

**CURRENT STATUS OF RESEARCH AND  
DEVELOPMENT ON JATROPHA (*JATROPHA  
CURCUS*) FOR SUSTAINABLE BIOFUEL  
PRODUCTION IN INDIA**

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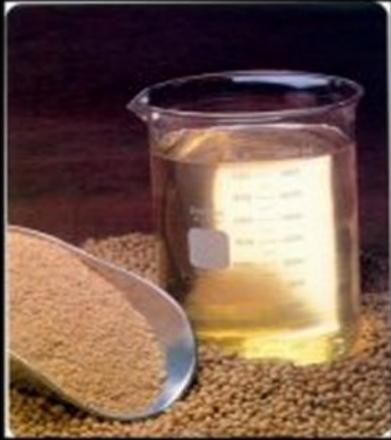
# Requirement of Petroleum Products

■ Global requirement	:	16498 MMT
■ USA		776 MMT
■ China		205 MMT
■ India		124 MMT
- from own sources		34 MMT
- from import		90 MMT
- Petrol		10 MMT
- Diesel		52 MMT

# Future Demand of Fuel

- The depletion and over commitment to use the fossil fuel is likely to lead us to the energy crisis situation in the years to come.
- The demand for diesel is likely to touch 66 million tonnes in 2011-12 and 80 million tonnes in 2014-15.
- Therefore, attempt needs to be made to reduce dependence on imports and seek better alternatives.
- The best alternatives are bio-fuels (Bio-diesel and Bio-ethanol)
- Biodiesel can be produced from various sources namely virgin or used vegetable oils,
- Tree borne oilseeds like **Jatropha**, **Karanja** (*Pongamia pinnata*), Neem, Oil Palm etc.
  - Bio-ethanol derived from sugar and starch crops, cellulosic bio-mass such as herbaceous and woody plants, agricultural and forestry residues

**BIO-DIESEL**



# Biodiesel



## TRANS-ESTRIFICATION PROCESS

(Na OH as Catalyst)

100 pounds + 10 pounds = 100 pounds + 10 pounds  
Jaropha Oil      Methanol      Biodiesel      Glycerine

B100 = Biodiesel

Specified by ASTM D 6751

B20 = 20 % B100 blended with 80% petrodiesel

## ■ **BIO-DIESEL**

- All vegetable oils, both edible & non-edible, on simple chemical treatment called transesterification, produce **BIODIESEL**.
- Biodiesel resembles Petro diesel in combustion properties
- Can be used in any engine which runs on diesel

## ■ **ADVANTAGES OF BIODIESEL**

- Environment friendly
- Low emission of PM,HC,CM,CO
- Higher flash point
- Clean burning
- Renewable fuel
- No engine modification
- Increase engine life
- Biodegradable and non-toxic
- Easy to handle and store



# **INTERNATIONAL SCENERIO**

- **More than 30 countries initiated bio-diesel production**
- **National Policy for bio-diesel promotion drawn**
- **Tax support (free excise duty) is being provided for bio-diesel promotion in India**
- **No tax being levied on bio-diesel production by Germany & Italy**
- **More than 100 bio-diesel plants established world wide**
- **More than 2.5 MT Bio-diesel is produced worldwide.**

## TARGET OF BIO-DIESEL PRODUCTION IN INDIA

Year	Diesel Demand MMT	Bio-Diesel @ 5% MMT (Area In m ha)	Bio-Diesel @ 10% MMT (Area In m ha)	Bio-Diesel @ 20% MMT (Area In m ha)
2006-07	52.33	2.62 (2.19)	5.23 (4.38)	10.47 (8.76)
2011-12	66.90	3.35 (2.79)	6.69 (5.58)	13.38 (11.19)
2012-15	80.00	4.00 (3.50)	8.00 (7.00)	16.00 (14.00)

# RAW MATERIAL (FEED STOCK) FOR BIODIESEL

- Rapeseed oil
- Sunflower oil
- Soybean oil
- Palm oil
- Linseed oil
- Olive oils
- Jatropha oil
- Karanja (Pongamia) Oil
- Cottonseed oil
- Frying oil

## Potential & possibilities

- ◆ India with just 2.4% of global area supports more than 16% of the human population and 17% of the cattle population.
- ◆ India is one of the largest importer of edible oil.
- ◆ Tree Borne Oilseeds available.
- ◆ Wasteland is available.
- ◆ Low cost labour and higher unemployment.



# WASTELAND FOR JATROPHA CULTIVATION

S. N.	States	Potential Area for Jatropha cultivation (m ha.)	S. N.	States	Potential Area for Jatropha cultivation (mha.)
1.	Andhra Pradesh	4.396	11.	Maharashtra	4.855
2.	Arunachal Pradesh	0.997	12.	Manipur	1.262
3.	Assam	1.456	13.	Meghalaya	0.937
4.	Bihar/Jharkhand	1.860	14.	Mizoram	0.407
5.	Goa	0.040	15.	Nagaland	0.840
6.	Gujarat	2.871	16.	Orissa	1.888
7.	Haryana	0.262	17.	Punjab	0.106
8.	Karnataka	1.789	18.	Rajasthan	5.688
9.	Kerala	0.10	19.	Sikkim	0.213
10.	Madhya Pradesh/ Chhattisgarh	6.620	20.	Tamil Nadu	1.795
			21.	Tripura	0.128
			22.	Uttar Pradesh/ Uttranchal	1.214
			23.	West Bengal	0.258
				<b>Grand Total</b>	<b>40.037</b>

# JATROPHA



# SCIENTIFIC CLASSIFICATION

- Kingdom : Plantae
- Division : Magnoliophyta
- Class : Magnoliopsida
- Order : Malpighiales
- Family : Euphorbiaceae
- Subfamily : Crotonoideae
- Tribe : Jatropeae
- Genus : *Jatropha*

- Species

- Approximately 175

# DESCRIPTION OF THE PLANT

- Botanical Name : *Jatropha curcus* L.
- Family : Euphorbiaceae
- Ploidy Level : Diploid
- Genomic no. (X) : 11
- Chromosome No. (2n) : 22
- No. of species : 175
- Pollinaion Behaviour : Cross-pollinated, Monocious, protoandry/protogyne
- Centre of Origin : the Caribbean  
**South America  
probably Near  
Mexico**
- Introduced in Africa, Asia and India by Purtgues traders. Closely related to other important cultivated plants like rubber, castor etc.

