BIO-FUEL FOR ALTERNATIVE ENERGY: A REVIEW OF *JATROPHA CURCAS* L.

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ABSTRACT

The present world is realm of high energy input. Energy requirements at present are mainly fulfilled by fossil fuels. But there are many undesirable aspects of fossil fuel production and utilization. These include ecosystem damage due to mining, pollution to the land and water systems, unstable supplies, limited and localized presence, high cost etc. As fossil fuel resources tend towards extinction, there is change of focus towards alternative fuels. Biofuel is also one of them. Bio fuels are fuels produced by renewable plant material. These include ethanol based and oil based fuels. Among oil based fuels many seed oil producing plants are being investigated. *Jatropha curcas* is one of the most promising bio fuel plants, which produces large quantities of oil and needs exceptionally low maintenance in production. The present paper deals with history, botanical aspects, cultivation and future of this plant as an important biofuel crop.

Keywords: Biofuel, *Jatropha curcas*, Petroplant, seed oil.

INTRODUCTION

The Republic of India is the seventh-largest country by area and the second-most populous country after China in the world. It has a multilingual and multiethnic population of over 1.3 billion. An efficient administration for equity, a tradition of learning that has produced not only a huge technical workforce but accelerated economic growth, are certain exclusive properties of the nation could make India a global leader in any sector. India has made tremendous successes in atomic energy and space technology, having developed one of the most advanced nuclear reactors and put a vehicle on the moon. Nevertheless, 40 percent of the population, particularly in rural areas, lacks electricity and other kinds of commercial energy like modern cooking fuels. Rising levels of literacy, now close to 70 percent, as well as access to electronic media, rapid democratic empowerment, and political awareness warrant the widespread availability of affordable energy as soon as possible. This is the greatest challenge in the energy sector. Availability and access to energy are the catalysts for growth and the eradication of poverty. The main sources of energy in India are fossil fuels like coal, oil and natural gas. Oil and gas both need to be imported from various parts of the world and mainly the Middle East.

The first petroleum scarcity arose in 1973 when the OAPEC countries announced an oil embargo. This embargo increased the rates of crude oil from $3 per barrel to $12 per barrel. The second oil crisis or shock came in 1979 with similar problems caused by oil exporting countries. This was the first time that the world thought about alternative sources of energy that could replace oil. To overcome the energy problems a great deal of research on solar energy, wind energy, hydropower, biomass energy and biogas has been carried out by government organizations and educational institutes in different countries. A number of options for alternative liquid fuel production have been considered in many countries. Some of them are based on biomass, a renewable source of fuel. An important alternative can be the use of oil from oil seeds.

The oil seed option could complement alcohol fuel alternatives, in that the seed oils are more suited for diesel than for petrol engines. In view of the uncertainties in the availability and price of liquid fuels from petroleum, it appeared prudent to carry out research and development of seed oils as alternative fuels for diesel engines in order that their production and use could be rapidly implemented, should the need arise. Tests were also made in India with diesel engines using *Jatropha curcas* L. oil as part of a research project carried out with the co-operation of Yanmar (Thailand) Co. Ltd. and very satisfactory results were obtained. The engine performance and fuel consumption compared favourably with running the engines on normal diesel engine oil (Bhasabutra and Sutiponpeibun 1982). Utilization of *Jatropha curcas* oil as a new source of oil for diesel engine was thus well established. Since then a lot of published literatures are available to answer the many specific questions about its production and commercialization.

BOTANICAL ASPECTS-

Jatropha curcas L. is considered as one of the most interesting potential source of non-edible biofuel. The ex-President of India, Late Dr. Abdul Kalam, was one of the strong advocators of *Jatropha* cultivation for production of bio-diesel. Once in his recent speech, the Former President said that out of the 600,000 km² of wasteland that is available in India over 300,000 km² are suitable for *Jatropha* cultivation. Once this plant is grown the plant has a useful lifespan of several decades. During its life, *Jatropha* requires very little water when compared to other cash crops (Jaray 1984).

