

Jatropha

Cultivation

Jatropha is a genus of approximately 175 succulent plants, shrubs and trees (some are deciduous, like *Jatropha curcas* L.), from the family Euphorbiaceae. Jatropha is native to Central America and has become naturalised in many tropical and subtropical areas, including India, Africa and North America. Originating in the Caribbean, the Jatropha was spread as a valuable hedge plant to Africa and Asia by Portuguese traders. The hardy Jatropha is resistant to drought and pests and produces seeds containing up to 30-40% of non-edible oil. When the seeds are crushed and processed, the resulting oil can be used in a standard diesel engine, while the residue can also be processed into biomass to power electricity.

Although Jatropha comprises approximately 70 species, there is only one - the *Jatropha curcas* L. Euphorbiaceae - suitable for Jatropha oil production. The botanic name Jatropha is derived from Greek "Jatras" meaning Doctor and "trophe", Nutrition. The tree grows up to a height of 3 metres, which means harvesting is an easy task. A hybrid variety of Jatropha could give three harvests a year, compared to two harvests by other varieties of jatropha. It takes two years for a 'Jatropha' sapling to begin producing seeds and they can produce seeds for up to 30 years. The seeds are crushed to extract the raw oil.

Jatropha curcas grows almost anywhere, even on gravelly, sandy and saline soils. It can thrive on the poorest stony soil. It can grow even in the crevices of rocks. The leaves shed during the winter months form mulch around the base of the plant. 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. Climatically, *Jatropha curcas* is found in the tropics and subtropics and likes heat; although it does well even in lower temperatures and can withstand a light frost. Its water requirement is extremely low and it can stand long periods of drought by shedding most of its leaves to reduce transpiration loss. *Jatropha curcas* is also suitable for preventing soil erosion and shifting of sand dunes.

Some of the properties which make it useful as source of oil for the biodiesel industry are as follows:

- *Jatropha* grows well on low fertility soils. However, increased yields can be obtained using a fertiliser containing small amounts of magnesium, sulphur and calcium.
- *Jatropha* can be intercropped with many cash crops such as coffee, sugar, fruits and vegetables, with the *Jatropha* offering both fertiliser and protection against livestock.
- *Jatropha* needs at least 600mm of rain annually to thrive. However, it can survive three years of drought by dropping its leaves.
- *Jatropha* is excellent at preventing soil erosion and the leaves it drops act as a wonderful soil enriching mulch.
- *Jatropha* prefers alkaline soils.

Production

All crops need fertile soils with adequate moisture to be productive. As any other crop, *Jatropha* plants absorb nutrients from the soil. *Jatropha* plants grow on medium and low fertility soils and in low and high rainfall areas. *Jatropha* seeds have high oil content (30-40%). The plant can produce seeds between the first and second years under very favourable conditions. Seed production become stable after 4-5 years depending on soil fertility and rainfall. *Jatropha* trees develop fruit during the winter the leaves have fallen. However, in optimal conditions (warm temperatures and moist soil) several crops per year are possible. The fruits form in bunches of around ten and are initially olive green in colour. Over the following three or so months, the seeds contained within the fruits mature, while the fruit changes from green to yellow to black. At this stage, the fruits should be harvested either by hand or using olive harvesting equipment. The fruit is made up of a husk (seed coat) which must be removed

(can be composted) and the Jatropha seeds which hold the oil. After a couple of days of sun-drying, the seeds can easily be popped out of the fruits by hand.

Seeds must be well dried before pressing since moist seeds can develop mould and can also jam the pressing equipment. Pressing of the seeds is carried out by a mechanical seed press; human-powered or with an electric or diesel motor. Where a direct injection diesel motor is used to power the seed press, pressed oil can be used directly as a fuel; typically around 5% of the pressed oil would be used in this way. There is no need to heat the seeds as warm ambient temperatures are sufficient to obtain high yields with cold-pressing.

The important aspects of production can be summarised as:

- After the first five years, the typical annual yield of a Jatropha tree is 3.5kg of beans.
- Jatropha trees are productive for up to 30-40 years.
- 2,200 trees can be planted per hectare (approximately 1,000 per acre).
- One hectare should yield around 7 tonnes of seeds per year.
- The oil pressed from 4kg of seeds is needed to make 1 litre of biodiesel.
- 91%+ of the oil can be extracted with cold-pressing.
- One hectare should yield around 2.2-2.7 tonnes of oil.
- Press cake (seed cake) is left after the oil is pressed from the seeds. This can be composted and used as a high grade nitrogen-rich organic fertiliser (green manure).

Composition and Properties

The basic details of the genus are shown in the following table:

- Size : up to 6 metres high.
- Productive life : 30-40 years.
- Stem straight, thick branches.
- Green leaves : 6-15 cm long and wide.
- Fruit : oval 40 mm long approximately.
- Each fruit contains 2-3 seeds.
- Seeds colour : black.
- Seeds : average long 18 mm (11-30).
- Seeds : average width 10mm (7-11).
- 1000 seeds : 0.750 a 1.0 Kg approximately.
- Oil in seeds : more than 30%.
- Branches contain whitish latex.
- Normally five roots in germinated seeds.
- One central root and four laterals in seed. Each Jatropha seedling should be given a 2m x 2m area to grow into.
- Without leaves in drought and winter.
- Plant without leaves remain latent.
- Do not stand cold or frost.

