Rice straw collection and storage

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INTERNATIONAL WORKSHOP ON THE INNOVATIVE USE OF RICE STRAW AND RICE HUSK
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Rice straw collection and storage: conceptual framework.

Rice Plant

- Rice grain
- Residues

Ecosystem services

- Socio-economics, sustainability, target systems

Rice straw collection and storage: conceptual framework.

Collection

- Husk
- Straw

Feasibility, LCA, Economics, Energy Balance

Other uses

Straw

Densification

Transport

Storage

Energy Production

Clean and economic energy

Utilization of ash
Issues around rice straw collection

• How: feasibility of straw collection, behind combine or from threshing heaps?
• Feasibility of collection from small fields?
• Collection after rains so that some of the K/Ca is already leached?
• Energy balance of collection and transport;
Issues around rice straw storage

- How can straw be stored in a tropical environment: outside, under cover, under roof?
- At the end of the wet season, the straw might be wet but storage conditions are drier (DS);
- At the end of the dry season the straw is dry but storage conditions are humid (WS);
- How does the straw quality change during storage?
- Energy balance of storage;
Baler as the tool for straw collection

- Baling to increase bulk density;
- To facilitate easy handling, transportation & storage;
- The straw bales produced are between 200 to 400 kg, 1 m in diameter, and 1.2 m long;
Indoor or outdoor storage in the wet season?

Experimentation started at the beginning of the 2012 wet season.

Overview of the treatments tested:

T1: Dry bales indoor storage
T2: Wet bales Indoor storage
T3: Dry bales outdoor storage
T4: Wet bales outdoor storage
T5: Dry bales plastic covered (semi-permeable)
T6: Wet bales plastic covered (semi-permeable)

The same setup is used in the next dry and wet season.
Parameters measured in the experiment:

Automatically measured characteristics in the bales:

- Temperature
- Volumetric water content
- Conductivity

Automatically measured climatic parameters:

- Solar radiation
- Relative humidity
- Rainfall

Manually measured parameters:

- Weight
- Sampling for chemical and calorimetric analysis
Some preliminary results

**Dry Bales Indoor**

- Temperature (°C)
- Weight (kg)

**Wet Bales Indoor**

- Temperature (°C)

**Dry Bales Outdoor**

- Temperature (°C)
- Weight (kg)
Moisture Content of Rice Straw Bales Sampling

Moisture Content (DBI)

Moisture Content (WBI)

Moisture Content (DBO)

Moisture Content (WBO)
Bale Opening at the End of the Season

<table>
<thead>
<tr>
<th></th>
<th>Depth 10 cm</th>
<th>Depth 20 cm</th>
<th>Depth 40 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>DBI 1</td>
<td>5.85</td>
<td>6.16</td>
<td>7.49</td>
</tr>
<tr>
<td>DBI 2</td>
<td>6.89</td>
<td>6.82</td>
<td>7.46</td>
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<tr>
<td>DBI 3</td>
<td>5.57</td>
<td>5.33</td>
<td>11.55</td>
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<tr>
<td>WBI 1</td>
<td>7.33</td>
<td>7.34</td>
<td>9.25</td>
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<tr>
<td>WBI 2</td>
<td>11.9</td>
<td>10.91</td>
<td>9.56</td>
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<tr>
<td>WBI 3</td>
<td>7.23</td>
<td>8.74</td>
<td>10.0</td>
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<tr>
<td>DBO 1</td>
<td>13.18</td>
<td>5.28</td>
<td>6.99</td>
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<tr>
<td>DBO 2</td>
<td>18.75</td>
<td>8.54</td>
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<tr>
<td>DBO 3</td>
<td>14.75</td>
<td>10.85</td>
<td>10.41</td>
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<tr>
<td>WBO 1</td>
<td>15.9</td>
<td>7.86</td>
<td>7.62</td>
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<tr>
<td>WBO 2</td>
<td>9</td>
<td>8.19</td>
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<tr>
<td>WBO 3</td>
<td>18.11</td>
<td>12.43</td>
<td>8.2</td>
</tr>
</tbody>
</table>
Next Steps

• **Energetics**

Total Energy **Input** = HHB + HHL + HHUL +HHT+HHLU

Total energy **output** = High heating value of rice straw at the end of the storage

High heating value of diesel & engine oil = 38.9 MJ L⁻¹
Economics

\[
\text{Cost} = \sum \text{Machines} + \sum \text{Fuel} + \sum \text{Labour} + \sum \text{Maintenance} + \sum \text{Depreciation} + \sum \text{Insurance}
\]

**Maintenance**

\[
RM = (RF1)(P)(\frac{h}{1000})^{RF2}
\]

Where \( RM \) = accumulated repair and maintenance cost ($)

RF1 and RF2 are repair and maintenance factors

\( P \) = Machine list price in current dollars

\( h \) = accumulated hours of machine use

**Depreciation**

6% of the original value over 15 years lifetime

10% salvage value at the end 15 years
CO₂ Estimation
HH value of diesel=38.9 MJ L⁻¹
1 liter diesel burnt=2.45 kg of CO₂ emission

Estimation of CO, NOₓ and SO₂,
\[ E_i = P \times OpHrs \times LF \times EF_i \]

Where:
- \( E_i \) = Emission of substance \( i \) for a specific engine type (kg y⁻¹)
- \( P \) = Average rated engine power (kW)
- \( OpHrs \) = Vehicle operating hours (h y⁻¹)
- \( LF \) = Load factor utilized in facility operations for equipment type
- \( EF_i \) = Emission factor of substance \( i \), for given engine and fuel type (kg kWh⁻¹)
- \( i \) = Substance \( i \)

\[ E_i = Ly \times EF_i \] (Road trans. Vehicle)

Where:
- \( E_i \) = Emission of substance \( i \) for a specific engine type (kg y⁻¹)
- \( Ly \) = Distance travelled in reporting year (km y⁻¹)
- \( EF_i \) = Emission factor of substance \( i \), for given engine and fuel type (kg km⁻¹)
- \( i \) = Substance \( i \)
Conclusion

• Outdoor and Indoor storage of rice straw bales showed slow drying in the wet season.
• Overall elements concentration in the bales, stored indoor and outdoor did not change significantly.
• Elemental concentration in different depths (10, 20, and 40 cm) of the rice straw bales were not significant.
• Rice Straw can be stored indoor and outdoor for energy production.