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Review

Jatropha: A multipurpose plant with considerable potential for the tropics

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***Jatropha curcas* L is a multipurpose shrub and a member of the family Euphorbeaceae with several attributes and considerable potential. The present review article discussed the reported recent research on the cultivation and utilization of various parts of jatropha plant for different applications. *J. curcas* L is a tropical plant that can be grown in marginal lands of low to high rainfall areas and can be used as a commercial crop. The plant can be used to prevent and/or control erosion, to reclaim land, grown as a live fence to protect agricultural fields from farm animals and can be planted as an alternate commercial crop. The plant produces many useful products, especially the seed, from which oil can be extracted; this oil can be used as a feed stock for biodiesel. The extracted oil can also be used for making soap, glue, dye, etc. The leaves, shoot latex, roots and seed oil has medicinal properties. The fruit exocarp (coat), seed shell and processed seed cake are rich in nitrogen, phosphorous and potassium and can be used as fertilizer. It could provide employment, save foreign exchanges, improve environment and develop the socio-economic status of poor resource farmers in developing countries. Much more research is required about management of *J. curcas* as to know more about the potential of its products.**

Key words: Physic nut (*Jatropha curcas* L), yield, economics, uses, bio-fertilizer, biodiesel.

INTRODUCTION

Identity of crop *Jatropha curcas*

The term “Jatropha” is usually used to refer to the species *J. curcas*, although there are approximately 170 known species of the plant (Dehgan, 1984). *J. curcas* L., a member of the family Euphorbiaceae, is a large drought-resistant multipurpose shrub with several attributes and considerable potential and has evoked interest all over the tropics as a potential biofuel crop (Takeda, 1982; Martin and Mayeux, 1984, 1985; Jones and Miller, 1991; Openshaw, 2000). It is a tall bush or small tree (up to 6 m height). The lifespan of this perennial bush is more than 50 years, and it can grow on marginal soils with low nutrient content (Foidl et al., 1996; Openshaw, 2000). *J. curcas*, or “physic nut” has a straight trunk with thick branchlets. It has green leaves with a length and width of 6 to 15 cm. Normally, five roots are formed from seeds: one tap root and 4 lateral roots and cuttings do not develop a taproot (Heller, 1996). Plants from cuttings do not develop the tap root, only the laterals. The branches contain whitish latex, which causes brown stains that are difficult to remove.

The plant is monoecious, occasionally hermaphrodite flowers occur (Dehgan and Webster, 1979). The fruits have an “American Football” type of shape (Figure 1) of about 40 mm length and contains 3 seeds (on average), which look like black beans with similar dimensions, of about 18 mm long and 10 mm wide. The average weight per 1000 seeds is about 500~800 g, which is equivalent to 1333 seeds per kg which look like black beans with similar dimensions of about 18 mm long and 10 mm wide. The seed coats constitute about 35~40% of the total seeds. The oil content in seeds ranges from 35 to 40% and the kernels 55 to 60% (www.jartropha.org). Many investigations have been done on the composition and content of the jatropha seeds (Table 1). The plant and its seeds are toxic to animals and humans and are therefore used worldwide as hedges to protect agricultural fields.

