Holistic Utilisation of Cotton Plants: Opportunities for Small Holder Farmers

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Indian Council of Agricultural Research (ICAR)
Ministry of Agriculture and Farmers Welfare, Govt. of India
### Properties of cotton stalks and other biomass

<table>
<thead>
<tr>
<th>Properties</th>
<th>Cotton stalk</th>
<th>Hardwoods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemicellulose (%)</td>
<td>16</td>
<td>24-40</td>
</tr>
<tr>
<td>Cellulose (%)</td>
<td>44</td>
<td>40-55</td>
</tr>
<tr>
<td>Lignin (%)</td>
<td>27</td>
<td>18-25</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Agro-wastes</th>
<th>Type</th>
<th>Volatile Matter (%)</th>
<th>Ash (%)</th>
<th>Fixed C (%)</th>
<th>HHV, MJ/Kg</th>
<th>Palletisation/Briquetting Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cotton</td>
<td>Stem</td>
<td>70.3</td>
<td>5.5</td>
<td>19.7</td>
<td>17.4</td>
<td>Very Good</td>
</tr>
<tr>
<td>2</td>
<td>Soybean</td>
<td>Stem</td>
<td>76.9</td>
<td>6.6</td>
<td>16.4</td>
<td>16.4</td>
<td>Good</td>
</tr>
<tr>
<td>3</td>
<td>Groundnut</td>
<td>Shell</td>
<td>68.0</td>
<td>2.8</td>
<td>19.1</td>
<td>16.7</td>
<td>Good</td>
</tr>
<tr>
<td>4</td>
<td>Sorghum</td>
<td>Stem</td>
<td>69.4</td>
<td>6.4</td>
<td>18.8</td>
<td>16.6</td>
<td>Good</td>
</tr>
<tr>
<td>5</td>
<td>Mustard</td>
<td>Stem</td>
<td>71.2</td>
<td>5.2</td>
<td>19.4</td>
<td>17.3</td>
<td>Good</td>
</tr>
<tr>
<td>6</td>
<td>Black gram</td>
<td>Stem</td>
<td>68.2</td>
<td>3.5</td>
<td>23.4</td>
<td>16.3</td>
<td>Good</td>
</tr>
<tr>
<td>7</td>
<td>Wheat</td>
<td>Stem</td>
<td>72.1</td>
<td>3.4</td>
<td>23.9</td>
<td>15.4</td>
<td>Good</td>
</tr>
<tr>
<td>8</td>
<td>Sugarcane</td>
<td>Stem</td>
<td>75.8</td>
<td>4.2</td>
<td>20.1</td>
<td>18.1</td>
<td>Very Good</td>
</tr>
</tbody>
</table>
## Products from Cotton Stalks

<table>
<thead>
<tr>
<th>Briquettes</th>
<th>Pellets</th>
<th>Particle Boards</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Briquettes" /></td>
<td><img src="image2" alt="Pellets" /></td>
<td><img src="image3" alt="Particle Boards" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mushroom</th>
<th>Charcoal</th>
<th>Composts</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image4" alt="Mushroom" /></td>
<td><img src="image5" alt="Charcoal" /></td>
<td><img src="image6" alt="Composts" /></td>
</tr>
</tbody>
</table>
## Availability and Value of Cotton Stalks

<table>
<thead>
<tr>
<th></th>
<th>Area (million ha)</th>
<th>Availability of Stalks (MMT)</th>
<th>Value (Million USD) (USD $ 12/Tonne)</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>32.0</td>
<td>80.0</td>
<td>$ 9600</td>
</tr>
<tr>
<td>India</td>
<td>12.0</td>
<td>30.0</td>
<td>$ 3600</td>
</tr>
</tbody>
</table>
Briquetting
Briquetting of Biomasses

• Densification of agro-residues: 100 to 1000 kg/m³
• **Binder: Lignin** - natural binding of particles into briquettes
• **Piston press** - high pressure technologies used for preparation of briquettes
• **Hydraulic press type** – desired density is issue
• Simple and easy process
Flow Chart For Briquetting Plant

Chipped Raw Material → Manual or Tractor Feeding → Screw Conveying → Briquetting by Extrusion → Finished product
Applications of Briquettes

