

# Cultivation of *Jatropha curcas* L

(Family: Euphorbiaceae)

## Introduction

In the recent past, bio-diesel derived from plant species has been a major renewable source of energy. Among various plants *Jatropha curcas* and *Pongamia pinnata* have been chosen as most potential species for varying situations. Between these two species *Jatropha curcas* is considered most potential 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.

Due to potential demand and better marketing opportunities, cultivation of *Jatropha* appears viable. *Jatropha* may not replace other important food crops since it is meant for flood free wastelands and unutilized fallow lands / less productive lands and in turn will not have a major impact on cropping pattern.

Among the many species, which yield oil as a source of energy in the form of biodiesel, *Jatropha curcas* L. has been identified as most suitable oil seed bearing plant due to its various favourable attributes like hardy nature, short gestation period, adaptability in a wide range agro-climatic conditions, high oil recovery and quality of oil etc. It can be planted on degraded lands through Joint Forest Management (JFM), farmer's field boundaries, road sides, both sides railway track, fallow lands and as agro forestry crop. It grows up to a height of 5 m. and can be maintained to a desired height and shape by trimming and pruning. Planning Commission, Govt. of India has identified two species for mass production of seeds for biodiesel viz., *Jatropha* and *Pongamia*. *Jatropha* is suitable for upland while *Pongamia* found adaptive for both uplands as well as wetland conditions.

Among these two species the following differences made *Jatropha* superior if otherwise the conditions are not unsuitable for it.

## Major Differences

<b><i>Jatropha curcas</i></b>	<b><i>Pongamia pinnata</i></b>
Minimum gestation –only 1 year	Gestation is more-about 6 years
A bushy shrub and by pruning the growing height may be maintained to a practical limit for harvesting and other operations	A large tree-block plantation in agricultural lands is not preferred. Due to its height seed collection becomes difficult, not farmers friendly.
Processing is comparatively easier due to low-density oil, thus liked by processors.	Due to higher density processing is more cumbersome comparative to <i>Jatropha</i> oil.
Even without <i>transesterification</i> the oil can	<i>Esterification</i> is necessary

be utilized for running static diesel engine	
High oil content-upto 40 %	Low oil content –27 – 34 %
Seed yield and oil yield is higher per ha of land	Seed yield is less comparative to Jatropha

Jatropha is preferred if the condition is free from water stagnation, and upland situation. For wet condition and river and stream-sides where temporary flooding may pose a problem Pongamia should be the choice.

Because of the above advantages the Biodiesel programme has been assumed as Jatropha programme and ultimately has taken as Jatropha Mission.

**Jatropha as a plantation crop offers the following advantages:**

- Easy to establish, grows quickly, hardy and require little care.
- It can grow in poor soils, in wastelands except flood prone and waterlogged areas. Reclamation of wasteland and degraded land is possible through its plantation. In fertile land it gives higher yields
- Plantation of Jatropha, oil extraction and nursery raising, can be rural based, hence promoter of rural economy besides ensuring energy security.
- It is suitable for preventing soil erosion including *Jhum fallows*.
- Jatropha is not a competitor of any crop rather it increases the yield.
- Due to *mycorrhizal* value in Jatropha roots it helps in getting phosphate from soil boon for acid soil.
- Improves the soil fertility throughout their life cycle.
- Possesses medicinal as well as other multiple uses.
- Generate net income for 30-35 years @ approx. Rs. 10,000 / ac/year from 4<sup>th</sup> year.
- Providing local jobs, lessening the need for local villagers to migrate to cities to find employment.

In India, *Jatropha curcas* is found in almost all the state and is generally grown, as a live fence for protection of agricultural fields from damage by livestock as cattle or goat does not eat it.

**Cultivation scope**

Due to potential demand and better marketing opportunities, cultivation of Jatropha appears viable. The crop is suitable particularly for garden land situations yet less productive, no irrigation facilities. Besides the crop must not replace other important food crops and in turn will not have a major impact on cropping pattern.