The Composition of the Seed and Shell

Product	Mass 60%	Shell 40%	Meal
Crude protein	25.6	4.5	61.2
Lipids (crude oil)	56.8	1.4	1.2
Ash	3.6	6.1	10.4
Neutral detergent fibre	3.5	85.8	8.1

Acid detergent fibre	3.0	75.6	6.8
Lignin acid detergent	0.1	47.5	0.3
Gross energy (MJ/Kg)	30.5	19.5	18.0

The fatty acid profile of Jatropha oil is mainly unsaturated, which is useful when considering the cold flow properties when used in the biodiesel process. The profile is compared with those of palm and coconut in the table below. As with all plants, this profile will vary with origin and variety and, in particular, the C18:1 content is shown in the literature as being 43% in the Nicaraguan variety and 34% in material from Mali.

Comparison of Fatty Acid Profile

Fatty Acid	Jatropha	Palm	Coconut
Caprylic Acid (C8:0)	-	-	8
Capric Acid (C10:0)	-	-	8
Lauric Acid (C12:0)	-	-	48
Myristic Acid (C14:0)	0.38	3.5	16.0
Palmitic Acid (C16:0)	16.0	39.5	8.5
Palmetoleic Acid (C16:1)	1-3.5	-	-
Stearic Acid (C18:0)	6-7	3.5	2.5
Oleic Acid (C18:1)	42-43.5	46	6.5
Linoleic Acid (C18:2)	33-34.5	7.5	2.0
Linolenic Acid (C18:3)	0.8	-	-
Production kg/Hectare	1590	5000	2260

Uses

Until recently, Jatropha had few uses other than a malaria treatment, a windbreak for animals, live fencing and candle-making. An ingredient in folk remedies around the world, it earned the nickname "physic nut", but its sap is a skin irritant. Being a perennial crop, it can be used for carbon capture and to alleviate soil degradation, desertification and deforestation. The oil from Jatropha seeds can also be used for production of soap, bio-pesticides and bio-diesel.

There is some discussion concerning the toxicity of the plant. Feeding studies on rats and fish established that the seed meal prepared from seeds collected from a wild variety of *Jatropha curcas* which originated from Mexico is non-toxic. The protein, energy, lipid and amino acid contents in the seeds of the non-toxic provenance are similar to those of toxic varieties. The meals contained significant levels of trypsin inhibitor, lectin and phytate, and their levels did not differ between the non-toxic and toxic varieties. However, it is unlikely that absence of phorbol esters in the seeds of non-toxic variety from Mexico suggests that one of the toxic principles in meals from toxic varieties is phorbol esters. The non-toxic variety of *Jatropha* from Mexico can be a suitable alternative to the toxic *Jatropha* varieties. This 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.

Keeping in view the advantages of the non-toxic variety, the seeds of this variety have been sent to Nicaragua, Zimbabwe, Mexico and India for cultivation through traditional and tissue culture techniques and comparison for yield, resistance to diseases, survival and nutrient requirements with the toxic varieties of the region. However, the material is not likely to become part of the food versus fuel debate in the near future.

The major use being discussed in the current climate is the fact that filtered Jatropha oil can be used as is in many diesel vehicles, with only small modifications required to the engine. It can also be used as a kerosene substitute for heating and lamps as it burns with a clear smokeless flame.

Future Prospects

The non-edible vegetable oil of *Jatropha curcas* has the requisite potential of providing a promising and commercially viable alternative to diesel oil since it has desirable physico-chemical and performance characteristics comparable to diesel. The *Jatropha* bush seems an unlikely prize in the hunt for alternative energy, being an ugly, fast-growing and poisonous weed. Hitherto, its use to humanity has principally been as a remedy for constipation. Very soon, however, it may be powering your car.

Almost overnight, the unloved *Jatropha curcus* has become an agricultural and economic celebrity, with the discovery that it may be the ideal biofuel crop, an alternative to fossil fuels for a world dangerously dependent on oil supplies and deeply alarmed by the effects of global warming. Some statistics from a major investment company are also of interest when considering its use as biodiesel:

- Crushing 1 tonne of *Jatropha* seeds costs around \$40 (£23).
- One tonne of seed cake (the leftovers after pressing) can be sold for \$100 (£55).
- The transport costs of shipping 1 tonne of *Jatropha* from India to Northern Europe is \$100 (£55).
- The landed cost of 1 tonne of *Jatropha* oil to Northern Europe is between \$348 and \$500 for oil contents of 29-40% (£180 to £260). Refining *Jatropha* oil into bio-diesel costs less than \$125 (£65) per tonne.

There have been several announcements recently of investments by joint venture companies, including major petroleum oil companies, into the production of *Jatropha*. This is in marked contrast to the lack of interest by the oil majors in bio-diesel and other first generation bio-fuels. It certainly appears that with further research in the agronomics of the plant, there is potential for it to become a major bio-fuel raw material.