IRRI Interventions on rice straw management for sustainable rice production

Presented by
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Scientist on rice residue and postharvest management

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International Rice Research Institute

Our Mission:
To reduce poverty and hunger, improve the health of rice farmers and consumers, and ensure environmental sustainability through collaborative research, partnerships, and the strengthening of national agricultural research and extension systems.

1000 Employees, 100 International Staff

Research station: Los Baños, Philippines
17 country offices: Bangladesh, Cambodia, India, Indonesia, Lao, Myanmar, Thailand, Vietnam, Africa program in 3 countries
250 ha Experiment Station
Why rice straw management now is more concerned? Combine harvesting as a game changer

- Spread by combine harvesters in the field
- Bulky (loose form: 70-80 kg/m$^3$)
- Intensive labor during harvesting

Some provinces in Cambodia and Vietnam now completely combine harvested
Asia: around 60% (300m tonnes/year) of rice straw burnt in the field for disposal

Images: NASA / Earth Observatory
:Punjab, India
### What should we do with rice straw?

<table>
<thead>
<tr>
<th>Components</th>
<th>N</th>
<th>P$_2$O$_5$</th>
<th>K$_2$O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content, %dm</td>
<td>0.5-0.8</td>
<td>0.2-0.3</td>
<td>1.4-2</td>
</tr>
<tr>
<td>kg/ ton straw</td>
<td>5-8</td>
<td>1.6-2.7</td>
<td>14-20</td>
</tr>
<tr>
<td>Lost during burning (%)</td>
<td>100</td>
<td>25</td>
<td>20</td>
</tr>
</tbody>
</table>

**Burn?**

**Collect/ remove?**

**Incorporate?**

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**for what and how?**
Processing and utilization routes of rice straw (IRRI-BMZ rice straw project)

**In-field options**
- Burning
- Mulching
- Incorporation

**Pre-processing**
- Leaching
- Drying and storage
- Chopping
- Densification (whole bale compaction, briquetting and pelletizing)

**Required depending on processing**
- Collection, handling, and transportation

**Off-field options**

**Agricultural uses**
- Carbonization (Bio-char)
- Composting
- Mushroom residue
- Livestock (bedding, fodder)

**Energy**
- Thermal (combustion, gasification, pyrolysis)
- Bio-chemical: AD, Fermentation, etc.
- Heat, electric power, syngas
- Biogas, ethanol, hydrogen, etc.

**Industrial uses**
- Building materials (fiber board, brick, etc.)
- Hi-end materials (silica, biofiber)

**Life cycle assessments** ➔ identify better, more sustainable practices
What we are doing?

Energy balance

Non-energy

Effects on soil

GHG emission

Nutrient balance

Carbon balance
What are the better practices?

<table>
<thead>
<tr>
<th>Matters</th>
<th>kg 1,4 DB-eq</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel burned</td>
<td>7.5</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>4.1</td>
</tr>
<tr>
<td>K₂O</td>
<td>0.5</td>
</tr>
<tr>
<td>P₂O₅</td>
<td>2</td>
</tr>
<tr>
<td>Herbicide</td>
<td>56</td>
</tr>
<tr>
<td>Particulates</td>
<td>0.82</td>
</tr>
</tbody>
</table>

Annual paddy yield (10.2 Mg/ha)

- Grain quality: head rice recovery (55.4%)
- GHGE (7.3 Mg CO₂-eq/ha)
- Net energy balance (4.7)
- Human toxicity (0.19 Mg 1,4 DB-eq/ha)

• Values in (…) are of the control scenario (Partial removal)
• Fold = ratio of scenario/control

• Complete removal
• Partial removal
• Burning

Source: Nguyen V Hung et al., working manuscript
Highlighted achievements: Mechanized collection in Vietnam

First demo of rice straw collection in 2013 ➔ Contest 2016 ➔ contribute to develop this practices in Vietnam ➔ 50% of rice straw in dry season now is collected  = reduce 50% burning in dry season = 2-3 million ton rice straw

Published in: http://www.sciencedirect.com/science/article/pii/S0378429016302854
Rice straw based composting

Machine development and field trials at IRRI (Hohenheim University and IRRI – 2017)

