Biodiesel-based Opportunities to Rehabilitate Degraded Lands and Income Generation

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The Nexus

Drought → Poverty

Poverty → Land Degradation

An Entry Point
Integrated Watershed Management

Water is the Key-Issue
Emerging Issues

- Food security
- Water Security
- Energy security
Rehabilitation of Degraded Common Lands

- Vast areas in India are in need of rehabilitation
- Few good examples of rehabilitation exist
- Biofuels are good candidate for rehabilitation
Pongamia Pinnata – An Experience

- Leguminous--N$_2$-fixing tree widely grown in India
- Grown on river banks, sea coast, and interior dry places up to 1000 m elevation in India
- Starts yielding from 4-7 years and seed yield varies from 10-250 kg tree$^{-1}$
- Medicinal value and wood is used for agricultural implements
- Oil cake is used as organic fertilizer, leaves are also used for mulching and composting, seed oil is a commercial product and used as biodiesel
Jatropha Curcas – An Experience

- Drought tolerant shrub, oil is used as biodiesel and has medicinal value
- Largest Jatropha cultivation in India was in Nashik
- Average yield in Nashik was low (<1 kg tree ≈ 1-1.5 t ha\(^{-1}\)) as against 9-12 t ha\(^{-1}\) reported yield
- Grown on productive land
- High labor costs
Development Model

- *Pongamia pinnata* as technology
- Doubling, tripling income is goal
- Women groups as delivery mechanism
- Carbon income as seed money
- Application in poor, arid areas thru watershed, agro-forestry interventions
- Focus on Adilabad district, Andhra Pradesh
Oil for Electricity

Principle

- *Pongamia* oil used in power generators
- Carbon income through VERs

Example

- Chalpadi: 7.5 kVA generator produces 10-12 kWh daily from 5-6 liters of *pongamia* oil
- Power system run by village women
- Successful experiment being replicated by state government in 100 villages
- 900 tCO2eq sold to Germany
- Carbon income=1 year income per family
GTZ-ICRISAT-SBT: PPP Initiative

- Collectors Model
- Growers Model
- Empowering the poor people
- Harnessing value chain benefits for the stakeholders
GoAP-ANGRAU-I CRI SAT-CRI DA Consortium

- Germplasm collection and evaluation
- Suitable agronomic practices
- Demonstrations and data collection
- Mass Multiplication methods
- Technological issues
NOVOD-I CRI SAT Initiative: Model to Benefit Landless People

- Collective action for minimizing land degradation
- CPRs are rehabilitated thru biodiesel plantations with SWM
- SHGs are formed and would benefit not only from the wages but will have usufruct rights
- Within six months usufruct rights awarded to SHGs
Evaluation of seed samples of *Jatropha* and *Pongamia* for oil content, seed weight and per cent germination