- **Boilers:** Sugar mills, Paper mills, Chemical plants, cement industries, Dyeing houses, Food Processing units, Oil extraction units, Vanaspati for steam generation and heating
- **Forges:** For metal heating and melting
- **Brick kilns and ceramic units:** For firing furnaces
- **Gasification:** Production of producer gases
# Properties of Biomass Briquettes

<table>
<thead>
<tr>
<th>Biomass</th>
<th>Bulk Density kg/m³</th>
<th>HHV, MJ/kg</th>
<th>Ash content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saw Dust</td>
<td>1100</td>
<td>19.2</td>
<td>0.7</td>
</tr>
<tr>
<td>Groundnut shell</td>
<td>1105</td>
<td>19.9</td>
<td>2.0</td>
</tr>
<tr>
<td>Cotton stalks</td>
<td>1150</td>
<td>18.4</td>
<td>5.6</td>
</tr>
<tr>
<td>Saw dust &amp; cotton</td>
<td>1200</td>
<td>18.0</td>
<td>8.0</td>
</tr>
<tr>
<td>Rice Husk</td>
<td>1300</td>
<td>15.5</td>
<td>18.0</td>
</tr>
<tr>
<td>Coal</td>
<td>1300</td>
<td>15.9-22.2</td>
<td>20-40</td>
</tr>
</tbody>
</table>
Establishment of a Briquetting Plant

Briquetting Machine

Press: 75 hp
Screw conveyor: 3 hp
Lubricant: 3 hp
Kuppi motor: 10 hp
Size of briquettes: 90 mm
Productivity: 1.2 t/h
INVESTMENT

Land: 1 ha

Machinery: USD 62,500

Total investment: USD 125,000

Operation cost: USD 12.5 per tonne

Electrical load: 90 HP

Energy: 35 units per hour

Maintenance: USD 30 (per 400 tonne) (USD 1/Tonne)
Commercial Briquetting Plant in Operation
UNCTAD Sponsored delegates to a briquetting plant near Nagpur, MS, India in 2019 for 4 African Nations
Pelleting
Pelleting is a process of densification of biomass 6-12 mm dia and 25-30 mm length

Pellets are easy to handle and burn easily as compared to briquettes

Uniform shape, size and high energy density

Wood pellets are utilized in many countries for cooking, heating & power generation

The biomass based pellets are as good as wood pellets

Flat die and ring dies are used

Torrefied and non-torrefied pellets
Biomass Torrefaction

- Heating at 250-300 °C, absence of oxygen/air, low heating rate (residence time of 1-2 h)
- Higher energy content and lower moisture content
- Hydrophobicity, easy grindability, low energy requirement for milling, pelleting and grinding
- Behaves more or less like coal, much easily used for co-firing in existing boilers
### Reasons for Trend in Pellet Market: Revised MoP Policy (08-10-2021)

<table>
<thead>
<tr>
<th>Type of Mill</th>
<th>Type of Agro-residue biomass pellets</th>
<th>Percentage of Blending (within 1 year)</th>
<th>Percentage of Blending (within 2 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bowl Mill</td>
<td>Non Torrefied/Torrefied</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Ball &amp; Race Mill</td>
<td>Torrefied</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Ball &amp; Tube Mill</td>
<td>Torrefied with volatile content below 22%</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>
# Pelleting Plant Equipment Options in India

## Specifications

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Standalone Flat Die Pelletiser</th>
<th>Dual feed Briquette Machine</th>
<th>Ring die Pelletiser</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Power</strong></td>
<td>20-50 HP</td>
<td>90 HP</td>
<td>250 HP</td>
</tr>
<tr>
<td><strong>Capacity</strong></td>
<td>100-400 kg/h</td>
<td>Briq: 2 TPH; Pellet: 1.4 TPH</td>
<td>2 TPH</td>
</tr>
<tr>
<td><strong>Pellet size</strong></td>
<td>6-10 mm</td>
<td>20 mm</td>
<td>6-10 mm</td>
</tr>
<tr>
<td><strong>Price</strong></td>
<td>Rs. 3-5 lakh ($3600 – 6000) (stand alone)</td>
<td>Rs. 20 lakh ($24,000) (stand alone)</td>
<td>Rs. 50 lakh ($60,000) (stand alone)</td>
</tr>
<tr>
<td><strong>Tech. viability</strong></td>
<td>Viable</td>
<td>Not sure</td>
<td>Viable</td>
</tr>
<tr>
<td><strong>Econ. viability</strong></td>
<td>Poor for commercial plants</td>
<td>-</td>
<td>Good</td>
</tr>
</tbody>
</table>
Standalone Flat Die Pelletiser