Jatropha curcas L. – First named by Linnaeus (1753) and the word is derived from Greek 'Jatros' (doctor) and 'trophe' (food/nutrition) which implies medicinal uses. *Jatropha curcas* L. is a native of America, cultivated throughout the tropics, and is casually subspontaneous in Mauritius and Seychelles. It was introduced in India by Portuguese as an oil yielding plant. It is commonly known as '*dravanti', 'jangii-arandi', 'ratanjyota', 'bagbherenda', 'jamalgota', 'kattamanakku'* in different States of India. It is known as 'Physic nut' and 'Purging nut' in English. Different names are given in different countries, like '*sabudam*' in Thailand, '*thinbankyekku*' and '*thinbaukyeksu*' in Burma, '*tuba*' in Philippines, '*ma gong chou*' in Chaina, '*kadam*' in Nepal, '*pinheiro de purga*' in Brazil, '*ricin d' Amerique*' in French and '*roppendaru*' in Sri Lanka.

BOTANICAL DESCRIPTION

Genus *Jatropha* is reported to comprise about 70 species, chiefly native of America, 4 are indigenous to India and 3 are naturalized. So far about 9 species have been recorded in India. Common species reported from India are *Jatropha gossypiifolia* that is a wild plant however *Jatropha podagrica* and *Jatropha rosea* are ornamental shrub**.** Lott (1984) has studies in detail about the species of *Jatropha* in Mexico. Chromosome number of *Jatropha curcas* was found to be 2n=22.

Jatropha curcas is a shrub or small tree with stem up to 20 cm. diameter and up to 6 meter height. Branches are stout, fleshy and glabrous. Bark is smooth pale greenish or light ash-coloured, wood soft and spongy. Leaves are alternate, petiolate, ovate-rounded, widely cordate at the base, five-angled and smooth. Petiole is rounded and smooth.

Flowers are protogyne i.e. female flowers mature first than male flowers. Flower in loose panicles of axillary cymes, yellowish green, peduncles and pedicels more or less tomentose. The male flowers at the extremities of the ramifications, on short, articulated pedicels and the female ones in their divisions, with their pedicels not articulated. In male flower corolla-10, fused, volvate, slightly yellow, calyx-5, sepaloid, androecium-10 in two alternate whorls with the numbers of outer whorl opposite to the petal.

Female flowers are hypogynous, ovary tri-carpellary, syncarpous, one anatropous ovule in each locule with axile placentation. Pollination is entomophillous type. Capsules are ellipsoid, scarcely lobed.

Fruit is long, dull dark brown or black, ovoid-oblong, breaking up into 3 two-valved cocci, 2.4 – 2.7 cm long, seeds are normally 3, ovoid-oblong, 0.5 – 0.6 gm. in weight, 1.6 – 1.7 cm in length and 1.0 – 1.1 cm in diameter. It has also been observed in moist conditions that seeds start sprouting on the tree inside the capsule before harvesting.

CULTIVATION

This shrubby plant is commonly grown in semi-wild condition as a hedge plant around cultivated fields and in the vicinity of villages. It is one of the promising drought tolerant perennial crops and is adaptable to various kinds of soil conditions. It grows well on moderately sodic and saline degraded and eroded soils so that their production does not exert any pressure on agricultural lands. The plant can be grown directly by seed or by vegetative propagation or by transplantation of one month old seedling in May or June. The proper time for seed germination is from second week of April to last week of May. Interspacing between plants should be minimum 1 x 2 x 2 m. The plant can be grown on the setting of winter by propagation of stem cuttings. Stem cuttings sizes must be between 10 cm to 20 cm. The growth of the plant is slow in the beginning but accelerates in August – September after rainy season. It flowers in hot and rainy seasons and set fruits in winter. The plants become leafless at the end of winter and new leaves arise at the start of spring (Datta and Pandey 1992, 2013).