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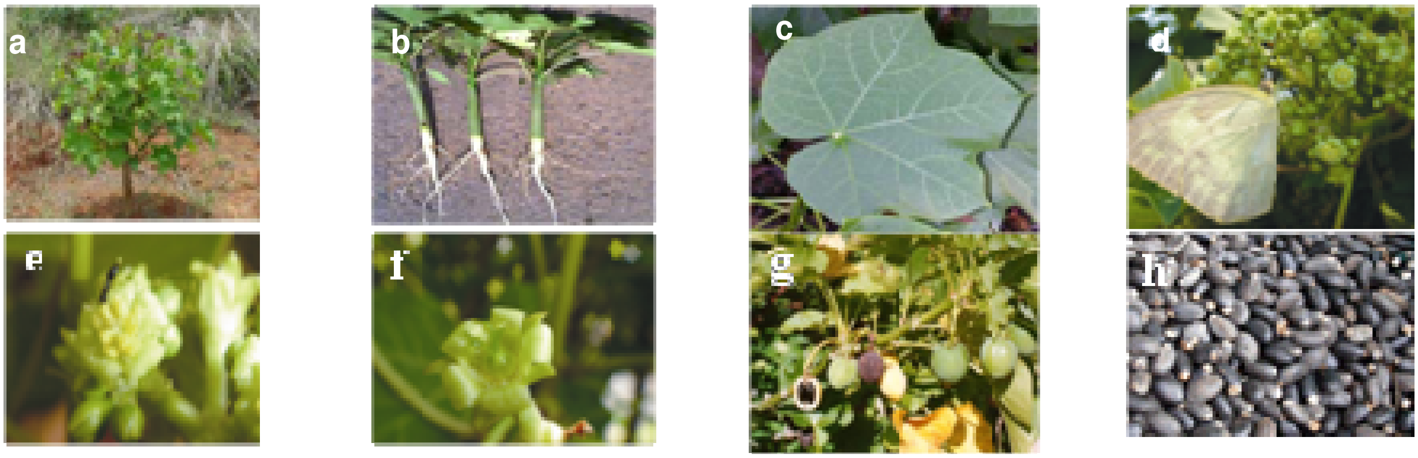

Figure 1. Important parts of the physic nut: a) plant, b) seedlings with root, c) leaf veinature, d) flowering branch, e) staminate flower, f) pistillate flower, g) fruits and cross cut of a mature fruit, h) seeds.

Table 1. Chemical properties of the jatropha seeds

Material	Kernel (60% of weight)	Shell (40% of weight)	Meal	Soybean meal
Crude protein	22.2-27.2	4.3-4.5	56.4-63.8	45.7
Lipid (crude fat)	56.8-58.4	0.5-1.4	1.0-1.5	1.8
Ash	3.6-4.3	2.8-6.1	9.6-10.4	6.4
Neutral detergent fibre	3.5-3.8	83.9-89.4	8.1-9.1	17.2
Acid detergent fibre	2.4-3.0	74.6-78.3	5.7-7.0	12.2
Acid detergent lignin	0.0-0.2	45.1-47.5	0.1-0.4	0.0
Gross energy (MJ/kg)	30.5-31.1	19.3-19.5	18.0-18.3	19.4

Sources: (Trabi, 1998; Makkar et al., 1997).

Occurrence, distribution and habitat

It is still uncertain where the centre of origin of *J. curcas* is, but it is believed to be a native of Mexico and the Central American region. It has been introduced to Africa and Asia and cultivated world-wide in many parts of the tropics and subtropics where it is grown as a hedge crop and for traditional use (Heller, 1996; Kumar and Sharma, 2008). Names used can also vary (English- physic nut, purging nut; Hindi - ratanjyot, jangli erandi; Malayalam - katamanak; Tamil - kattamanakku; Thailand - tuba, Gujarathi - jepal; Sanskrit - kanana randa, Indonesia - jarak pagar, Malay - jarak etc.), according to region/country. It is most commonly known as “physic nut” or “hedge castor oil plant”. The current distribution shows that introduction has been most successful in the drier regions of the tropics and can grow under a wide range of rainfall regimes from 250 to over 1200 mm per annum (Katwal and Soni, 2003). It occurs mainly at lower altitudes (0 to 500 m) in areas with average annual temperatures well above 20℃ but can grow at higher altitudes and tolerates slight frost. It grows on well-drained soils with good aeration and is well adapted to marginal soils with low nutrient content.

Jatropha growing climate and soil

Temperature is an important aspect of climate and can be used to grade climatic zones on a scale of five (e.g. http://www.jatrophaworld.org/47.html): tropical, subtropical, temperate, cold and polar. Jatropha can be grown in wide range of soils in all countries falling under tropical, subtropical zones (Figure 2) and in certain countries fall in temperate climate. It can be grown well on degraded soils having low fertility and moisture and also on stony, shallow and even on calcareous soils. For economic returns, a soil with moderate fertility is preferred. The emergence of seed requires hot and humid climate. It can be cultivated successfully in the regions having scanty to heavy rainfall.