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Sample No.</th>
<th>Source</th>
<th>100 seed weight (g)</th>
<th>% Oil content</th>
<th>Germination %</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Jatropha Curcus</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>IJC-1</td>
<td>Rajgarh</td>
<td>63.8</td>
<td>28.0</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>IJC-2</td>
<td>AP</td>
<td>68.2</td>
<td>38.4</td>
<td>90</td>
</tr>
<tr>
<td>3</td>
<td>IJC-4</td>
<td>Tamilnadu (Erode local)</td>
<td>44.0</td>
<td>28.6</td>
<td>85</td>
</tr>
<tr>
<td>4</td>
<td>IJC-6</td>
<td>Rajasthan</td>
<td>69.5</td>
<td>34.8</td>
<td>78</td>
</tr>
<tr>
<td>5</td>
<td>IJC-8</td>
<td>JNKV</td>
<td>72.6</td>
<td>34.7</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>IJC-10</td>
<td>MONDC</td>
<td>69.2</td>
<td>31.8</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>IJC-11</td>
<td>CHRK-GBR</td>
<td>69.4</td>
<td>34.4</td>
<td>17</td>
</tr>
<tr>
<td>8</td>
<td>IJC-12</td>
<td>TFRI</td>
<td>66.5</td>
<td>33.5</td>
<td>-</td>
</tr>
<tr>
<td>9</td>
<td>IJC-15</td>
<td>-do-</td>
<td>60.67</td>
<td>33.6</td>
<td>42</td>
</tr>
<tr>
<td><strong>Pongamia Pinnata</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>IPC 1</td>
<td>Bombay</td>
<td>233.2</td>
<td>30.4</td>
<td>90</td>
</tr>
<tr>
<td>2</td>
<td>IPC -2</td>
<td>Goa</td>
<td>132.7</td>
<td>21.3</td>
<td>90</td>
</tr>
<tr>
<td>3</td>
<td>IPC -4</td>
<td>Bangalore</td>
<td>177.0</td>
<td>40.9</td>
<td>90</td>
</tr>
<tr>
<td>4</td>
<td>IPC -5</td>
<td>Adilabad</td>
<td>102.4</td>
<td>39.5</td>
<td>90</td>
</tr>
<tr>
<td>5</td>
<td>IPC -6</td>
<td>Adilabad (Behranguda)</td>
<td>105.2</td>
<td>32.9</td>
<td>90</td>
</tr>
<tr>
<td>6</td>
<td>IPC -9</td>
<td>-do-</td>
<td>101.2</td>
<td>36.6</td>
<td>85</td>
</tr>
<tr>
<td>7</td>
<td>IPC -10</td>
<td>-do-</td>
<td>102.0</td>
<td>33.1</td>
<td>85</td>
</tr>
</tbody>
</table>
**Effect of mycorrhizal inoculation on growth of *Jatropha* seedlings in nursery**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plant height (cm)</th>
<th>Stem girth (cm)</th>
<th>Number of leaves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inoculated</td>
<td>47</td>
<td>6.5</td>
<td>16</td>
</tr>
<tr>
<td>Non-inoculated (control)</td>
<td>35</td>
<td>5.9</td>
<td>12</td>
</tr>
</tbody>
</table>
Plant height (cm) of *Jatropha curcas* from different treatments such as irrigation, spacing, manurial trials, at ICRISAT, Patancheru.

Control (no irrigation), S1 = 2 × 2 m, S2 = 3 × 2 m, T1 = 50 g urea (U) + 38 g SSP, T2 = 50 g U + 76 g SSP, T3 = 100 g U + 38 g SSP, T4 = 100 g U + 76 g SSP.
Chemical composition of oilcakes analyzed at ICRISAT, Patancheru, India

<table>
<thead>
<tr>
<th>Nutrients</th>
<th><em>Jatropha</em>¹</th>
<th><em>Pongamia</em>²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (%)</td>
<td>4.91</td>
<td>4.28</td>
</tr>
<tr>
<td>Phosphorous (%)</td>
<td>0.90</td>
<td>0.40</td>
</tr>
<tr>
<td>Potassium (%)</td>
<td>1.75</td>
<td>0.74</td>
</tr>
<tr>
<td>Calcium (%)</td>
<td>0.31</td>
<td>0.25</td>
</tr>
<tr>
<td>Magnesium (%)</td>
<td>0.68</td>
<td>0.17</td>
</tr>
<tr>
<td>Zinc (ppm)</td>
<td>55</td>
<td>59</td>
</tr>
<tr>
<td>Iron (ppm)</td>
<td>772</td>
<td>1000</td>
</tr>
<tr>
<td>Copper (ppm)</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>Manganese (ppm)</td>
<td>85</td>
<td>74</td>
</tr>
<tr>
<td>Boron (ppm)</td>
<td>20</td>
<td>19</td>
</tr>
<tr>
<td>Sulphur (ppm)</td>
<td>2433</td>
<td>1894</td>
</tr>
</tbody>
</table>

On-station Work at ICRISAT, Patancheru

Pests on *Jatropha*

Caterpillars damage
On-station Work at ICRISAT, Patancheru (Contd..)

Pests on *Jatropha*

*Leaf miner damage*
Stem borer damage

Pests on *Jatropha*
On-station Work at I CRI SAT, Patancheru

Intercropping in *Jatropha*

*Pigeonpea intercrop*
## Oil Seed Cake for Increasing Crop Yields

Grain yield response of soybean to the application of *Pongamia* press cake and inorganic fertilizers