# DISTRIBUTION

- Today *Jatropha* is found in almost all the tropical and sub tropical regions of the world.
- There are more than 200 names for it all over the world
- In India, *Jatropha curcas* is found in almost all the states
- Generally grown as a live fence for protection of agricultural fields from damage by livestock as it is not eaten by cattle or goat.
- *Jatropha* is adapted to a wide range of climatic and soils.
- It can grow almost on any type of soil whether gravelly, sandy or saline and thrives even on the poorest stony soils and rock crevices.
- It is a drought resistant, perennial, living up to 50 years.

# SUITABILITY OF JATROPHA

- Thrives on any type of soil
- Needs minimal inputs or management
- Has no insect pests
- Not browsed by cattle or sheep
- Can survive long periods of drought
- Propagation by seed/cutting is easy
- Rapid growth
- Yield from the 2nd year onwards
- Yield from established plantations 5 tonne per ha.
- 30% oil from seeds by expelling
- Seed meal excellent organic manure



# Ecological Requirements & Plant Expression

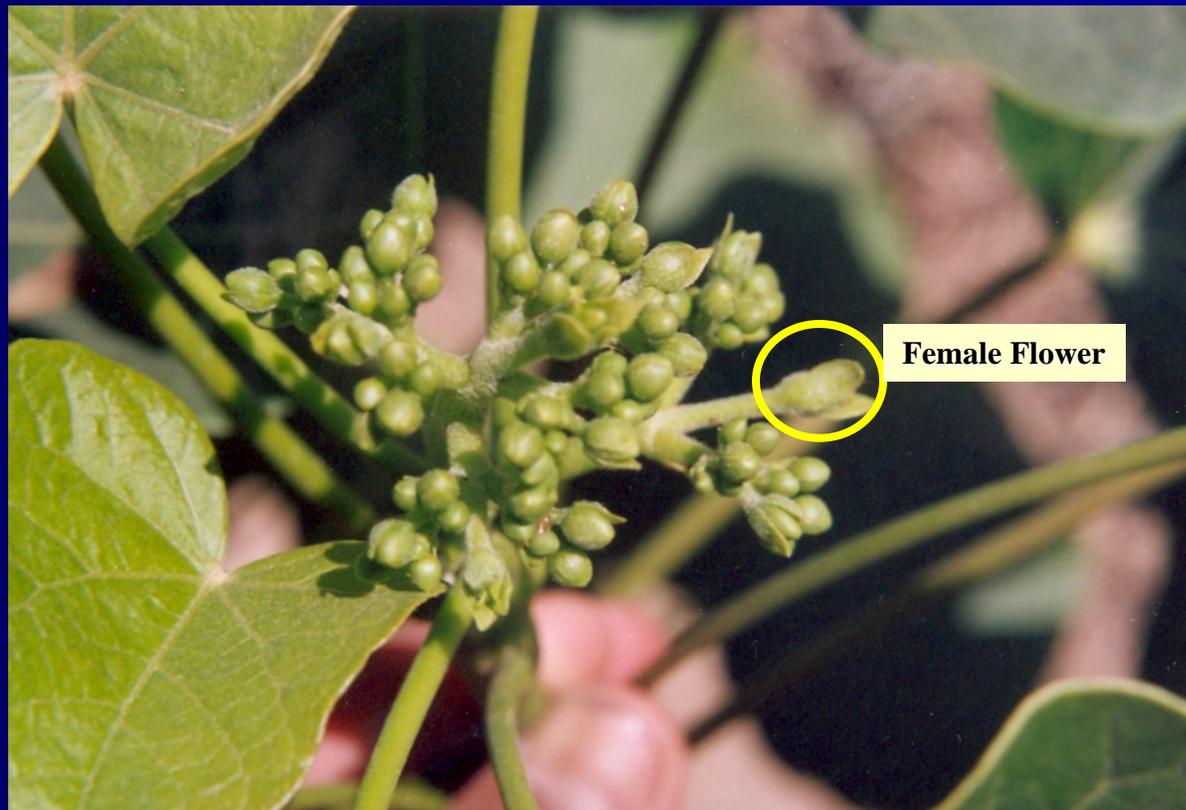
- Hardy to dry weather conditions
- Grows over wide range of arid or semi arid climatic conditions
- Grows in low rainfall conditions (200 mm) to as high as 1900 mm
- Withstand long periods of drought and saturation – Sheds off its leaves
- Tolerates annual temperature range of 08-28 °C
  - Even higher ranges but can't tolerate harsh winter or fog
- Good seed emergence in hot and humid climate
- Flowering induced in rainy season and fruiting in winter, shows continuous flowering on moisture availability
- Foliage drops with dip in temperature during winter and with rise starts blooming
- Strong adoptive mechanism to sustain variable climate
  - Frost damages plants and high temperature affects yield
  - High temperature triggers sensitivity to sex switching and drying staminate flowers during summer (high temperature coupled with low humidity) pistillate flowers exhibit reduced stigma receptivity