Jatropha cultivation

J. curcas can be established from seed, seedlings and

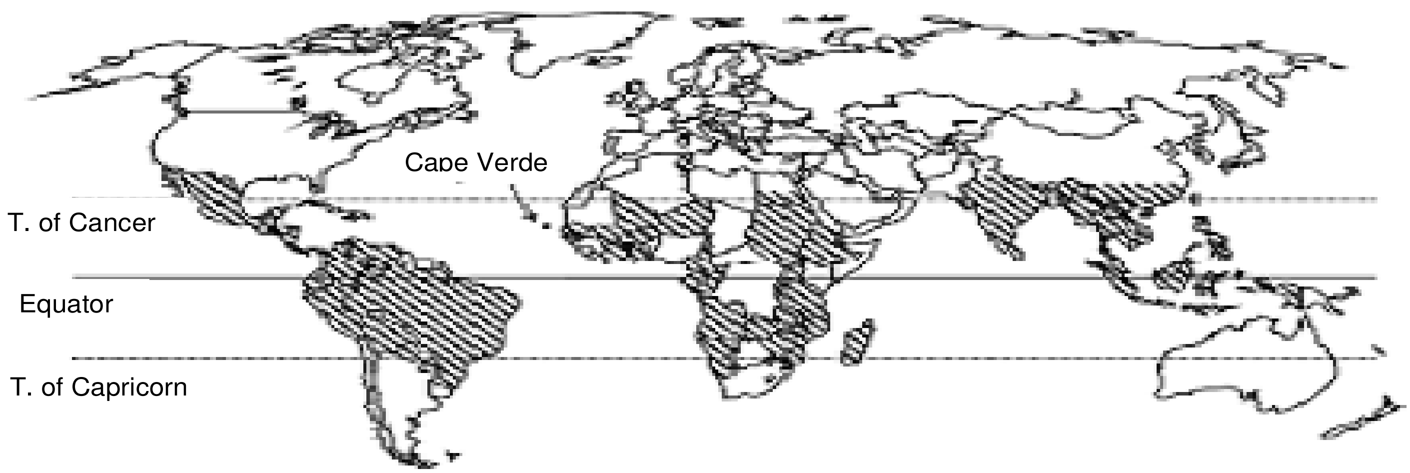

Figure 2. Global indication of the most suitable climatic conditions for the growth and production of physic nut (*Jatropha curcas* L) (30°N, 35°S) (Heller, 1996; King et al., 2009).

cuttings. The best time for planting is in the warm season before or at the onset of the rains. In the former case, watering of the plants is required. The recommended spacing for plantation is 2 to 3 m by 1.5 to 3 m for plantations (Jones and Miller, 1992). The number of trees per hectare at planting may range from 1100 to 3300. Plant growth is dependent on soil fertility and rainfall. A poor nutrient level will lead to increased failure of seed development (Gubitz et al., 1997). Thus, it is important to maintain soil fertility; this is contrary to statements made in some publications (Mauwa, 1995). Like all perennial plants, it displays vigorous growth in youth; this will tail off gradually towards maturity. Management of jatropha requires the addition of manure and NPK to the planting hole at 2 kg compost, 20 g urea, 120 g SSP(single surer phosphate) and 16 g MOP (muriate of potash) and urea should be applied in two splits (1 and 2 months after transplanting) at 10 g per plant (Singh et al., 1996). Yearly top dressings of fertilizers including the seed cake should be done.

Yield of *J. curcas* and income

J. curcas begins bearing seeds within 9 months, reaches commercial productivity in 3 years and lives for up to 50 years. The potential seed yield of jatropha after 5 years is 6 tons to as high as 12 tons/ha depending on the soil, climate and plants management. The seed yields reported for different countries ranged from 0.1 to 15 tons ha^{-1} $year^{-1}$ (Heller, 1996; Jones and Miller, 1993). Henning et al. (1995, 2004) reported that some 18-month-old trees were producing approximately 2.5 kg of seeds per tree but in literature; the yield reports are varying and confusing. This may be attributed to one or a combination of the following factors including: yields are sometimes given in terms of fruits, seeds, nuts, or kernels, variance in germplasm, unstipulated spacing between plants, no specific data on soils (ranging from marginal to fertile, and if fertilizer was applied), no information on rainfall and other climatic conditions, and if irrigation is being used. Jatropha can generate net income for 30 to 35 years at approximately US$ 205 $acre^{-1}$ $year^{-1}$ from the 4th year.