- Pellet Mill Motor: 25 HP
- Feeder Motor: 3 HP
- Production capacity: 100 kg/h

About: Rs. 35 lakh ($ 42,000)

Ease of operation: Difficult to very difficult

Manpower: 2 persons

Manufacturing cost: Rs. 3500-4000 ($ 42 – 48)/tonne

Selling Price: Rs. 10000 ($ 120) /tonne

Uses: Fuel for cooking stoves where 6 mm pellets of 4000+kCal/kg and Less than 5% Ash Content is needed
Small Pelleting Plant in Operation
Viable Commercial Size Non Torrefied Pellet Plants

10-40 mm thickness material

3-8 mm material
- Rs. 12-15 lakh ($ 14,400 – 18,000)/(2TPH; 65 HP)

Wherever possible machinery shall be purchased on turnkey basis from a reliable vendor

A tractor loader is needed for loading and mixing the material

Dryer is needed if, material is wet: Cost about 45 lakh ($ 54,000)
Pelleting Plant machinery (2-5TPH)

- Drum Chipper
- Rotary Drum Drier
- Hammer Mill
- Magnetic Separator
- Cooler
- Pellet Mill
Land: 2 Acre

Shed: 10,000 sq. Feet (30 feet height)

Capacity: 2 TPH (min)

Budget: 4-5 crore ($4,80,000 – 6,00,000) in establishment; Rs 25-30 lakh ($30000 -36000)/month raw material cost for 2TPH plant

PRODUCTION COST: Rs 2300-2500 ($27.5 – 30.0)/tonne

Selling cost: Rs 6500-8000 ($78 – 96)/tonne: Rs. 8500 ($102)/tonne 75% saw dust

Ring die is better option

Raw material arrangement is most crucial

For rainy season, Rs 1 crore ($1,20,000) is needed to store material for 4 month duration
Known Supplier of Pellet Plants in India

R K Machines
Halol, Gujarat, India.
Mob: +91-9910357477,
+91-8128198945
Email: sales@rkmachines.in
kapil@rkmachines.in

R K Bio Feed Machines
Halol, Gujarat, India.
M: +91 - 9824095862
E: info@rkbfm.com

Vidarbha Sales
MIDC, Nagpur
093716 34105

RAGHAVENDRA INDUSTRIES
Mr. Nagarjuna O.
Plot No. 41, 42, Laxmi Narayana Nagar, IDA, Uppal,
Uppal, Hyderabad, Telangana, India - 500039
Mobile: +91-9885504440, +91-9949914040, +91-8588874408
Web Site: http://www.raghavendraindustries.in
Famous for Flat Die Pelleting machines

Hidustan Equipments Pvt. Ltd.
Sector-C, Industrial Area,
Indore (M.P.)-452015 (INDIA)
Email : info@hindustanengineering.in
Phone : +91 731 427850
Operation of a Pelleting Plant
Operation of a Pelleting Plant
Mandatory protocol for Successful Operation of Pellet Plants

- Biomasses must be screened to appropriate size after hammer mill, choking may occur in pellet mill
- Moisture shall be around 15-16%; high moisture will produce porous pellets; low moisture will create fine dusts
- Dry material may cause less pellet realisation
- Homogenous mixing prior to pelletising
- Biomasses, water and binders must be thoroughly mixed preferably with tractor loader before feeding to elevator
Binders used in Pelleting

- Binder provides lustrous surface
- Binder: 5% sal seed DoC is most preferred in the market
- Charoli powder, babool and tamarind seeds
- Binders must be arranged for a minimum 4 months duration at a time