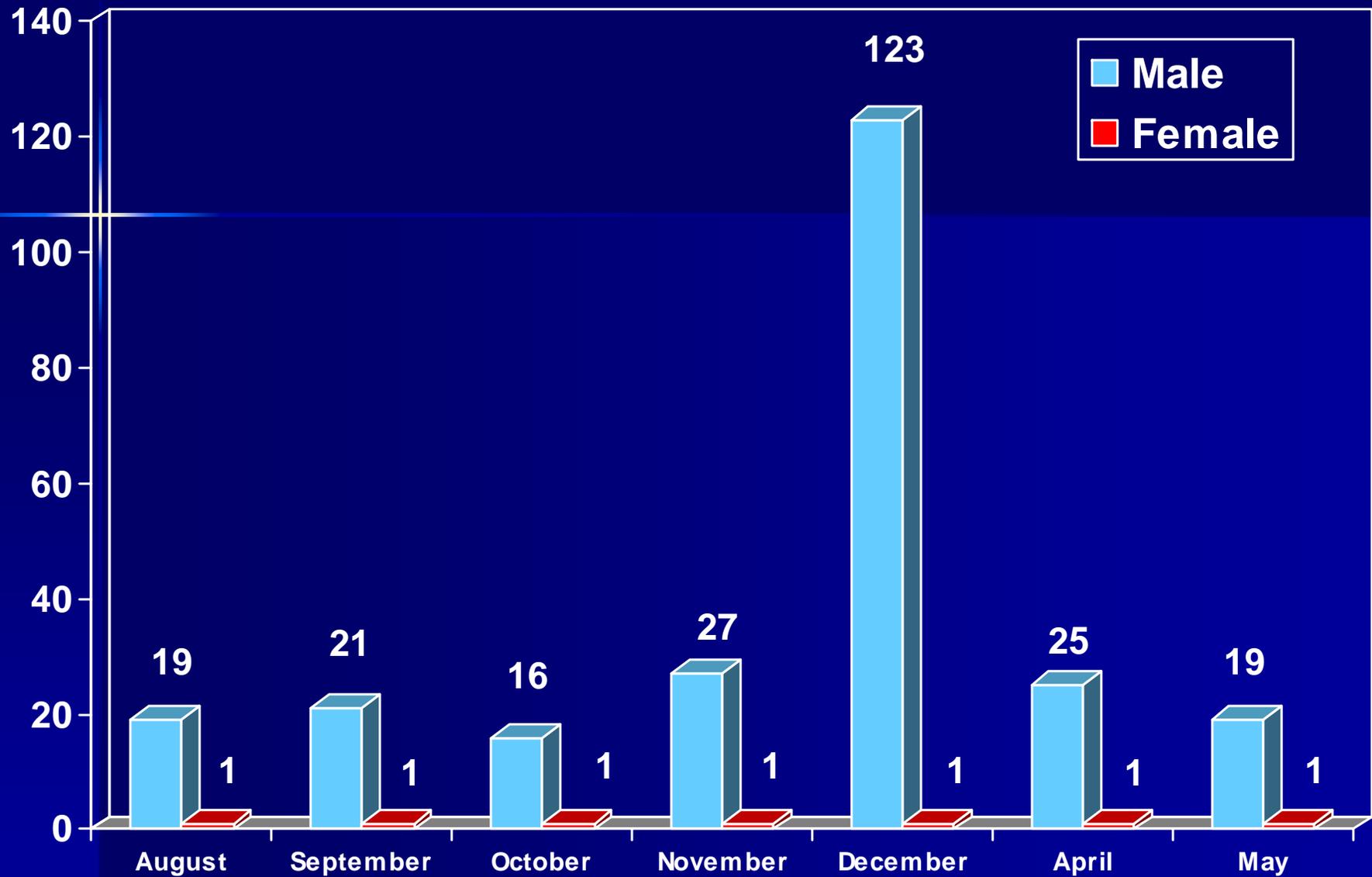
# MORPHOLOGY

- It is a small tree or shrub
- smooth gray bark, which exudes a whitish colored, watery, latex when cut.
- Normally, it grows between three and five meters in height, but can attain a height of up to eight or ten meters under favourable conditions

# Inflorescence

Plant	:	Monoecious
Inflorescence	:	Racemose with dichasial cymose pattern
Flowers	:	Female flowers relatively larger





**Male-Female ratio in *Jatropha curcas* during flowering months**

# FLOWERING TIME

- In India, it flowers twice in a year i.e in March-April and September-October.
- Seeds matures in June-July and November-December.
- The seeds are crushed to extract raw oil, a process that also provides organic fertilizer from the husks.
- Jatropha seeds contain about 30-40% of non-edible oil.



**Female & Male flowers**



**Developing capsules &  
aborted buds**

# Jatropha oil

- Jatropha the wonder plant produces seeds with an oil content of 30-40%.
- The oil can be combusted as fuel without being refined.
- It burns with clear smoke-free flame, tested successfully as fuel for simple diesel engine.
- The by-products are press cake a good organic fertilizer, oil contains also insecticide

### 13. 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 at 15 <sup>0</sup> C	0.918-0.923
4.	Refractive Index at 40 <sup>0</sup> C	1.462-1.465
5.	Acid value	19.00
6.	Saponification value	188-196
7.	Iodine value	93-107%
8.	Hydroxy value	4-20