Harvesting and processing

Seeds can usually be harvested one year after planting. It is best to harvest the fruits when their color turned yellow to dark brown. Approximately two to three months after flowering, the seeds should be collected when the capsules have split open. The IPGRI report gives a conversion factor of 30 kg of fruits yielding approximately 18 kg of seed. One might assume that the fruit to seed ratio may be higher in areas of higher rainfall. One kilogram of jatropha seeds consists of 600 to 1,600 pieces of seeds. Seeds are de-hulled by using wooden plank and then winnowed to separate the hulls from the seeds. Before storing, the seeds must be air dried to 5 to 7% moisture content and stored in air-tight containers. Seeds can be stored up to one year at room temperature. Seeds for replanting can be gathered when fruits are already yellow to dark brown. Seeds should not be dried in direct sunlight because it will affect its germination. Dry, black seeds can be used for oil extraction.

Use of various parts of *J. curcas* plant

J. curcas is a promising species because of its useful and profitable by-products. The chemical composition of various parts of *J. curcas* plant, which has industrial

Table 2. Chemical composition of different parts of jatropha *curcas* plant.

Various parts	Chemical composition with references
Root	β-sitosterol and its β-D-glucoside, marmesin, propacin, the curculathyranes A and B and the curcusones A–D, diterpenoids jatrophol and jatropholone A and B, the coumarin tomentin, the coumarino-lignan jatrophin as well as taraxerol [Naengchomnong et al., 1986, 1994].
Stembark	β-Amyrin, β-sitosterol and taraxerol [Mitra et al., 1970]
Leaves	Flavaonoids apigenin, vitexin, isovitexin, dimmer of atriterpene alcohol ($C_{63}H_{117}O_9$) and two flavonoidal glycosides [Mitra et al., 1970; Khafagy et al., 1977; Hufford and Oguntimein, 1987]
Aerial parts	Organic acids (o and p-coumaric acid, p-OH-benzoic acid, protocatechuic acid, resorsilic acid, saponins and tannins, β-Amyrin, β-sitosterol and taraxerol [Hemalatha and Radhakrishnaiah, 1993]
Latex	Curcacycline A, a cyclic octapeptide, Curcain (a protease) [Van den Berg et al., 1995; Nath and Dutta, 1991]
Seeds	Curcin, lectin, phorbolesters, esterases (JEA) and lipase (JEB) [Stirpe et al., 1976; Adolf et al., 1984; Makkar et al., 1997; Staubmann et al., 1999]
Oil cake and kernel	Phytates, saponins and trypsine inhibitor [Aregheore et al., 1997; Makkar and Becker, 1997; Wink et al., 1997]

Source: Kumar and Sharma (2008)

applications is given in Table 2. Jatropha oil has various uses and apart from its use as a biofuel, the oil has been used to produce soup, medicine and pesticides (Shanker and Dhyani, 2006). The utilization of various parts of *J. curcas* L. is reviewed here, to know the potentials for improving economic situation of various tropical and subtropical countries (Figure 3).

Erosion control as hedge plant and biofence

J. curcas has the advantage that not only is it capable of growing on marginal land, but it can also help to reclaim problematic lands and restore eroded areas. The cultivation of jatropha leads to the primary conservation benefits such as improved soil restoration and management. It can protect soil from erosion and plants from wind erosion (Haller, 1996). Jatropha plant can serve as live fence for the protection of agricultural fields against damage by live stocks. The plant acts as cost effective biofence compared to wire fence. Jatropha is chosen for this purpose mainly because it can easily be propagated by cuttings, densely planted for this purpose, and because the said species is not browsed by cattle.

