_2	17.67	8.00	5.00
Exhaust % of CO	0.00	1.00	1.00
*50% *Jatropha curcas* biodiesel and 50% petroleum diesel *Source:* Rahman et al. 2010			

Characteristics of Jatropha Oil

Jatropha oil has similar characteristics to fossil diesel fuel, and it can be directly used in the diesel engines of buses, trucks, tractors, and other diesel engines. The high stability in low temperatures makes it very attractive for use in jet fuels, and this has been tested successfully. Table 1 shows the characteristics of Jatropha oil in comparison with fossil diesel. Jatropha oil causes less air pollution during engine operation because it contains lower S concentration than petroleum diesel. Jatropha is also safer to store than petroleum diesel since it has a higher ash point. In addition, Jatropha oil viscosity is slightly lower than the fossil diesel, which allows smooth flow of the oil through the injector (Brittaine and Lutaladio 2010).

Environmental Impact

As a perennial shrub, Jatropha can sequester carbon (C). A full-grown tree absorbs around 17.4 lb (7.9 kg) of CO_2 every year (PSO 2010). If the plant density is 1,012 plants/acre (2,500 plants/ha), it is possible to acquire an 8.7 t/acre (18.1 t/ha) of greenhouse gas sequestration per year. Jatropha produces renewable energy in the form of biodiesel, which emits 80% less CO_2 and 100% less SO_2 than fossil diesel (Tiwari et al. 2007). Biodiesel from food crops such as corn can cause food shortages. For biodiesel, Jatropha yields similar fuel per acre (ha) than soybean or other energy crops (Chawla 2010).

Production Cost

The cost of a plantation in the United States has been estimated to be around $1,000/acre ($550/ha). Jatropha plantation includes site preparation, soil preparation, fertilizer and manure application, planting, irrigating, weeding, plant protection, and maintenance for a year (Meng 2009).

An integrated Jatropha biodiesel plantation has three stages: sowing of seeds, producing oil from the seeds, and finally converting raw oil to biodiesel through transesterification. The biodiesel industry is relatively small, so as the industry expands with increased infrastructure, the costs of producing and marketing biodiesel may decline. New cost-saving technologies will likely be developed to help producers use energy more efficiently and increase conversion yields. The supply of soybeans, rape seeds, and other feedstock available for biodiesel production will be limited by increased food and land demand.

The key to the future of biodiesel is finding inexpensive feedstock that can be grown by farmers on marginal agricultural land without adverse environmental consequences, and Jatropha may be one of these alternative crops. If Jatropha proves to be a promising biofuel, this tree species may emerge as a viable alternative to petroleum diesel. In Florida, breeding and genetic improvement programs initiated at the University of Florida's Tropical Research and Education Center (UF/TREC) may provide new hybrid cultivars with several characteristics of interest, including cold tolerance, high oil content in seeds, and low toxicity, which are the key for expanding cultivation areas in Florida (Crane et al. 2010).

The mass of crude biodiesel after washing and drying was measured, and the biodiesel yield was calculated from the equation:

$$\text{Biodiesel yield (\%)} = \frac{\text{Mass of crude BD after washing \& drying (g)} * 100}{\text{Mass of triglycerides in jatropha seeds (g)}}$$

With mass of triglycerides in jatropha seeds (g)=Mass of oil contained in jatropha seeds (g) * glycerides fraction content in jatropha oil (%) * triglyceride content in glyceride fraction (%),

The biodiesel yield is calculated on the basis of a pure biodiesel (i.e containing only fatty acid methyl esters). Taking into account the fact that components contained in the crude biodiesel are not only fatty acid methyl esters, such formula may lead to a potential source of error. Each experiment was conducted twice to give an average biodiesel yield with corresponding standard deviation. After the filtrate separation, the cake was not washed with methanol to take out the esters, meaning that it still contained a part of the fatty acid methyl esters produced during the in situ transesterification. It was directly dried overnight at room temperature, and the total volatile matter content and the n-hexane extracted matters content (i.e weight loss upon n-hexane extraction) were then determined according to standards. All determinations were carried out in duplicate. The effect of three other operating conditions (stirring speed, temperature and reaction time) on biodiesel yield and biodiesel quality was studied in the second stage. The corresponding experiments were conducted using a methanol to seed ratio of 6:1 (v/w) and 0.075 mol/L KOH in methanol. The stirring speed, the temperature and the reaction time were 700-900 rpm, 40-600C and 3-5hr, respectively. Sample collection and analyses were performed using the same procedure as for effect of methanol to seed ratio and amount of KOH on biodiesel yield and biodiesel quality. Each experiment was duplicated, and biodiesel yield was taken as the average with corresponding standard deviation. The randomized factorial experimental design with ANOVA (F-test at p=0.05) was used to study the effects of stirring speed, temperature and reaction time on biodiesel yield and biodiesel quality using SAS software.

AFRICAN CLIMATE CHANGE RESEARCH CENTER (ACCREC) MAIDUGURI FIELD OFFICE VIEW AND APPROACH ON CLIMATE CHANGE AND EFFORTS IN PROPAGATING JATROPHA IN BORNO STATE AND NORTHEAST IN GENERAL

Climate change has been a major challenge throughout the world ranging from drought, flooding, water scarcity, climate related diseases, decline in crop yield, low soil fertility, rise in sea level and melting ice cap. Without doubt the climate has been changing throughout history and this has been stable in the past years. But a severe impact was witnessed called the sudano sahelian drought in the

1983/84 where a lot has been lost in terms of agriculture, and livelihood and Yobe state especially the Geidam axis is not an exception. Climate change is multidimensional and multi-disciplinary it crosscut along social, economic and political spheres.

African Climate Change Research Center (ACCREC) established in 2014 with operation in Borno and plans to extend to the entire North East, is committed towards addressing climate change adaptation, mitigation and

Complimenting GGW Borno project. So far we have donated more than 8,000 trees in various communities and provide direct and indirect employment to about 50 community members.

To keep link with the international climate change community, ACCREC has participated in the United Nations Framework Convention on Climate Change (UNFCCC) for six (6) years. Our research areas focus on tree varieties that are economical and can withstand the long term of dryness and can reclaim degraded lands in the northern part of Borno in which Lake Chad is found. The region is facing Water scarcity thereby utilizing the beginning of the rainy season and river banks. Drying of rivers and lower/no vegetation covers hinders sequestration of carbon.

Propagation of Jatropha in the Northeast by ACCREC

i. Our plantation houses 500 or more trees of jatropha

ii. ACCREC has for two years consecutively embarked on massive enlightenment of the use of jatropha economically and socially

iii. ACCREC has for 6 years since inception of our jatropha campaign been engaging the IDPs in raising seedlings

iv. Research ongoing on the nutritional boost of soil by jatropha plants, been carried out by our research and scientific officer.

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