# Jatropha oil quality

## Fatty acid composition

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

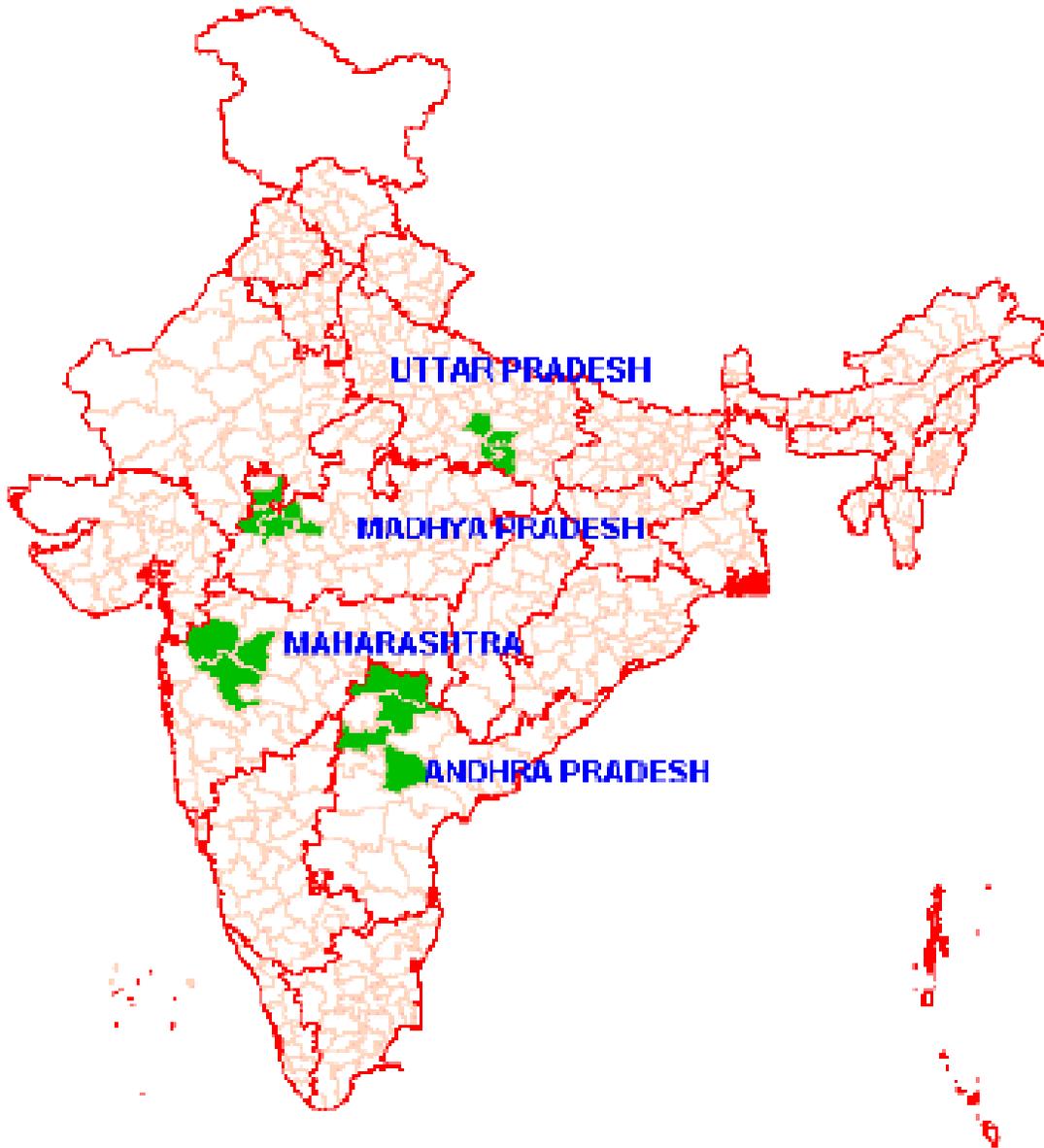
# USES OF JATROPHA

- Jatropha oil is used for making soap, candles, and varnish and as lubricant, hydraulic oil etc.
- Jatropha oil is an environmentally safe, cost-effective, renewable source of non-conventional energy
- A substitute for diesel, kerosene and other fuel oils.
- The oil can be mixed up to 50% and used for tractors and oil engines.

# As medicinal plant

- The latex of Jatropha plant contains an alkaloid known as "Jatrophine" which is believed to have anti-carcinogenic properties.
- It is also used as an external application for skin diseases and rheumatism and for sores on domestic livestock.
- In addition, the tender twigs of the plant are used for cleaning teeth,
- while the juice of the leaf is used as an external application for piles.

# JATROPHA IN INDIA



Cultivated in tropical and subtropical area ( arid and Semi arid regions)

Areas with 500-1200 mm rainfall

Avoid flood affected and areas prone to frosts

Total area : About 300,000 ha

Area required : 2.5 m ha  
To produce 5 %  
Biodiesel blending

# NOVOD Board Programmes for Jatropha Promotion in India

- Nursery raising and Model Plantation
- Establishment of TBOs (Tree Borne Oilseeds) Gardens in 14 states
- Transfer of technology
- Research and development (R & D)
- Back Ended Credit Link Subsidy programme

## Model plantation with superior *Jatropha* planting material under NOVOD Board program

S. No	Name of State	Area (in ha.)	S. No	Name of State	Area (in ha.)
1	A.P.	355	10	Manipur	250
2	Arunachal Pr.	185	11	Mizoram	500
3	Bihar	10	12	Meghalaya	113
4	Chhattisgarh	604	13	Maharashtra	1634
5	Gujarat	1429	14	M.P	742
6	Haryana	460	15	Nagaland	440
7	Jharkhand	700	16	Rajasthan	176
8	Karnataka	374	17	Sikkim	100
9	Kerala	50	18	Tamil Nadu	464
			19	U.P.	779
			20	Uttarakhand	618
			21	West Bengal	100

**Total = 10083 ha.**

# Problems associated with Jatropha

# Jatropha is sensitive to frosts



**Frost injury to Jatropha plants**



**Jatropha plants regenerated after  
frost injury**

# Sex Switching & Drying of Flowers



During summer days when temperature rises above  $42 \pm 2$  the inflorescence which normally exhibits protandry turns to bit protogyny. This is due to the anticipation of strong signal transduction such switching of sex occurs. The losses due to this phenomenon and adaptation measures are being taken up.