Medicinal use

Jatropha is known as the physic or purging nut for its use as purgative/laxative, and is widely known as medicinal for treatment of a variety of ailments. Preparations of all parts of the plant, including seeds, leaves and bark, fresh or as a decoction, are used in traditional medicine and veterinary purposes (Dalziel, 1955; Duke, 1985, 1988). The methanol extract of Jathropa leaves showed potent cardiovascular action in animals and might be a source of beta-blocker agent for humans. The sap flowing from the stem is used to control the bleeding of wounds. The latex of jatropha contains alkaloids including Jatrophine, jatropham and curcain with anti-cancerous properties (Van den Berg et al., 1995; Thomas et al., 2008). The roots are reported as an antidote for snake-bites. The anti-inflammatory activity of *J. curcas* L. root powder in paste form, was confirmed through the investigation conducted on albino mice by Mujumdar and Misar (2004). The oil has a strong purgative action and is widely used to treat skin diseases and to soothe pain from rheumatism (Heller, 1996; Marroquin et al., 1997). The 36% linoleic acid (C18:2) content in jatropha kernel oil is of possible interest for skincare. Research is underway on the potential of this plant against HIV.

Plant protectant

Extracts from all parts of the physic nut showed insecticidal properties on plants (Grainge and Ahmed, 1988; Consoli et al., 1989; Jain and Trivedi, 1997; Meshram et al., 1994). Most of the experiments done are still in experimental stage. The oil and aqueous extract from oil has potential as an insecticide. For instance, it has been used in the control of insect pests of cotton

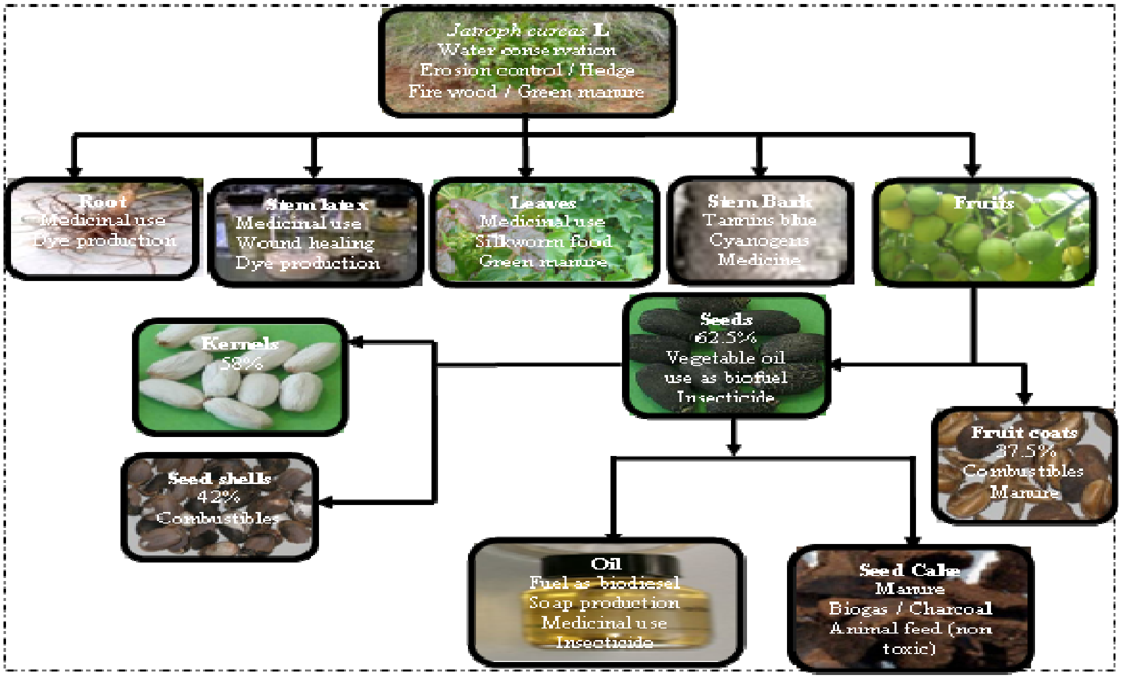

Figure 3. Uses of various parts of *Jatropha curcas* plant.

including cotton bollworm, and on pests of pulses, potato and corn (Kaushik and Kumar, 2004). The pesticidal action of the seed oil is also the subject of research of International Crops Research Institute for the Semi-Arid Tropics, (ICRISAT) in India.

