

JATROPHA

An alternate source for biodiesel



NATIONAL OILSEEDS AND VEGETABLE OILS DEVELOPMENT BOARD

Ministry of Agriculture, Govt. of India

86, Sector -18, Institutional Area, Gurgaon- 122015

Website: www.novodboard.org



सत्यमेव जयते

सचिव, भारत सरकार
Secretary
Government of India

P.K. Mishra



भारत सरकार
कृषि मंत्रालय
कृषि एवं सहकारिता विभाग
कृषि भवन, नई दिल्ली-110 001
Government of India
Ministry of Agriculture
Department of Agriculture & Cooperation
Krishi Bhawan, New Delhi-110001
दूरभाष/Phone : 23382651, 23388444
फैक्स/Fax No. 23386004

PREFACE

It gives me immense pleasure to learn that the National Oilseeds & Vegetable Oils Development (NOVOD) Board, Gurgaon is promoting Jatropha as a substitute bio-diesel in the culturable wasteland of the country through various programmes such as development of elite planting material and model plantation, research & development, technology transfer and awareness. The efforts made by NOVOD Board in publishing a booklet on Jatropha is commendable. This booklet covers important technical aspects: habitat & occurrence, botanical features, soil & climate, advanced propagation techniques, package of practices, flowering, yield, post-harvest technology, soil characteristics, physico-chemical properties and fatty acid composition, uses and economic feasibility of Jatropha cultivation.

I appreciate the intensive efforts of the board in bringing out such an important technical booklet and hope that it will help farmers, agro-based entrepreneurs, farming community and others to enhance their income from limited resources by growing more Jatropha trees in the culturable wastelands of potential states, generating rural employment opportunities for the poor and contributing to the nation in saving outflow of Indian currency for import of petro-diesel.

5th October 2007
New Delhi


(P. K. Mishra)



Dr. M.S.PUNIA

EXECUTIVE DIRECTOR

National Oilseeds & Vegetable Oils Development Board,
(Ministry of Agriculture, Govt of India),

FOREWORD

India stands at sixth place in the world in energy need and overall demand of crude oil which is expected to rise annually by 5.6% upto 2011. The scenario of rising prices in the world oil market and respective foreign exchange cost are the main risk factors for Indian economy and social development prospects. Moreover, increased consumption and high dependence on non-renewable sources which substantially contributed to global warming and environmental pollution, presents a window of opportunity for looking at the alternative strategies to meet increasing energy needs. Bio-diesel, a renewable source of energy offers a great potential to ease and mitigate limitation and supplement supplies of fossil fuel. The demand and supply gap of fuel is bridged with the import of petroleum products. If the existing trend continues, the situation shall become more grim. Therefore, existing potential of alternative sources need to be trapped which are scattered across the country. *Jatropha* is one of the best alternative sources available for bio-diesel production and its potential needs to be explored.


Jatropha (Jatropha curcas) belongs to Euphorbiaceae family is a fast growing shrub capable to grow and establish in tropical and sub-tropical region of the country and even on wasteland. It has various advantageous characteristic features viz. not browsed by cattle, best hedge plant, less gestation period (two years), capable to grow and

establish in various biotic and abiotic stress conditions, high oil content (30-42% in seed), multiple uses including lubricant and illumination etc.

Continuing efforts for bringing out various technical bulletins on various TBOs i.e. Neem, Jojoba, Wild apricot etc., the Board has brought out this technical bulletin covering all important technical aspects viz. habitat & occurrence, botanical features, soil and climate, propagation techniques, package of practices, flowering & fruiting, yield, post harvest technology, oil characteristics, physico-chemical properties & fatty acid composition, uses and economic feasibility of *Jatropha* cultivation.

I hope this bulletin will definitely be helpful to the farmers, agricultural scientists, field workers and other functionaries, who are involved in the promotion of *Jatropha*. The result based technical informations will boost the potential of this important plant resulting in generation of additional income, employment, availability of indigenous petro-diesel substitute and reducing import burden etc. The suggestions of readers are welcomed to make this booklet more useful.

I congratulate to the NOVOD Board officers and officials who are directly and indirectly involved in bringing out this technical publication successfully.