Jatropha adapts well to marginal lands as well as live fence, as farm animals do not browse it. All parts of the shrub are used in traditional medicine and as raw material for pharmaceutical and cosmetic industries. The use of Jatropha oil in the production of soap in rural areas gives direct benefit, where as indirectly this will help to save edible vegetable oil. The large scale cultivation of *Jatropha 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. Use of bio-diesel at the

village level for operating oil engines for pumping water and operating small machinery are another good opportunity, which will be a boon to the farmers.

*Jatropha* is not an alternative to agriculture or plantation but it is an addition to it.

### **Scope of Jobs for all**

*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 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. This will be a great boon to the development and enhancement of the quality of life of the rural women.

### **Distribution**

*Jatropha curcas* is a tropical shrub native to Mexico and Central America, but is widely distributed in wild or semi cultivated stands in Latin America, Africa, India and South-East Asia. In India, Portuguese Navigators introduced it in the 16<sup>th</sup> century. It occurs in almost all parts of India including Andaman Island and generally grown as live fence. The tree is well adapted to arid conditions. It is suitable for sand dune stabilization and soil conservation areas.

### **Botanical description of *Jatropha curcas***

*Jatropha* derived from the Greek word 'Jatros' means 'Doctor' and 'trophe' means 'Nutrition'. Botanically this is known as *Jatropha curcas* L. and belongs to the family Euphorbiaceae. It is a multipurpose shrub and is found throughout the tropics and is known by nearly 200 different names, indicating its occurrence in various countries. Common vernacular names of *Jatropha curcas* in India are Ratanjyot, Safed arand, Physic nut, Purging nut, Chandrajyot etc. *Jatropha* is a deciduous large shrub or small tree 3-5 m in height with smooth gray bark, which exudes watery and sticky latex, when cut. The cut branches sprout readily and grow rapidly which makes it suitable for fencing.

The genus is cosmopolitan in distribution except in the arctic region; they are distributed in the tropical and sub-tropical Himalayas, the mountains of Western and Eastern Ghats and plains of South India.

The leaves simple, angular, deeply palmately 3-5 lobed with long petiole. Ciliate glands usually represent the stipules. The venation is palmate. The leaves are green to pale green broad and glabrous. Phyllotaxy is spiral.

### **Flower and seed setting**

Flowers unisexual, monoecious, greenish yellow in terminal long, peduncled paniculate cymes. The central flowers in the cyme or in its forks usually female. Male flowers- Calyx segments 5, nearly equal, elliptic or obvate; Corolla Campanulate, lobes 5, connate, hairy inside, exceeding the calyx, each lobe bear inside a gland at the base, stamens 10 in two series, outer five filaments free, inner five filaments connate, anthers dithecous erect, opening by longitudinal slit. Female flowers- Calyx as in male, corolla

scarcely exceeding the calyx lobes united, villous inside, carpels connate into a 3-celled ovary, styles 3 connate at base, stigma bifid, ovules solitary in each cell. Pollination is by insect.

After pollination fruit is usually a three chambered and schizocarpic capsule splitting into three one-seeded cocci. The exocarp remains fleshy until the seeds mature. It may produce more than one crop during a year, or produce continuous flowering and fruiting under irrigated conditions if soil moisture and temperatures are good. Each inflorescence yields a bunch of ovoid fruits. The seeds are albuminous, testa crustaceous. It is a diploid species with  $2n=22$  chromosomes.

Seeds resemble castor in seed shape, ovoid oblong and black in colour. The seeds become mature when the capsule changes from green to yellow, after two months of fruit setting. The nut is a violent purgative. Each fruit bears three seeds. The seeds contain 25-35 % oil. The oil can be used in soap manufacture.

#### **Soil and climate:**

It is a tropical species and grows well in subtropical conditions. It can tolerate extremes of temperature but not the frost and water stagnation.. It grows almost everywhere- even on gravelly, sandy, acidic and alkaline soils having pH ranging from 5.5 to 8.5. It can thrive in poorest stony soils. It grows even in the cracks and crevices of rocks on all types of soil except one subjected to water inundation. If the rising water table engulfs the major root system and continues for a considerable period plant will die. The plant is undemanding in soil type and even does not require tillage.