Raw material for dye

The bark of *J. curcas* yields a dark blue dye which is reported to be used for coloring cloth, fishing nets and lines. The dye may be extracted from leaves and tender stems and concentrated to yellowish syrup or dried to blackish brown lumpy mass. The dye imparts to cotton different shades of tan and brown which are fairly fast. Further research in this field can open up great possibilities.

Firewood and input for charcoal production

The plants and fruit hulls could be used for firewood. Jatropha wood is a very light wood and is not popular as a fuel wood source because it burns too rapidly. Some have suggested converting press cake into charcoal. Seed cake can result to a very high-quality charcoal that has the potential to be used in high-value markets. But press cake is much more valuable to use as a fertilizer to ameliorate the impoverished soils in the developing countries with organic matter and increase crop production (Benge, 2006). No experiments are known so far. The scientist concluded that jatropha wood would not be of much value for either charcoal or firewood (Benge, 2006).

Input for biogas production

The seed cake can in principle be converted into biogas by digestion in biogas tanks as still it contains oil, together with other input materials, such as dung, leaves etc. The biogas can be used for cooking and lighting. The residue can still be used as organic fertilizer, as it retains all of its minerals and nutrients. The use of seed cake as a single digestion input has been researched by Foidl and Eder (1997) but requires further investigation.

Human consumption

Jatropha can be toxic when consumed and many cases of poisoning with physic nut are reported in the literature (Siegel, 1893). However, a non-toxic variety of jatropha is reported to exist in some provenances of Mexico and Central America, said not to contain toxic Phorbol esters (Makkar et al., 1998a, b). This variety is used for human consumption after roasting the seeds/nuts (Delgado and Parado, 1989), and "the young leaves may be safely eaten, steamed or stewed." When grown from seeds, the plants are edible for the first 3 months, since the toxic material has not been developed yet. Levingston and Zamora (1983) report that jatropha seeds are edible once the embryo has been removed; nevertheless on principal, consumption of seeds should be avoided. Non-toxic variety of jatropha could be a potential source of oil for human consumption, and the seed cake can be a good protein source for humans as well as for livestock (Becker, 1996; Makkar and Becker, 1997, 1999; Aregheore, 2003).

Oil for lighting and cooking

Although many researchers have described jatropha as a potential domestic fuel for cooking and lighting, with properties similar to kerosene, it cannot be used directly in conventional kerosene stoves or lamps. High ignition temperatures and viscosity (75.7 10^{-6} m^2/s) as compared to kerosene (50-55°C, and $2.2x10^{-6}$ m^2/s, respectively), mean that jatropha oil will not burn as well, and would

Table 3. Properties of diesel, methanol, jatropha oil and jatropha oil methyl ester

Properties	Diesel	Methanol	Jatropha oil	Jatropha oil methyl ester	European standard
Density (kgm^{-3})	840	790	918.6	880	860-900
Calorific value (kjkg^{-1})	42490	19674	39774	38450	-
Viscosity (cst) (40°C)	4.59	-	49.93	5.65	3.5-5.0
Cetane number	45-55	3-5	40-45	50	>51
Flash point (°C)	50	-	240	170	101
Carbon residue (%)	0.1	0.0	64	0.5	<0.3

Source: (Vinayak and Kanwarjit, 1991; Basker, 1993).

Table 4. Fertilizer value of *Jatropha curcas* oil cake, root and other manures.

Fertilizer properties	*Jatropha curcas* oil cake (%)	*Jatropha curcas* root (%)	Cow dung (%)	Neem oil cake (%)	Chicken manure (%)
Nitrogen	3.2 - 4.44	2.16	0.97	5.00	3.04
Phosphorus	1.4 - 2.09	0.08	0.69	1.00	6.27
Potassium	1.2 - 1.68	2.18	1.66	1.50	2.08
Moisture	4.58	-	9.70	-	10.19

Source: Delgado and Parado (1989), www.dovebiotech.com

clog up all the tubes and nozzles in a conventional stove or lamp. A low intensity lamp with a wick has been developed to circumvent these problems. The oil lamp and stove require a very short wick, so that the flame is very close to the oil surface. Further research is required to make available that special stove and lamp.