Machine development, field trials, and business models in Vietnam (Nong Lam University, Tien Giang University, IRRI)

Rice straw, fruit waste, green cut, animal manual: Optimized C/N = 25-30

High demand of compost substrate for fruit-plants (e.g. dragon fruit-plant)
Developing the technologies of rice straw silage for cattle feed based on:

- Assessments of the actual practices in Vietnam (TH True Milk company)
- In collaboration with ILRI
- Building the demos, and capacity building to scale out the technologies and practices
Straw chopping and pelletizing

Testing ongoing

- Pelletizing cost: 21 USD/ton (for depreciation, energy, labor, …)
- Potential for energy, cattle feeds

Source: TGU, NLU-IRRI ongoing research
Energy: combustion

Cross-flow furnace for rice straw and paddy drying

ENERTIME-IRRI project: Feasibility of 1MW power plant

Organic Ranking Cycle (ORC)
Rice straw AD power plant 1.2 MWe (assessed in India)

- 15,000 ton straw/year ➔ 18 MWh/day (Self-consumption: 3 MWh/day).
- First stage 35°C, retention time (RT) 21 days.
- Second stage 35°C, RT 20 days.
- Biogas yield: 400 m³ gas/ (1 ton straw (80 %TS) + 5% cow dung (20% TS)); CH₄ concentration is 50%.

Challenges: Collection, transportation, storage, pretreatment/chopping
IRRI-designed Batch AD – hermetic bag

- Low cost
- Portable
- Residue after AD can easily be unloaded and used as fertilizer
- Energy efficiency 15-25% + fertilizer (Residential time = 100 days)

Limitations: small scale, on-going development

Published in: http://www.sciencedirect.com/science/article/pii/S235248471630018X
Example rice straw supply chain in Vietnam (sustainable alternative to avoid burning – BMZ funded project)

Exp: Business model of collection + compacting: Net profit 38,000 $US/year; Capital return = 1 year
Value chain of straw mushroom in the Mekong Delta

Net profit of mushroom cultivation: 50-100 USD/ton of straw used

Source: IRRI – CCAFS, Toan’s master thesis and IRRI – BMZ
Summary: what can we do better for rice straw?

Negative practices

- Burn ➔ GHGE, pollutions, and nutrient losses
- Incorporate all straw: Increase 30-50% GHGE + short turn around time for decomposition ➔ causing Methane toxicity

Better practices

Partial removal

Mechanized collection, baler (net profit: 10-20 USD/ton – case in Vietnam)

Mushroom + 50-100 USD/ton

Cattle feed

Intake 1 kg/day/100kg live weight

Increase digestibility by leaching, ensilaging with Urea: needs to be developed and verified

No “one solution fits all” ➔ identify and develop good (suitable) practices corresponding to the specific rice production value chain/environment/market.
Our recent related rice straw publications:

Processing rice husks and straw

Rice straw collection

Energy efficiency, greenhouse gas emissions, and cost of rice straw collection in the Mekong river delta of Vietnam

Rice straw AD

Generating a positive energy balance from using rice straw for anaerobic digestion

GHGE

How does burning of rice straw affect CH₄ and N₂O emissions? A comparative experiment of different on-field straw management practices

Rice husk and rice straw furnace

Improving energy efficiency and developing an air-cooled grate for the downdraft rice husk furnace
Nguyen Van Hung, Reianne Quilloy, Martin Gummert

more resources on www.ricestraw.irri.org
On-going IRRI’s projects and collaborative potentials on/involving rice straw

On-going projects:
- BMZ-funded rice straw management project (Cambodia, Philippines, Vietnam – 2016-2019)
- SDC funded CORIGAP (2014-2022)
- VnSAT (Vietnam Agri. Sustainable Transformation, 2017-2020)

Potentials:
- Rice straw Circular Economy Hub, with York University and Vietnam partners, UK-GCRF fund, targeting 2018-2020)
- Sustainable rice straw management for bioenergy, food, and feed in the Philippines (submitted proposal, targeting 2018-2019)
- Inquiry from FAO to develop rice straw project for India and Srilanca
Look forward to having further collaborations (e.g. Country partners + CSAM + FAO + CYMIT + IRRI + …) ➔ maximize integrated development, minimize overlap works

Thank you

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