Babool (arcacia) seeds
Rs. 5500/tonne

Tamarinds (Imli) seeds
Rs. 5500/tonne

Sal seed DoC
Rs. 7500/tonne
**Premium Grade Pellets from Cotton Stalks**

- Prepared Premium grade pellets from cotton stalk by blending with binders

<table>
<thead>
<tr>
<th>Binder</th>
<th>MC (%)</th>
<th>Pellet Dia (mm)</th>
<th>Length (mm)</th>
<th>Fines (%)</th>
<th>Bulk Density (kg/m³)</th>
<th>PDI (%)</th>
<th>Ash Content (%)</th>
<th>CV (kcal/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cashew shell powder (5%)</td>
<td>8.0</td>
<td>6.0</td>
<td>25.0</td>
<td>0.04</td>
<td>640</td>
<td>97.1</td>
<td>4.1</td>
<td>4150</td>
</tr>
<tr>
<td>Cuddapah almond powder (5%)</td>
<td>8.0</td>
<td>6.0</td>
<td>25.0</td>
<td>0.05</td>
<td>630</td>
<td>97.5</td>
<td>4.6</td>
<td>4050</td>
</tr>
</tbody>
</table>
Biomass Collection
Methods of Cotton Stalk Collection

- Manual uprooting and collection of cotton stalks: collected at the side of the field
- Tractor operated uprooting and manual collection and heaping of stalks
- Chipping of cotton stalks using tractor driven chippers and storage of material in a mini trucks: supplied to briquetting and pelleting plants
- Shredding and chipping of cotton stalks using a tractor drawn shredder cum chipper and storage of material in a trolley: supplied to power plants
In this method, a tractor operated uprooting tool is used for uprooting of cotton stalks.

Two labours are required for collection and heaping of uprooted stalks.

Rs. 1000 (\$ 12) expenditure is required for uprooting and collection of stalks.

Farm is ploughed in this method, farmers pays around Rs. 600 (\$ 7.2) for this process.
In this method, cotton stalks (20-25% moisture) are chipped in fields using a tractor driven chipper. Chipped material is directed into a tractor trolley or a truck. A team of 11 persons are needed for feeding. Rs. 800 ($ 9.6) / tonne for chipping and Rs. 800 ($ 9.6) / tonne as transportation charges. Total cost comes to Rs. 3000 ($ 36) per tonne at factory gate.
Demonstration of ICAR-CIRCOT appropriate logistics adopted by group farmers to the international delegates
Chipping of Cotton Stalks
Compost from Cotton Stalks

Compost production:
- Cotton Stalk – 1000 kg
- Cow Dung (Fresh) – 150 kg
- Urea – 12 kg (1.2%)
- Microbial cultures – 10 ltrs.

Microbial Cultures
- Phenerochaete chrysosporium
- Pleurotus sajor caju
- P. flabellatus

Efficient microbial cultures can be used to reduce the composting period.

Enrichment of compost can be done with Biofertilizers like Rhizobium, Azospirillum, Azotobacter, Pseudomonas etc.

Farm waste compost contain about 1.0% Nitrogen, 0.4% phosphorus and 0.5% Potassium.
Composting – Pit or Heap

Pit Method

One tonne cotton stalk – 700 – 800 kg Compost

1 kg compost @ Rs. 10 ($ 0.125)

From 1 tonne cotton stalk – Rs. 7000 to 8000 ($ 84 – 96)

Heap Method

Preparation of heaps of cotton stalks
Mushroom Cultivation from Agro-residues

- Mushroom can be cultivated using cotton stalks as substrate

- One kg of mushroom (Oyster mushroom) can be produced from 5 kg of cotton stalk

- One kg mushroom price – Rs. 150 to 200 ($ 2 to 2.5); Cost of Cotton stalks – Rs. 5 to 10 ($ 0.06 to 0.12)
Biochar - a porous carbonaceous solid material with a high degree of aromatization and high resistance to decomposition formed through the thermal breakdown of biomass from plants that is thermally decomposed in the absence of oxygen.
Application of Briquettes in Cremation
Burning of Dead body in ICAR-CIRCOT Green Crematorium

Cost Reduction: 55%
Fast cremation
No need of ghee for fire initiation
Thank You!

Email: skshukla.circot@gmail.com
Mobile: 9158507741