Oil as a biodiesel

Jatropha oil can be used as fuel in diesel engines directly and by blending it with methanol (Gubitz et al., 1999). More recently, the clear oil expressed from the seed has been suggested for energetic purposes as a substitute for diesel. The oil obtained from the jatropha seed was used as diesel substitute during the World War II (Agarwal and Agarwal, 2007). The tests conducted during those days at Thailand were shown as a satisfactory engine performance (Takeda, 1982). Most importantly, it is significant to point out that the oil of *J. curcas* is a viable alternative to diesel fuel since it has desirable physico-chemical and performance characteristics as diesel (Table 3). The obtained biodiesel from jatropha oil after transesterfication confirms the standard requirements of American and European countries (Azam et al., 2005; Fairless, 2007; Tiwari et al., 2007). Cars and trucks could be run with *J. curcas* oil without requiring much change in engine design. However, there are several points of view that differ considerably regarding jatropha's suitability as a substitute for petroleum products. The seed oil of jatropha may not be used directly in engines because of lower cetane number and higher viscosity at low temperatures as compared to conventional diesel. This may be due to the fact that, the diesel is a hydrocarbon with 8 to 10 carbon atoms per molecule whereas jatropoha seed oil has 16 to 18 carbon atoms per molecule. The transesterification process was adopted to convert jatropha seed oil into biodiesel. The Washington State University study optimistically concludes that while many vegetable oils are used to manufacture biodiesel, a given amount of land will produce much more oil from jatropha than from the common alternatives (soybeans, cotton seed, rapeseed, sunflower, groundnuts).

Oil for soap production

The local production of soap is one of the most economically attractive uses of jatropha oil. The glycerin by-product of the trans-esertification process can be used to make a high quality soap, or it can be refined and sold at a range of prices, depending on its purity, to be used in an immense range of products, including cosmetics, toothpaste, embalming fluids, pipe joint cement, cough medicine, and tobacco (as a moistening agent). The soap has positive effects on the skin and is therefore marketed for medicinal purposes. Jatropha oil is used mainly in the manufacture of high quality soap. According to the IPGI report, pressing of 12 kg of seeds yields 3 L of oil that is then transformed into soap, 28 pieces of soap of 170 g each, which is 4.76 kg. This takes 5 h of work (estimated). The total input is added to US $3.04. The soap can be sold for US $4.20, and the resulting 9 kg of press cake is well appreciated as organic fertilizer and can be sold for US $0.27; a total revenue of US $4.47 (Benge, 2006).

Seed cake use as manure

The byproduct of oil extraction from the seeds and kernels is called seed cake. Jatropha seed cake contains curcin, a highly toxic protein similar to ricin in Castor, making it unsuitable for animal feed. However, it does have potential as good organic manure (Staubmann et al., 1997; Gubitz et al., 1999), replacing chemical fertilizer since it has nitrogen content (Kumar and Sharma, 2008) similar to that of neem oil cake, castor bean, cow/chicken manure (Table 4). The nitrogen content ranges from 3.2 to 3.8% (Juillet et al., 1955; Moreira, 1979; Vohringer, 1987). Application showed phytotoxicity, expressed as reduced germination, when high rates of up to 5 tonnes ha^{-1} was used. The GTZ project in Mali carried out a fertilizer trial with pearl millet where the effects of manure (5 tonnes/ha), physic nut oil cake (5 tonnes/ha) and mineral fertilizer (100 kg ammonium phosphate and 50 kg urea/ha) on pearl millet were compared (Henning et al., 1995). Pearl millet yields per hectare were maximum (1366 kg) in physic nut oil cake treatment. As the costs for mineral fertilizer were higher than those of the oil cake (Henning et al., 1995), it is appreciated by the farmers and can be sold for 10 FCFA per kg (US $ 0.02/kg).