# Climatic variation & Morphological Changes



## High Temperature & Low moisture

- Foliage colour
- Stem colour near collar turns yellow
- Foliage drops
- Change in male Female ratio

## Low Temperature

- Stem colour 2-3 leaves below tip turns milky
- Change in male Female ratio
- Shows hermaphrodite flowers

Do not grow Jatropha  
in flood affected areas

# Quality Planting Material

## Quality Planting Material is the Need and Priority

### Constraint:

#### Non availability of quality planting material:

Requires collection, evaluation and testing : Time required look to be more due to perennial nature, gestation period and hurry due to continued hike in fuel prices and searching all solutions in Jatropha; It has an inherent potential but the optimum time needed for varietal improvement and developing production technology can't be shortened due to the natural behavior of the target species.

#### Because....

- Material of unknown yield potential can't be planted due to the risk of low yielding ability &
- Substitution of such plantation would involve lot of money, time and labour

# **NATIONAL BIODIESEL MISSION IN INDIA (under consideration of Govt.)**

- **BUDGET : Rs.14000 million (USD 3700 million)**
- **Targets: Promotional programmes (2.5 m ha by 2011-12)**
  - **Jatropha plantation on Govt & community land : 0.5 m ha**
  - **Commercial plantation on private land : 2.0 m ha**

## **Extension activities :**

- **Field Demonstrations**
- **Trainings**
- **Publicity**
- **Instalation of Pilot or model biodiesel Plants (1 TPD)**
- **Subsidy**
- **Establishments of Jatropha seed orchards**

**R & D (Rs. 2000 million)**

# 'National Network on Jatropha' (40 centres)

S.No	Name of Institutes /Universities	S.No	Name of Institutes /Universities
1	AAU, Jorhat, Assam	21.	MPUA&T, Udaipur
2	BAU, Ranchi (Jharkhand)	22.	MPUA&T, Udaipur (Tissue Culture)
3	BCKV, Nadia (WB)	23.	NAU, Navsari
4	CAU, Pasighat (Ar.Pradesh)	24.	NBPGR, New Delhi (Cryo-preservation)
5	CCS HAU RRS, Bawal	25.	NBRI, Lucknow
6	CCS HAU, Hissar	26.	NCRC, Agro Forestry, Jhansi
7	CFTRI, Mysore (Detoxification of Oil cake of Jatropha)	27.	NDUA&T, Faizabad
8	CRIDA, Hyderabad	28.	PAU, Ludhiana
9.	CSAUA&T, Kanpur	29.	PDKV, Akola
10	CSFER, Allahabad	30	RAU, Bikaner
11	CSKVV, Palampur	31.	RAU, Samastipur
12	GBPUA&T, Pantnagar	32	RRL, Bhubaneshwar (Tissue culture)
13	ICAR, RCNEH, Manipur	33	RRL, Bhubaneswar
14	ICAR, RCNEH, Meghalaya	34	RRS, CCS HAU, Karnal (Tissue culture)
15	ICAR, RCNEH, Tripura	35	SDAU, S.K. Nagar Gujarat
16.	ICAR, RCNEH, Nagaland	36	SFRI, Jabalpur
17.	IGAU, Raipur	37	SKUA&T, Jammu
18.	IIT, New Delhi (Machine & Tools)	38	TERI, New Delhi (Oil Analysis)
19.	JNKVV, Jabalpur	39	TFRI, Jabalpur
20.	MPKV, Rahuri	40	TNAU, Mettupalayam

# Genetic Improvement

# BREEDING APPROACHES

- Introduction
  - \* Selection
  - \* Population Improvement
  - \* Hybridization
  - \* Mutation
  - \* Clonal Selection
  - \* Molecular Manipulation

# POPULATION IMPROVEMENT

- **MASS SELECTION**
- **EAR TO ROW METHOD**
- **HALF SIB SELECTION**
- **FULL SIB SELECTION**
- **RECURRENT SELECTION**

# HYBRIDISATION

# Hybridization

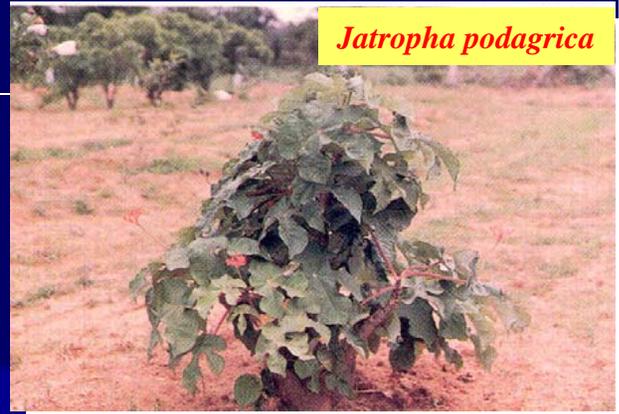
- **Intraspecific hybridization**
  - Exploitation of hybrid vigour
  - Recombination selection cycle
- **Interspecific hybridization**
  - Exploitation of hybrid vigour
  - Recombination selection cycle
  - Differential response observed in cross of *J. curcas* and *J. integerrima*

# Jatropha Germplasm

- Total collection is about 5000 accessions
- Wild species : 15
- Candidate Plus trees (CPTs) : 2092
- Conservation in National Gene Banks : 505 genotypes
- National Trial I : 20 genotypes
- National trial II : 15 genotypes