(M.S.Punia)

Dated: 16th October 2007

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R. S. Kureel
C.B. Singh
A.K. Gupta
Ashutosh Pandey



National Oilseeds & Vegetable Oils Development Board
(Ministry of Agriculture, Govt. of India)
86, Sector-18, Institutional Area
Gurgaon - 122015

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JATROPHA

An alternate source for bio-fuel

Jatropha (*Jatropha curcas*) belonging to Euphorbiaceae family is a fast growing shrub. It can be cultivated in tropical and sub-tropical regions of the country and even on waste lands. Ratanjyot, Jamalghota, Jangli arandi etc. are some of the common names of *Jatropha*. The seed oil of *Jatropha* has been found a promising and commercially viable alternative to diesel, which is a renewable source of energy.

Alternate fuels for diesel engines have become increasingly important due to diminishing petroleum reserves and awareness of the increased environmental consequences of emissions from petroleum-fuelled engines. A number of studies have shown that oils and fats from plant source hold promise as alternative fuels for diesels engines. However, the high viscosity, low volatility and poor cold flow properties of triglycerides, which result in severe engine deposits, injector chocking and piston ring sticking, have prevented them from being used directly in diesel engines. One way to improve the fuel properties of triglycerides is their catalytic trans-esterification with alcohols to form monoalkyl esters of long-chain fatty acids, and another method is the super critical method of producing biodiesel, which is quite similar to hydrocarbon-based diesel fuels in its main characteristics and provides similar engine performance with low emission levels unlike fossil fuels. Economic feasibility study shows that the biodiesel obtained from non-edible oils is cheaper than that from edible oils.

1. HABITAT AND OCCURANCE

Jatropha is native of South America and has a long history of its propagation by Portugese into Africa and Asia. It grows well throughout India. Andhra Pradesh, Gujarat, Rajasthan, Karnataka, Chattisgarh, Uttrakhand, Tamil Nadu, Maharashtra, Orissa, North Eastern states are some of the promising states where it occurs in the vicinity of villages and town as semi wild bush or shrub and also as hedge vegetation. It is hardy shrub to dry weather conditions and is not browsed by cattle.

2. BOTANICAL FEATURES

It is a bushy plant with numerous side branches that arise from its main stem and it attains a height of 3-4 m. Leaves are 10-15 cm. long and 7-12 cm broad with pointed edges.

The flowers are yellowish green in loose panicles. The flowering occurs twice in a year i.e in March-April and in September-October. The

ripe fruits are about 2-5 cm. large and ripen fruits are yellow in colour. The seeds resembles with castor seed in shape and are about 1.8-2.0 cm long and shape is either ovoid or oblong and are covered in a dull brownish black capsule.

3. CLIMATE & SOIL

Jatropha is a wildly growing hardy plant, in arid and semi-arid regions of the country on degraded soils having low fertility and moisture. It can thrives well on stony, gravelly or shallow and even on calcareous soils. It can be grown under wide range of arid and semi-arid climatic conditions but can not with stand during heavy frost. For better seed germination, mixed hot and humid climate is required. It can be cultivated successfully in the regions having scanty to heavy rainfall with annual rainfall ranges from 500-1200 mm.

4. PROPOGATION PRACTICES

Jatropha can grows easily from seeds. However, commercially it can be propagated by three different ways such as by seeds, nursery and stem cutting.

i. BY SEEDS

Fully matured seeds should be selected for sowing. Pre-soaking in water for 24 hrs is advised. Another way is to soak seeds in cow-dung slurry for 12 hrs before sowing. Soaked seeds are generally sown in polybags of 10 x20 cm size filled with soil, sand and FYM (Farm yard manure) in the ratio of 1:2:1 respectively. Germination is generally noticed after 4-5 days and continues upto 15 days.If the seedlings are to be retained by 5-6 months before transplantation, then bigger polybags(15x25 cm) should be taken.