SEED OIL

Seeds contain 30 – 50% semi-drying oil of pale yellow colour with acrid taste and 7% moisture. The seed oil can be extracted by solvent extraction or mechanically by using hydraulic press or simple screw press. The oil contains about 21% saturated fatty acid and 79% unsaturated fatty acids, palmitic, stearic, oleic and linoleic acids being the major fatty acids, GLC analysis of fatty acid methyl esters gave following results : Palmitic acid – 18.5%, Stearic acid – 2.3%, Oleic acid – 49.0% and Linoleic acid – 29.7%. Fatty acid composition in ripening seeds has been reported (Datta and Pandey 1996a). Banerji *et al*. (1985) determined the oil contents, physic-chemical properties, fatty acid composition and energy value of seed samples of four *Jatropha* species.

Seed oil is used as a lubricant, illuminating agent, as an adulterant for groundnut oil and for making soaps and candles. The oil can also be used as a varnish for furniture's after mixing with iron oxide. The latex can be used for making resin and dye. The oil of the plant can silkworm. The oil is also used as a lubricant for bullock carts axles and other agricultural implements by village people.

In former times Portugal imported *Jatropha* seeds from Cape Verde Islands to produce soap. In India, Nepal and Zimbabwe the prize of tallow or the prize of J*atropha* and other plant oils is at least 2.5 times the selling prize of diesel. Obviously, selling *Jatropha* oil for soap making is far more profitable in these countries than using it as a diesel or kerosene substitute (Openshaw 2000).

A POTENTIAL SUBSTITUTE FOR DIESEL ENGINE FUEL

An extensive work on the performance of *Jatropha curcas* oil as a diesel engine fuel was performed by Forson *et al*. in 2004 on Lister model single cylinder, air cooled, direct injection air cooled engine. They perform the test by operating the engine by Jatropha oil and blend of diesel and Jatropha oil in proportions of 97.4%/2.6%;80%/20%; and 50%/50% by volume. They have performed a range of operating loads on the engine. Forson *et al*. studied for the chemical and physical properties of the fuels, brake specific fuel consumption, brake power, brake thermal efficiency, engine torque, and the concentrations of carbon monoxide, carbon dioxide and oxygen in the exhaust gases. They also studied on carbon dioxide emissions, the trend for same was similar for the fuels but diesel fuel showed slightly lower emissions to the atmosphere. The result showed that Jatropha oil could be conveniently used as a diesel substitute in a diesel engine. The result further showed increases in brake thermal efficiency, brake power and reduction of specific fuel consumption for *Jatropha* oil and its blends with diesel generally, but the most significant conclusion from the study is that the 97.4% diesel/2.6% *Jatropha* fuel blend produced maximum values of the brake power and brake thermal efficiency as well as minimum values of the specific fuel consumption. The 97.4%/2.6% fuel blend yielded the highest cetane number and even better engine performance than the diesel fuel suggesting that *Jatropha* oil can be used as an ignition-accelerator additive for diesel.

Previously it has been tested that the seed oil can be used as a substitute for diesel engine fuel. A Kubota 4 – stroke cycle diesel engine (7 hp/2200 rpm) with a small piston and water cooling system and an Yanmar diesel engine (18 hp/2400 rpm) show better performance when run with curcas oil. During exhaust gas test it has been observed that engine when run with curcas oil, the value of carbon monoxide and smoke was lower than the accepted value as per the standard specification of the environmental board. There was no emission of sulphur dioxide in curcas oil exhaust gas as compared to 125 ppm in diesel engine exhaust gas.

CONCLUSION

According to available literature, *J. curcas* is adaptable to various kinds of soil conditions. Therefore, an attempt was made to study the performance of *J. curcas* under soil condition. The seeds of *J. curcas* were treated with different doses of gamma rays and different concentrations of colchicine and sown in the beds of Banthra Research Station, Lucknow (the soil being sodic characterised by high pH i.e. 8.7 to 10). Attempts are being made to select suitable strains from gamma ray and colchicine's treated population, suitable for growing under alkaline conditions (Datta and Pandey 1996b, 1998, 2005, Pandey 2015). Present investigations suggest that with proper isolation, evaluation, selection and improvement of *J. curcas*, a sustainable oil seed plantation can be made feasible for commercial exploitation.

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