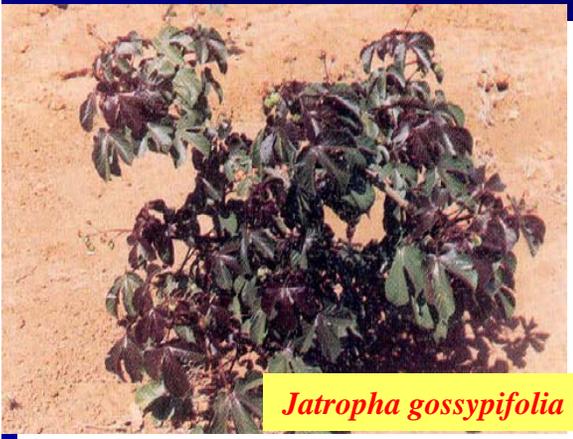
*Jatropha curcas*



*Jatropha podagrica*



*Jatropha integerrima*



*Jatropha gossypifolia*



*Jatropha multifida*

# Germplasm of *Jatropha*

- Jatropha curcas*
- Jatropha gossypifolia*
- Jatropha podagrica*
- Jatropha integerrima*
- Jatropha multifida*

# Intra-specific hybridization

1. Development of hybrids
2. Screening superior clones for higher productivity, resistance and drought tolerance
3. Developing strategies for mass multiplication of superior cultivars
4. Development of non-toxic *Jatropha*
5. Production, supply & establishment of bio-diesel park in every agro-ecological zones



## Hybrids developed



**More number of  
fruits per bunch**



**More number of  
bunches per plant**





Hybrids



Hybrids developed at TNAU



## HYBRIDS TRIALS





**Progeny trial**

# 'National Network on Jatropha'

## Superior plants of Jatropha





**More No. of Fruits per Bunch**

# Inter-specific hybridization



## Germplasm

Species collection

*Jatropha curcas*

*Jatropha curcas* (nontoxic)

*J. curcas* x *J. integrerrima*

*Jatropha gossypifolia*

*Jatropha glandulifera*

*Jatropha tanjorensis*

*Jatropha multifida*

*Jatropha podagrica*

*Jatropha integrerrima*



# Artificial hybridization in *Jatropha* species



*Jatropha curcas*



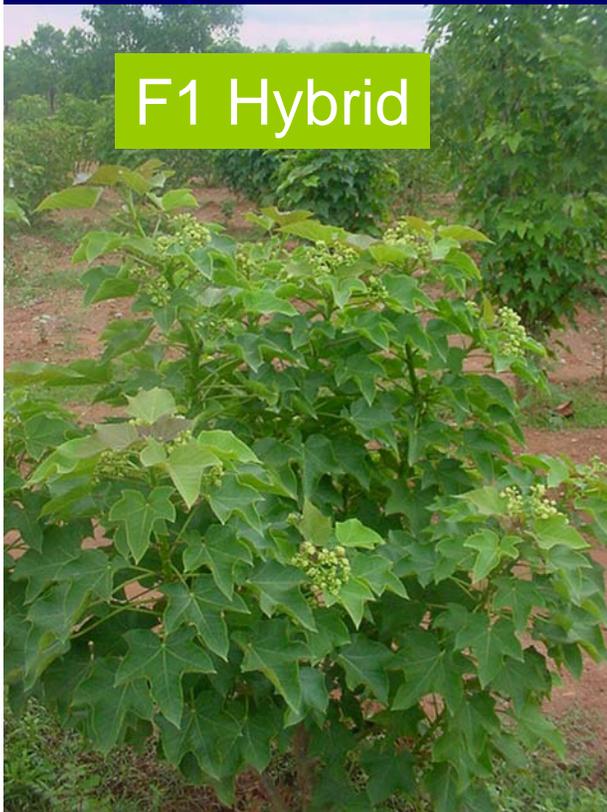
x *Jatropha integerrima*

F1 31 clones

**Higher oil content**

**Disease resistant**

*J. curcas x J. integerrima*



# Hybrids developed



# MUTATION BREEDING

# Mutation

- Induced variability to simultaneously tackle each trait to save time
- Tackle Sex switching through thermo-insensitive lines
- Elimination of toxic substances/constituents
- Floral changes
  - Hermaphrodite flowers/unisexual flowers
  - Inflorescence with high proportion of pistillate flowers
  - Male sterility
  - Oil content
    - High quality oil
    - Longer self life
    - Non toxic
  - High number of seeds