Bold & disease free seeds from fresh collections are to be used for obtaining better germination percentage and growth performance. Low

germination percentages and high mortality rates were found if the seeds from previous years are used.

ii. SOWING IN NURSERY BEDS

Raised beds (10 cm high) are prepared by digging and mixing soil with sand and FYM in 1:1:1 ratio. Each bed is prepared having 1 m x 5 m dimensions. Shallow furrows of 2 cm depth are made by finger or using a stick. Soaked seeds are placed in furrows at an interval of 5 cm. and covered with a thin layer of soil. Care is taken to avoid deep sowing. Light irrigations are given after seed germination and bare rooted seedlings are transplanted after 3-4 months in the field during the rainy season.



iii. BY STEM CUTTING

Jatropha responds well for vegetative propagation. Propagation through branch cuttings is not new and farmers know this technique. In fact, 90% Jatropha spread throughout the country for 'live fence' was by branch cuttings only. Cuttings planted during monsoon immediately after Ist showers give better root initiation, high survival rate and good growth performance.



- i. Superior Jatropha trait/ genotypes are selected on the basis of their high seed yield and oil content.
- ii. From the selected tree, collect the branches having 2-3 cm diameter, put them in a bucket of water.

- iii. Cut them into 15-20 cm long pieces with a knife or a mini hand-saw.
- iv. Dip the cuttings into a tub rooting hormone mixture (may be commercial Seradix or growth hormones like IBA or NAA of 100 ppm concentration).
- v. Put the cuttings in a poly bagged rooting media (Soil + Sand in 1:1) by inserting the basal region (about 3 cm).
- vi. Place the poly bags inside a closed polythene chamber or mist chamber to avoid the drying of cuttings. Allow the cuttings inside the chamber for a period of 2-3 weeks.

Rooting can be seen through the transparent polybags in about 3 weeks of time. Rooting response is always better in hormone treated cuttings than in untreated cuttings. After removing from polychamber, the clones (vegetative propagules) are to be kept out side under partial shade for 2 weeks before transferring them to the field for transplanting. Using polythene chamber or mist chamber is advantageous because the plants do not lose more water through evapotranspiration due to checking of wind velocity, the cuttings are kept always moistened thus not allowing them to become dry and ensures easy and profuse rooting.

The cuttings are planted in the month of February-March to get best sprouting and survival. Experience gained suggests heavy mortality in cuttings if planted during rainy season.

5. PLANTATION PRACTICES

The disease free and bold seedlings of *Jatropha* are transplanted in rows at a spacing of 3x2 meter under irrigated condition accommodating 1666 plants/ha. On rainfed wasteland, a high density planting at 2 m x 2 m accommodating 2500 plants/ ha. is recommended.

i. Direct planting by seeds

The land is ploughed once or twice depending upon the nature of soil. In case of heavy soil, deep ploughing is desirable whereas in light soil shallow ploughing is sufficient.



The 30 cm x 30 cm pits dug in the field at required spacing should be filled with a mixture of soil, FYM(2-3 kg) and fertilizer (20 g urea, 120 g single super phosphate and 16 g murate of potash. Two seeds per pit should be dibbled at each pit with the onset of monsoon. When the seedlings are 4 weeks old, the weaker seedlings can be removed and the other bold seedlings can be used for gap filling.

ii. Transplanting

Eight to ten week old seedlings are to be planted in 30 cm x 30 cm pits dug in the field at required spacings and filled with a mixture of soil, FYM (2-3 kg.) and fertilizer (20 gm Urea, 120 g Single Super Phosphate and 16 g Murate of Potash).

iii. Fertilizer

The NPK in the ratio of 46:48:24 kg per ha are to be applied in split doses from second year onwards so as to obtain economic yields and high oil content in seeds.

iv. Agri-silvicultural practice (Inter cropping)

Since, the gestation period of jatropha is 2 years, the inter-cropping may be taken initially for two years which will yield additional income to the growers. The intercrops selected by various institutions for intercropping in jatropha depending upon soil & climatic requirements are Chickpea, Rice, Green gram, Black Gram, Sesamum (Til), Ginger, Turmeric, Arhar, Masoor (Lantil), Ragi, Kulthi, Niger, Soybean, Moong, Urad, Wheat, Cowpea,



Cluster bean, Water melon, Mustard, Guar and Dhaincha as well as Mothbean for green manuring. In addition, in assured irrigation and wide spacing in between the rows, some leafy and fodder and short duration shade loving crops may be under taken after two years.