Seed cake use as animal feed

Press-cake derived from the non-toxic varieties of *J. curcas* may be used as animal feed. When processed as a cottage industry, the seed cake still contains approximately 11% oil, has 58 to 60% crude protein (53 to 55% true protein content), and the level of essential amino acids except lysine is higher than the FAO reference protein. Seed cake from Mexico and Central American non-toxic varieties may not be toxic. Non-toxic varieties are not grown in Asia and Africa.

Other uses

Jatropha oil is also used to soften leather and lubricate machinery (e.g. chain saws). If seed cake is available in large quantities, it can also be used as a fuel for steam turbines to generate electricity. Apart from the bio-diesel application, the oil finds the application in cosmetic industries, for the manufacture of candles and soap. The extraction of the biodiesel after transesterification of the seed oil, leads to two main by-products that is glycerol and press or oil cake. Glycerol has many useful industrial applications as a raw material for the synthesis of 1, 3 propane-diol and other polymeric materials (Sharma, 2008). The bark of jatropha contains tannin. It can also have the honey production potential as the flowers can attract bees.

CONSTRAINTS AND LIMITATIONS

There is a little published information about the crop management and fertilizer requirements of *J. curcas*. A key determinant of the economics of jatropha as a source of biodiesel fuel, is the efficiency with which oil is extracted from the seed. Another constrain of jatropha technology is the unavailability of efficient oil extraction methods. Jatropha oil does not store well without processing, perhaps for only a few months; therefore, this would make it difficult to provide fuel to power the year-around (Benge, 2006). Bark, fruit, leaf, root, and wood are all reported to contain HCN. Seeds contain the dangerous toxalbumin curcin, rendering them potentially fatally toxic. Two seeds are strong purgative. Four to five seed are said to have caused death, but the roasted seed is said to be nearly innocuous. The toxicity of the seeds is mainly due to the presence of ‘curcin’ and ‘diterpine’. Jatropha has the potential to be weedy because of its toxic seeds that can spread rather easily and create dense stands on uncultivated lands. It is reported as a weed in many places including Australia, Brazil, Fiji, Honduras, India, Jamaica, Panama, Puerto Rico, and Salvador.

CULTIVATION SCOPE AND FUTURE OUTLOOK

Due to potential demand and better marketing opportunities, cultivation of jatropha appears viable. jatropha adapts well to marginal lands as well as live fence, as farm animals do not browse it. The crop can easily be raised without any difficulty; the rural women can be engaged in all kinds of activities like raising seedlings, collection of seeds, de-shelling, etc. The large scale cultivation of *J. curcas* on wastelands with poor soils and low rainfall in drought prone areas could provide regular employment and could improve their living conditions by providing additional income. Jatropha is not an alternative to agriculture or plantation but it is a new addition to it.

To increase *J. curcas* cultivation, it becomes more important to develop new varieties that produce the maximum amount of oil and by-products with the minimum amount of input. A thorough evaluation of the existing germplasm, with particular emphasis on desirable material is also required. In addition to the natural genetic variation available within the species, mutation breeding or the creation of inter-specific and intra-specific hybrids, could also allow a wider range of agronomically beneficial traits to be incorporated into cultivars.

CONCLUSION

J. curcas is a “miracle tree” and certainly a highly interesting plant with potential uses, particularly as biofuel to help in combating the energy crisis throughout the world and generate income in rural areas of developing countries. The jatropha plant can become globally competitive due to the fact that it belongs to a non-edible category and does not compete with food. Jatropha oil is a clean fuel reducing greenhouse gas emissions, has greater lubricity and reduces engine wear. Pure jatropha biodiesel is non-toxic in nature. The literature findings reveals several successful application of jatropha which includes functions like soil water conservation, soil reclamation, erosion control, living fences, green manure, lightning fuel, local use in soap production, insecticide and as raw material for pharmaceutical and cosmetic industries. From the above discussions, it is clear that the jatropha plant has capabilities to provide the products for different applications apart as a diesel substitute which needs to be captured and improved. Jatropha is economically viable not only to the growers but also to the processors and end users. To the rural society, the crop can create regular employment opportunities, as it provides never ending marketing potential. The research on the utilization of the by-products of jatropha namely seed husk, seed kernel, glycerol, etc. in the material manufacturing area needs to be explored.

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