**Variety:** There is no recommended variety for this region yet. However, the variety grown in NE region is also found productive. The female: male ratio of flower which is indicative of productivity is observed to be 1:12 compared to 1:16 to 1: 20 found in other states. Fruit setting in NE region is nearly 90-95 %. The occurrence of fungal diseases due to high humidity and high soil moisture, the newly introduced materials from drier belts are difficult to establish. However, high yielding types developed elsewhere are also ideal for cultivation. The plantation can be started with locally available one.

#### **Propagation:**

Jatropha is usually propagated on mass scale both by seed as well as stem cuttings. For commercial cultivation normally it is propagated by seeds. Well-developed plump seeds are selected for sowing. Before sowing, seeds are soaked in cowdung solution for 12 hours and kept under the wet gunny bags for 12 hours. Hot and humid weather is preferred for good germination of seed. Germinated seeds are sown in poly bags of 15 x 25 cm size filled with soil, sand and farm yard manure in the ratio of 1:1:1 respectively. Seeds or cuttings can be directly planted in main field. But pre-rooted cuttings in poly bags and then transplanted in the main field give better results.

**Seed rate**

For one-hectare plantation about 5 -- 7.5 kg seeds are required. Fruiting starts from 2<sup>nd</sup> year if propagated by stem cutting but it takes one year more while raised by seed.

**Planting in field**

The land should be ploughed once or twice depending upon the nature of soil. In direct planting system the seed/cuttings should be planted in the main field with onset of monsoon as a spacing of 3m x 2m. In hilly areas where ploughing is not possible, after clearing jungles, pits of size 30 cm x 30 cm x 30 cm is dug at required spacing, refilled with top soil and organic manures (500 g FYM + 100 g Neem cake or Jatropha oil cake + 100 g super phosphate) and then planted.

Smaller spacing would be preferred if growing the plant as a hedgerow, for a fence, or for soil conserving purposes. Actual spacing will be determined based on end-use, soil quality / condition, humidity, rainfall, intercropping, etc. On the side slope of embankment 2m x 2m is advisable.

**Aftercare**

Two to three weeding are necessary; it does not require supplementary irrigation if planted in onset of rain. Jatropha is deciduous in nature and the fallen leaves during winter months form mulch around the base of the plant. The organic matter from fallen leaves enhances earthworm activity in the soil around the root zone of the plants, which improves the fertility of the soil.

Light harrowing is beneficial during early growth stage. Pinching the terminal is essential at six months age to induce laterals. Application of GA @ 100-PPM spray induces early flowering and capsule development.

**Canopy management (Pruning and trimming)**

To give a bushy shape the plant should be trimmed during spring (Feb-March) upto 5 years including one pruning when the plants attains 1.5 m height. The terminal-growing twig is to be pinched to induce secondary branches. Likewise the secondary and tertiary branches are to be pinched or pruned at the end of first year to induce a minimum of 25 branches at the end of second year. Once in ten years, the plant may be cut leaving one-foot height from ground level for rejuvenation. The growth is quick and the plant will start yielding in about a year period. This will be useful to induce new growth and yield stabilization there on.

**Manuring**

At the time of planting compost @ 2 kg /pit should be applied. Afterwards depending on soil type manuring @ 3-5 kg/plant along with and NPK should be applied near the crown following ring method before monsoon.

In general application of super phosphate @ 150kg/ha and alternate with one dose of 20 : 120 : 60 kg NPK/year from second year improves yield. From 4<sup>th</sup> year onwards 150 kg super phosphate should be added to the above dose.

### Intercropping

Some shade loving crops like *Rouvolfia serpentina*, *Asparagus racemosus*, *Kaempferia galanga*, *Homalomena aromatica*, Tulsi and *Smilax china* etc and also short duration pulses like blackgram and vegetables like tomato, bitter gourd, pumpkin, ash gourd, cucumber can be profitably grown under *Jatropha* for the first two years. Patchouli –a shade loving aromatic herb could be a suitable intercrop for *Jatropha* plantation that gives first harvest of leaves after 4 months of planting. Vanilla can also be cultivated under it successfully.

### Diseases

Collar rot may be the problem in the beginning that can be controlled with 0.2% COC or by application of 1 % Bordeaux Mixture drenching.