v. Inter-culturing and weeding

Inter-culturing should be carried out whenever necessary. Annually, 3-4 weeding may be carried out manually for keeping weed free field during initial growth period.

vi. Irrigation

During dry period only life saving irrigations should be applied to the plants as and when required. Usually from second year onwards irrigation is not required unless soils are shallow and sandy. Two irrigations in a year if applied at both the flowering period stages will enhance the yield.



vii. Plant protection

Jatropha plants are less prone to attack by diseases and insects. Following few common diseases & insects are to be checked time to time for better seed yields:-

(A) Diseases

S. No.	Name of disease	Causal organism	Control
1.	Damping off	<i>Phytophthora pithium</i>	Spray of Keptan 50% @ 0.2%
2.	Collar rot	<i>Myerophomina phaseolina</i>	Drenching of 1% Baurdeax mixture
3.	Root rot	<i>Fusarium moniliforme</i>	Spray of Thiram @ 0.2%
4.	Leaf spot	<i>Helminthosporium utramera</i>	Spray of Blitox @ 0.2%

(B) Insects

1.	Leaf minor	Spray of 1.5 ml/litre of water of Metasystox 25 CC
2.	Blue Bug	Spray of Phosphomedin/ Dimethoate @ 2.0 ml/3 lt. of water
3.	Green bug	Spray of 2 ml/3 lt. water of Phosphomedin

6. FLOWERING AND FRUITING



In India, it flowers between September-December and March-April. The fruiting extends from September to December. The fruits mature 2-4 months after flowering.



7. YIELD

With proper care, an average seed yield under rainfed condition is expected as under:

Years	Expected seed (Kg/ha/yr)
2	250-300
3	500-600
4	1000-1500
5	1600-2000
6 & onwards	2500-4000

8. COLLECTION AND PROCESSING

The ripe fruits are plucked from short trees. The collected seeds are sun dried and decorticated manually or by decorticators. One person could collect and decorticate 25-30 kg seed per day. Kernels are sold in the market in small quantities. This is an income generating village level activity and can be integrated with the rural development programme alongwith collection of other non-traditional oilseeds like mango stones, karanj and neem.

9. OIL CHARACTERISTICS

The seed resemble castor seed in shape but is smaller in size and is dark in colour. Weight of the seed ranges 0.5-0.7 g. and length 1-2 cms. The seed contains moisture (6.62%), protein (18.02%), fat (38%), carbohydrates (17.98%), fibre (15.50%) and ash (4.50%). Besides,

starch, sucrose, dextrose, gluten, a free acid and an active lipase are also present.

10. PHYSICO-CHEMICAL PROPERTIES AND FATTY ACID COMPOSITION

S.No.	Characteristics	Value
1.	Oil content in kernel	46-58%
2.	Oil content in seed	30-40%
3.	Sp. Gravity 15%	0.918-0.923
4.	Refractive Index at 40°C	1.462-1.465
5.	Acid value	19.00
6.	Saponification	188-196
7.	Iodine value	93-107%
8.	Hydroxy value	4-20

Fatty acid composition

Fatty acid	Per cent
Oleic acid	37-68
Linoleic acid	19-41
Palmitic acid	12-17

11. USES

- i. The oil is used as lubricants, soap and candle manufacturing. It has also been reported as hair growth stimulant and thus can be used as hair oil. In animals/live stock, its application is useful against sores.
- ii. As a manure, it is useful and contains 4.44% Nitrogen, 1.4% phosphorus and 1.2% potash.
- iii. In England, it is used in wool spinning and in China for manufacturing of non or semi drying alkaloids and for varnishing after boiling Jatropha oil with iron oxide. These uses can be explored in India.
- iv. Plant is useful for large scale plantations in poor or marginal lands as oil yield from established plantations will be around 1 to 2 tones per hectare.
- v. **Trans-esterification**
Bio-diesel is a methyl ester formed by a process called Trans-esterification. Oil can be extracted from seeds of Jatropha with a simple oil expeller (as used for mustard seeds) with some modification in compression chamber and steam heating/ cooker arrangement. The Jatropha oil is reacted with methanol in the