<table>
<thead>
<tr>
<th>Treatment</th>
<th>N applied (kg ha⁻¹)</th>
<th>Yield (kg ha⁻¹)</th>
<th>% increase over farmers’ practice</th>
<th>Net benefit over farmers’ practice (Rs. ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farmers’ practice (DAP – 100 kg)</td>
<td>16</td>
<td>900</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>Pongamia</em> press cake (300 kg)</td>
<td>12</td>
<td>1340</td>
<td>49</td>
<td>4230</td>
</tr>
<tr>
<td>Fertilizer (Urea – 50 kg)</td>
<td>23</td>
<td>1450</td>
<td>61</td>
<td>6800</td>
</tr>
<tr>
<td>½ <em>Pongamia</em> cake (150 kg) + ½ Urea (25 kg)</td>
<td>17</td>
<td>1650</td>
<td>83</td>
<td>7950</td>
</tr>
</tbody>
</table>
Current Scenario

- Increased demand for biodiesel locally and internationally
- Increased awareness about biodiesel amongst policymakers and planners
- Enhanced support from planners
- Industries are gearing up to handle market demand
- Processing technologies are available
- Farmers are looking for alternate crops
Harness the existing material through collective action

Develop Wastelands using biodiesel plantations along with soil and water conservation

Low quality lands with supplemental irrigation could be brought under biodiesel plantation
Strategy for Operationalizing Biodiesel Initiative (Contd..)

- Undertake vigorous research on various aspects of biodiesel plantations
- Establish good demonstration-cum-research plots in different agro-ecoregions
- Good productive lands to be spared for crop production to achieve food security
Where are We for Base Material Production

- Assessment of existing available material for processing
- We have no experience or data for growing biodiesel plantations in blocks
- Lack of identified high-yielding accessions/varieties
- Suitable agronomic practices for economic production are not available
- Mass multiplication techniques from high-yielding mother plants are needed
Where are We for Base Material Production (Contd..)

- Suitable agro-ecoregions in India for growing large scale plantations to be identified
- Pests and diseases on these crops when grown as block plantations
- Crop yields with irrigation and water requirement are not known
- Crops for intercropping to be identified
Economics?
Decentralized Biodiesel Making

Suitable for: Entrepreneurs, Transport companies and Farmer cooperatives

Suitable location: Town and district places

Feasible capacity: 1 kl per shift/3 kl per day

Plant capacity:
- 1 kl/shift: 4 tons of seeds, 480 ha
- For 3 kl/day: 12 tons of seeds, 1440 ha
Cost of Biodiesel Project – 1 kl Capacity

Plant and Machinery  
1. Crude oil extraction – 40 t seeds/day  \(23,333\)  
2. Trans desterification – 10 t biodiesel  \(55,556\)  
3. Utilities and storage etc  \(21,111\)  
   Basic cost  \(100,000\)  
Taxes, transport, erection & commissioning  \(33,333\)  
Total cost of plant  \(133,333\)  

Civil Construction  
4. Cost of civil construction  \(44,444\)  
5. Working capital  \(44,444\)  
Total project cost  \(222,221\)  

Source: Dhopeshwarkar et al. 2006.
<table>
<thead>
<tr>
<th></th>
<th>US$/L 300 kl/yr</th>
<th>US$/L 600 kl/yr</th>
<th>US$/L 900 kl/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seeds – 4 kg @ $ 0.11 per kg</td>
<td>0.44</td>
<td>0.44</td>
<td>0.44</td>
</tr>
<tr>
<td>Consumables</td>
<td>0.04</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>Fixed cost - at 100%</td>
<td>0.22</td>
<td>0.11</td>
<td>0.07</td>
</tr>
<tr>
<td>Operating cost</td>
<td>0.09</td>
<td>0.09</td>
<td>0.09</td>
</tr>
<tr>
<td>Total cost</td>
<td>0.79</td>
<td>0.68</td>
<td>0.64</td>
</tr>
<tr>
<td>By products sales (-)</td>
<td>0.22</td>
<td>0.22</td>
<td>0.22</td>
</tr>
<tr>
<td>Oil cake 3 kg @ $0.056 = $0.17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glycerine 0.1 kg @ $0.55 = $0.052</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net cost/L</td>
<td>0.57</td>
<td>0.46</td>
<td>0.42</td>
</tr>
<tr>
<td>Capacity utilization</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Bio-diesel Car

- Good processing technology
- Good parent material
- Production technologies
- Knowledge
- Good market demand
- Good policy support
- Good processing technology

Raw material
Conclusions

- Decentralized model for producing and processing raw material
- Intensive research to optimize productivity on sustainable basis
- Rehabilitation of wastelands through biodiesel plantations along with soil and water conservation measures
- Harness existing potential through organized collective action and increased awareness
Thank You