### Harvesting

The flowering is induced in rainy season and bears fruits and matures in winter. Pods are collected when they are turned yellowish and after drying seeds are separated mechanically or manually. Flowering is less and delayed when grown in shady conditions. In sunny condition flowering is more and early (July – September). Seedlings produce flowers 9 months after sowing. However, plants established through cuttings produce flowers from 6 months onwards. But economic yield starts from 3<sup>rd</sup> year-end. The dried pods are collected and seeds are separated either manually or mechanically. Seeds are dried for 4-5 days to reduce moisture level 10% before packing.

### Economic life

The economic life of *Jatropha* is 35-40 years. The plant survives upto 50 years if root zone does not come in contact with rising water table and continues for longer time.

**Yield:** There will be about 1675 plants /ha at 3m x 2m spacing. Grown up *Jatropha* from 6<sup>th</sup> year onwards yield 3-6 kg per plant under good management. The average productivity can be projected as follows:

Year of planting	Per plant yield	Per hectare yield in kg
2 <sup>nd</sup> year	0.5-1.0	1500 kg
3 <sup>rd</sup> year	1.0– 3.0 kg	2500 kg
4 <sup>rd</sup> year to 6 <sup>th</sup> year	3.0 – 5.0 kg	6000 kg
7 <sup>th</sup> year to 10 <sup>th</sup> year	3.5 - 5.5 kg	6500 kg

### Economics of cultivation

#### Poly bag raised seedlings (10,00,000 seedlings/year)

Assuming 10 % mortality, total number would be: 10 + 1 = 11 lakhs

No. of seeds per kg : 1400 – 1800 Average: 1500

Percentage of seed germination: 40 %

Seed requirement to raise 10 lakhs seedlings:

1 kg seeds gives : 1500 X 0.4 = 600 seedlings

To get 11 lakh seedlings it will require =  $\frac{11,00,000}{600 \times 100} = 18.3$  q seeds say = 20 q say

(Per hectare seed requirement= 5- 7.50 =average 6 kg)

**Estimate:**

Cost of seeds = Rs. 65/kg X 20 =	1.30 lakhs
Black poly bags per kg gives approx. 700 Nos	
For 11,00,000 =1571 kg or	
15.70 q @ Rs. 7000/q=Rs. 1.099	1.10 lakhs
Filling and arranging under shade @ per bag Rs. 0.50 =	5.50 lakhs
Rent of land @ 2000 X1.5 =	0.03 lakh
Fencing all around of 1.5 ha land with one wooden gate =	0.50 lakh
Overhead sprinklers =	0.50 lakhs
Development of water source and Construction of storage tank =	0.50 lakhs
Construction of removal sheds over seedlings =	0.50 lakhs
Construction of Labour sheds =	0.25 lakh
5 skilled labourers @ 2000/month for 12 months=	1.20 lakhs
Decomposed cowdung 20 truck loads ( 100 MT) @ Rs. 1000 =	0.20
Silt & light textured topsoil 150 trucks (1000 MT)	
@ Rs. 500/truck =	0.75 lakh
Tools and implements	0.25 lakh
Miscellaneous expenses=	0.15 lakhs
<b>Total</b>	<b>Rs. 12.73 Lakhs</b>

Cost of per seedlings = 12.730/10.00 = **Rs.1.258 say 1.30/poly bag raised seedling.**

**Cost of seedlings when raised directly in seedbeds**

Seeds sown in raised beds at 15 x 10 cm spacing  
 Bed size 1.5 m X 50 m with a gap of 0.5 m between two beds  
 There will be 300 beds or accommodating about 10 lakh seedlings  
 In beds mortality will be very minimum about 5 % thus the total seedlings  
 will be = 10.50 Lakhs and land requirement will be = about 1.5 ha

**Estimate**

Fencing of the area 1.5 ha =	1.5 ha
Land preparation and bed formation= @ 5000 =	0.09 lakh
Application of decomposed cowdung 30 MT	0.40 lakh
Cost of seeds 20 q x 6500 =	1.30 lakhs
Seeding including gap filling etc=	0.50
Watering through overhead sprinklers drawn from storage tank=	1.00 lakh
Weeding, plant protection etc =.	0.20 lakh
Labour cost 5 labourers/ha x 1.5 x 2000/month x 12 months =	1.80 lakh
Miscellaneous expenses	0.21

**Total Rs. 5.50 lakhs**

Overhead expenses= 1.50 lakhs , Total cost=7.00 lakhs

Cost of per seedlings =7.00/10.00 = **Rs. 0.70**

### Establishment of Seed Orchard

Quality seed production in sufficient quantity is most important for commercial programme. Jatropha is cross-pollinated crop. Hence a seed orchard, which is a plantation of genetically superior trees, isolated to reduce cross-pollination and intensively managed to ensure supply of good quality seed should be established. The minimum size of the seed orchard should be 2 ha or more. The seed orchard may be established by clonal propagation (stem cutting or tissue culture plant lets) from known source.