presence of a catalyst to yield methyl esters and glycerol. Sodium Hydroxide and Potassium Hydroxide are commonly used catalyst. Heat the oil at 65°C. Dissolve sodium hydroxide tablets in methanol to make a solution. The quantity of NaOH/KOH and methanol should be 2 and 25-30 percent, respectively, of the total quantity of Jatropha oil. After mixing this solution into hot Jatropha oil, the solution should be stirred for 5 to 7 minutes. Then keep this solution undisturbed at least for 4 hours. Glycerol being heavy will slowly settle down at the bottom and bio-diesel can be easily separated from the top. To strain the impurities like Sodium, this oil should be washed 2-3 times with water. Add water to the oil and after 5 minutes collect the oil floating on surface. Repeat this process and then finally heat the oil to evaporate the water and bio-diesel is ready to use.



12. COST-ECONOMICS OF JATROPHA CULTIVATION (A MODEL CALCULATION)

A. COST OF PLANTATION OF JATROPHA (ONE HA.)

Botanical name :	<i>Jatropha curcas</i>
Spacing :	2M X 2M
No. of plants / ha :	2500
Survival percentage :	80%
Gestation period (Years) :	2

(Rs.)

Particulars	Year						
	1st	2nd	3rd	4th	5th	6th	7th
Site preparation i.e. cleaning and levelling of field	600	-					
Alignment and staking	300	-					
Digging of pits (2500 Nos) of 30 Cm3 size @ 50 pits per MD	3000	-					

Particulars	(Rs.)						
	Year						
	1st	2nd	3rd	4th	5th	6th	7th
Cost of FYM (including carriage) 2 Kg. per pits during 1st year (2 MT) 1 Kg. per pit during second year onwards @ Rs. 400/MT	2000	-					
Cost of fertilizer @ Rs. 6 per kg (50 gm. per plant during 1st year and 25 gm from 2nd year onward and 2 MD for each application.	870	495					
Mixing of FYM, insecticides fertilizers and refilling of pits @100 pits per MD	1500	-					
Cost of plants (including carriage) 2500 Nos. during first year and 500 Nos. of plants during second year for replanting @ Rs. 4.0 per plant	10000	2000					
Planting and replanting cost 100 plants per MD.	1500	300					
Irrigation - 3 irrigation during 1st and one irrigation during 2nd year @ Rs. 500/- per irrigation.	1500	500					
Weeding and soil working	1200	1200					
Harvesting of fruits/seeds - 2 MD per 100kg of seed	-	-	-	1500	2400	3000	3000
Plant protection measure	300	-	-				
Sub total :	22770	4495	0	1500	2400	3000	3000
<i>Contingency (10% of the above)</i>	2277	449.5	0	150	240	300	300
Grand Total :	25047	4945	0	1650	2640	3300	3300
<ul style="list-style-type: none"> ◆ Cost from 6th year onwards to repeat in subsequent years. ◆ Model cost calculation is made for 14 years. ◆ Total plantation/ harvesting cost for 14 years = Rs. 63,982/- 							

**B. NET INCOME FROM PLANTATION OF JATROPHA
(ONE HA.)**

NET-INCOME TAKING 14YEARS OF SURVIVAL OF PLANT & YIELD STABILISATION FROM 6TH YEAR ONWARDS							
No. of plants per ha.	2500						
Plants for yield calculation	2500						
Yield/income/cost/ Stabilisation	From 6th year onwards						
Particulars	YEARS						Total (Rs.)
	1st	2nd	3rd	4th	5th	6th	(14 years period)
Cost of plantation, maintenance & harvesting (Rs.)	25047	4945	0	1650	2640	3300	63982
Seed yield kg/tree	0	0	0	0.5	0.8	1	
Seed yield (kg/ha)	0	0	0	1250	2000	2500	25750
Gross income (Selling price @ Rs. 7/kg)	0	0	0	8750	14000	17500	180250
Net Income	-25047	-4945	0	7100	11360	14200	116268
NB: The cost-economics may vary depending upon various agro-climatic conditions, wage rate, input cost etc.							