# Morphological Variations



# Sectorial Chimera



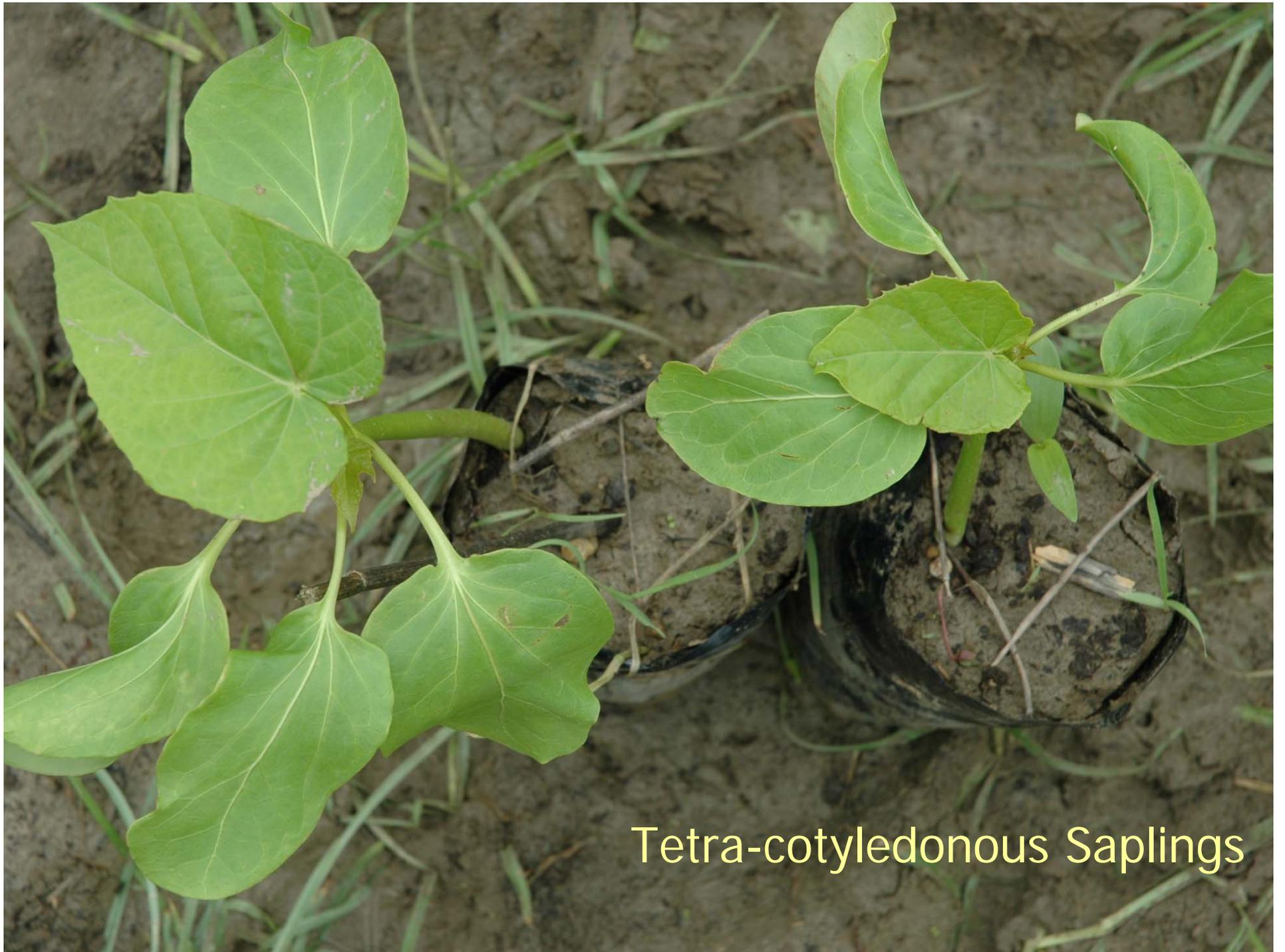
# Tricotyledonous saplings



## Easily Mutable Genes

(Assessed based on frequency of induction in  $M_1$   
-Genetic confirmation yet to be done)

- Stem colour (Whole Plant)
- Petiole colour (Whole Plant/Sector)
- Leaf margin (Whole Plant/Sector)
- Susceptibility to *Colletotrichum* leaf spot



Tetra-cotyledonous Saplings



Mutant developed at JNKVV

**Profuse  
Flowering  
Mutant**

**Broad View**

# **TISSUE CULTURE IN JATROPHA**



***Ex-plant – Nodal segments***

***Medium – MS (BAP + Kinetin)***

# 'National Network on Jatropha'

## Development of an efficient protocol for multiplication through Tissue Culture

- Partial success has been reported in tissue culture
- A commercially viable tissue culture protocols are not yet available



# **CULTIVATION OF JATROPHA**

# Jatropha cultivation

- It can be easily propagated by seeds or cuttings.
- The spacing is 2 x 2 M and this spacing can accommodate 2500 plants per hectare.
- The plant starts yielding from the first year itself but optimum yield can be obtained only from the 6th year.
- Jatropha curcus is a drought-resistant perennial, growing well in marginal/poor soil.
- It is easy to establish, grows relatively quickly and lives, producing seeds for 40-50 years.