#### Economics per hectare basis (Rs):

Nos of plants/ha 1670 at 2 M X 3 M spacing

Heads of exp.	1 <sup>st</sup> yr	2 <sup>nd</sup> yr	3 <sup>rd</sup> yr	4 <sup>th</sup> yr	5 <sup>th</sup> yr & above
Cost of seedlings including transport & gap filling @ Rs. 4.00 / seedlings 2000 Nos	8,000	-	-	-	-
Site development-Jungle cuttings etc.	2000	-	-	-	-
Initial land preparation	3000	-	-	-	-
Digging of pits and refilling (45 x 30 x 45 cm) @ Rs 3/- per pit	5000	-	-	-	-
Cost of FYM @ 2-3 kg/pit	3500	2500	3500	3500	3500
Cost of composite fertilizers (NPK) @ 50-100 gm/pit	2000	2000	2000	3500	3500
Cost of planting & gap filling	3500	-	-	-	-
Protective watering immediately after planting	500	-	-	-	-
Pruning & trimming	1500	1000	1000	1000	1000
Plant Protection	500	500	500	500	500
Intercultural operations	2000	2000	2000	1500	1500
Harvesting & post harvest	-	1000	1500	2500	3500
Contingencies	500	250	250	250	250

Total Rs. 32,000      9,250      10,750      12,750      13,750

Return: Dry seed yield	-	1500	2500	5000	6000
Gross return (@ Rs. 8.00/kg)		12000	20,000	40,000	48,000
Net return	- 32,000	2,750	9,250	27,250	34,250



### **Higher productivity and profitability can be achieved by**

- Pruning main stem upon 1.5-m growth for profuse branching and higher seed yield.
- Foliar spraying with growth promoters for higher yield of seeds and oil.
- Ensuring maximum exposure to sunlight for enhancing seed yield.

Jatropha plantation should **not be taken as highly profitable cash crop** if the value of by-products and other advantages are not considered. Besides, raising of intercrops along with oil, other potentially high value products such as glycerin and seed cake to make it more attractive should be effectively marketed and the environmental and socioeconomic returns such as wasteland reclamation need to be adequately accounted for.

### **Some immediate problems that may crop up to a farmer's mind**

1. Lack of confidence in farmers due to non-declaration of the biodiesel policy by the state government.
2. Low price of farmers' produces (seed). The present price Rs.5 /kg of seed that is being offered by some of the buyers is certainly not attractive for grower.
3. Non-declaration of minimum support price by some competent authority.
4. Non-availability of selling agents or centres of seeds by the farmers.
5. Non-availability of certified seed materials.
6. Non-declaration of incentives / subsidy and other benefits proposed to be provided in promotional drive.
7. Lack of extension services.
8. Non-availability of bankable schemes for plantation / processing.

### **Suggested measures to be taken immediately**

- It is to be taken only on cluster basis and not in isolation.
- Selection of high yielding and high oil content variety and make arrangements of large-scale supply of planting materials.
- Development of location specific agro-techniques and providing agronomic support through contract farming.
- Pilot scale trials should be conducted at different locations to demonstrate economics of cultivation and updating of location specific production technologies.
- Commercialization of potential byproducts like glycerin, oil cake as organic fertilizer and pest repellent, blue dye from leaves twigs and barks and explore the possibilities of taking more inter crops.
- The minimum support price should not be below Rs. 8.00/kg and this should be till the demand picks up.
- Provide liberal financial support to NGO / Line departments / other organisations for massive awareness and training campaign.
- Government of India should encourage NGO / Progressive farmers to visit other countries / states for on the spot studies.

### **Research need**

1. Screening and development of strains / varieties high yielding yet tolerant to wet condition.
2. Standardization of spacing for different terrain.

3. Pruning practices for maximum yield
4. Manurial and fertilizer requirement
5. Use of flower enhancing hormones
6. Use Bee hives for higher yield as well as honey production as byproduct.

### **Best Agronomic practices to increase seed yield**

1. Generation of elite planting materials from clonal seed blocks
2. Ensuring high yielding population with optimum plant density
3. Building the plant architecture by pruning
4. Use of plant growth regulants
5. Practicing integrated Nutrient Management (Use of fertilizers, VAM, Biofertilizers includes Azospyrillum, phosphobacteria, Zn / K mobilizer)
6. Use of Biocontrol agents Viz. Trichoderma / Pseudomonas
7. Manipulation of flowering by irrigation practices
8. Keeping Bee hives
9. Intercropping with seasonal crops to get income during gestation period

### **Jatropha growing feasibility**

#### **Targeted Growing Areas**

- Cultivable wastelands / vacant lands / colliery wastelands
- Rainfed lands (low rainfall zone / rainshadow areas)
- Water scarcity areas
- Replacing uneconomical crops
- Hedge plantation
- Railway track
- Roadsides
- Jhum fallows in Hilly areas
- Riverside that is not inundated
- To stabilize bunds (Embankments)
- Erosion prone watershed area

#### **Future Thrust Area for yield enhancement**

- # Systematic varietal improvement & hybridization programme
- # Generation of technology for yield enhancement
- # Technologies related to value addition of byproducts (oil cake / glycerol)
- # Demonstration of technologies through Model Farms / Focused Extension programme
- # Mass multiplication of elite plant material through Tissue Culture.

### **Commercial use of Jatropha plants**

#### **As a live fence**

*Jatropha curcas* is a plant of Latin American origin, a drought resistant perennial, living upto 50 years and growing upto 3-4 m high on marginal soils. It is a close relative of castor plant; its oil has same medical properties. Jatropha seed contain about 35 % of non-edible oil. The production of seed is about 0.8 kg /m hedge per year with an oil yield of 0.171 kg.

It is commonly grown as a live hedge around agricultural field as it can easily propagated by seeds or branch cuttings. It can be looped to any desired height and it is well adopted for edges around agricultural fields. It does not compete bunds. It can also be used as an edge around meadows and forestation areas as well as to prevent soil erosion.

### **Jatropha for enrichment of soil**

The oil cake is rich in nitrogen, phosphorus and potassium finds very good organic fertilizers. The leaves provide plentiful organic matter and increase the microbial activity including earthworms, which is an indication of ecological improvement of site.

### **As a non-conventional energy crop**

Jatropha oil is environmentally safe cost effective and renewable source of non-conventional energy as a promising substitute to hydel power, diesel, kerosene, LPG, coal and firewood. The protein content of Jatropha oil cake may be used as raw materials for plastic and synthetic fibers. This non-conventional source of energy will help in removing regional imbalance in energy use by making energy available in a decentralized manner.

It is a crop with low capital investment, short gestation period, long productive period, unlimited employment potential in the rural areas. Potential for creation of productive assets boosting of village based industries. Potential of wastelands developments

Generation employment and capital formation to increase nation's income and quick greening of the country.

### **Jatropha Oil Extraction Cost**

Parameters	1 t/day cap	1 t/hour cap	2 t/hour cap
Installation cost	Rs. 70,000	Rs. 3,00,000	Rs. 5,00,000
Power consumption	45 KWH	30 KWH	24 KWH
Cost of power consumption	Rs 225	Rs.125	Rs. 120
Steam	600 kg/ton	150 kg/ton	125 kg
Cost of steam	Rs. 180	Rs. 45	Rs. 37.50
Man Power	3/day	3/day	6/day
Cost of manpower	Rs. 450/ton	Rs. 20/ton	Rs. 20/ton
Processing cost/ton			
Investment	Rs. 885	Rs. 215	Rs. 177.5
Depreciation	Rs. 45	Rs. 7.5	Rs. 6.5
Total cost of Processing/ton	Rs. 900	Rs. 222.5	Rs. 184