# Jatropha nursery





# VEGETATIVE PROPAGATION OF JATROPHA



# QUALITY SEEDLING PRODUCTION

**Container size** -10 x 20 cm bag

**Soil Mix** - soil sand FYM  
(3:1:1)

**Biocontrol agents** – *Pseudomonas*  
and *Trichoderma*  
(5g/bag)

**Plan table age** - 2-3 months old  
seedlings



# TRANSPLANTING IN FIELD



Spacing – 2x2m to 3x3m



Irrigation

Nil – with proper & well distributed rainfall



Additional irrigation – need based

# NUTRIENT REQUIREMENT IN JATROPHA

## Fertilizer Application

Organic – FYM – 5 kg/plant

Inorganic – 20g of urea  
120 g super p  
16 g m.o.p

Biofertilizers – Azo. 10 g  
VAM 50 g



# DISEASE AND INSECTS

## Pest and Disease



Pest – Defoliator



Disease

Nursery –  
Damping off

Field – Root rot

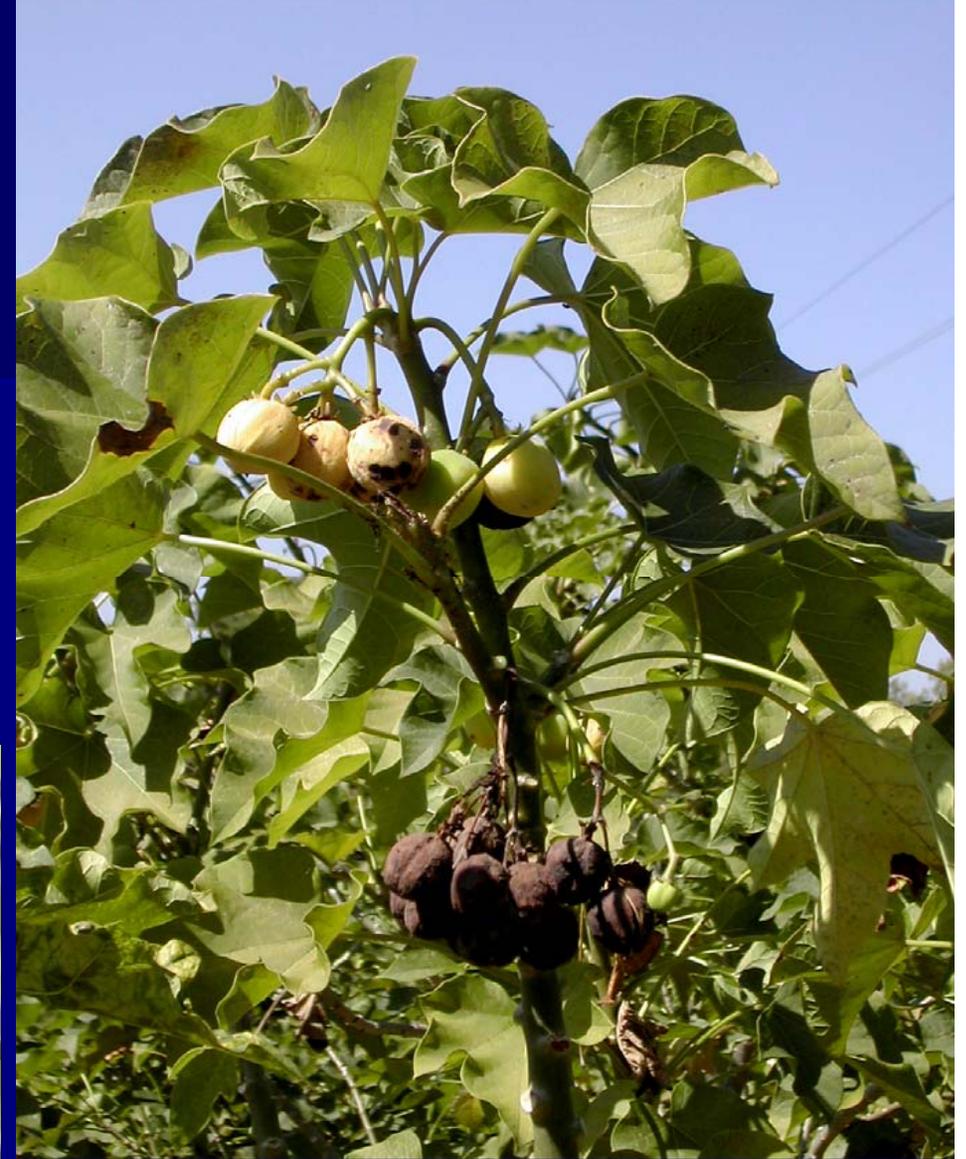
Bavistin & COC





# Pruning





## Stages of Maturity/ Harvest

# **INTER-CROPPING**

## Intercropping Trial (Sesamum + Jatropha),



## Intercropping Trial (Moong + Jatropha)



# Wheat intercropped with Jatropha



# Jatropha + Groundnut



# Sunflower intercropped with Jatropha



# Jatropha and Tomato



# Jatropha + cowpea



# Black gram intercropped with Jatropha



# SEED YIELD IN JATROPHA



## SEED AND OIL YIELD

### Under irrigated conditions

Ist Year	: Nil
2 <sup>nd</sup> year	: 500-1000 g/plant
3 <sup>rd</sup> year	: 1.5 – 2.5 Kg/plant
5 <sup>th</sup> year	: 2.0 – 4.0 kg/plant
6 <sup>th</sup> year onwards	: 5.0 kg/plant (3.0 – 4.5 ton/ha)
Av. Oil content	: 30-35 %
Oil yield/ha	: average 1.25 – 1.5 ton

**Under rain-fed conditions seed yield is  
Almost 50% of the above projected  
figures**



# Cost of plantation of jatropha (Rs. per ha)

**Hypothesis:** Spacing 2Mx2M, No. of plants per ha. - 2,500 Gestation period: 3 years.

S. No	Component	Cost of plantation (Rs. per ha.)	
		First Year	Second Year
1.	Site preparation i.e. cleaning and leveling of field	600	-
2.	Alignment and staking	300	-
3.	Digging of pits (2500 Nos.) of 30 Cm <sup>3</sup> size	3000	-
4.	Cost of FYM (including carriage) 2 kg per pits	2000	-
5.	Cost of fertilizer @ Rs. 6 per kg (50 gm. per plan during 1 <sup>st</sup> year and 25 gm from 2 <sup>nd</sup> year onward).	870	495
6.	Mixing of FYM, insecticides fertilizers and refilling of pits	1500	-
7.	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
8.	Planting and replanting cost	1500	300
9.	Irrigation – 3 irrigation during 1 <sup>st</sup> and one irrigation during 2 <sup>nd</sup> year @ Rs. 500/- per irrigation.	1500	500
10.	Weeding and soil working	1200	1200
11.	Plant protection measure	300	-
	<b>Sub Total</b>	<b>22770</b>	<b>4495</b>
	Contingency (10% of the above)	2277	450
	<b>Grand Total</b>	<b>25047</b>	<b>4945</b>

# Cost of Bio-diesel production

S.No	Component	Total expenditure/ revenue		
		S.C. – Rs.5/kg T.C.-Rs.5/litre G-Rs.20/kg	S.C. – Rs.5/kg T.C.-Rs.5/litre G-Rs.30/kg	S.C. – Rs.5/kg T.C.-Rs.5/litre G-Rs.40/kg
1.	Cost (Rs.)			
1.1.	Seed cost(SC) – 100 kg seed	500	500	500
1.2.	Oil extraction (100 kg seed @ Rs.1 per day)	100	100	100
1.3.	Trans-esterification cost (TC) for 33 litre oil	165	165	165
	Sub-Total	765	765	765
2.	Recovery (Rs.)			
2.1.	Oil meal – 65 kg @ Rs. 3 per kg	195	195	195
2.2.	Glycerol (G) – 10 kg	200	300	400
	Sub-Total	395	495	594
3.	Cost of bio-diesel (Rs./litre) {Cost – recovery/33 litre}	11.21	8.18	5.15

THANK YOU