Mechanization and postharvest management for sustainable rice production

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International Rice Research Institute (IRRI)
IRRI Research Centre in Los Baños

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
Country offices: Bangladesh, Cambodia, India, Indonesia, Lao, Myanmar, Thailand, Vietnam, Africa program in 3 countries
250 ha Experiment Station
Key points

• Problems/challenges of mechanization and postharvest for rice production
• Overview of available technologies/solutions applied and developed by IRRI
• Sustainability analysis and best practices
• Other supporting tools/factors
• Summary and recommendations
Rice production

What significant roles do mechanization and postharvest management have in sustainable rice production?
Problems/challenges

Land preparation

- Small/fragment fields ➔ hampering mechanization, low land use efficiency

- Unleveled fields ➔
  - Difficult crop establishment
  - High irrigation water requirement
  - Less effective weed control
  - More lodging ➔ harvesting loss + lower quality
  - Uneven maturing ➔ higher processing loss
Crop establishment and care

- Laborious
- Uneven application
- Health hazards
- Environmental hazard

Manual transplanting

Fertilizer - manual spreading

Agro chemicals
Knapsack sprayer
Harvesting issues

- Labor shortage – high harvesting cost
- Often delays because of labor shortage and unavailability of machines

➔ losses

Pics: Gummert, 2015
Drying and storage issues and losses

- High losses in sun drying
- Low quality dryer
- Intensification – combine use – more crop to dry
- Poor storage

Assume loss = 5%

≈ 15 million tons/year in Asia
≈ 7,500 million USD/year

Traffic of paddy drying

MRD-Vietnam 2013

Myanmar 2016
Physical losses

Case study of postharvest losses in Myanmar
(ACIAR IRRI MyRice- Gummert, Wet season 2015)

Source: Gummert, 2015

- BMP: Best practice management
- FP: Farmer practices – x weeks of paddy delayed in the field
Rice straw management issues

Asia: 60% = 300 million tons rice straw is burning in the field each year

CH₄, N₂O, CO, toxic matters, etc

Problems of straw burning in Ha Noi, vnexpress.net – July 2016

Avoid burning straw – MONRE – Viet Nam (Nov 10, 2017)
Solutions?

- Advanced and **sustainable technologies/solutions**
- **Best/sustainable practices fixing the specific contexts** quantified through decision making tools such as Lifecycle assessment.
- **Sustainably integrated system/value chain**
- **Supporting tools/factors** such as Private-Public-Partnership models, Learning alliance, etc.
Component technologies/solutions

Laser controlled land leveling

Applying LLL for 1 ha of rice field ➔ can reduce 282 kg CO$_2$ eq
+ Increase yield: 5-15% + Saving water: 20-25%

(Source: IRRI)
Crop establishment and care

- Drum seeding
- Precision plot seeder
- Transplanter
- Fertilizer spreader – cum – chemical sprayer
- Chemical sprayer

- Time saving
- Precision and even application
- Safety and health of operator
- Options to further mechanize, auto-steering, GPS, etc
Combine harvester

- Address problem caused by labor shortage
- Saving 50% harvesting cost from manual operation.
- Reduce losses to 1-3%

Vietnam: >10,000 units (2013); 90% of paddy harvested by combine

Source: Gummert et al. 2016
Drying and storage

Solar Bubble Dryer: uses only solar energy, zero emission

Flatbed dryer with rice husk furnace (NLU)
- Use renewable energy
- Reduce 2-5% loss

Hermetic Storage System
No energy consumed, no pesticide used
Recirculating columnar dryer and two-stage drying system

NLU-IRRI recirculating columnar dryer

Two-stage drying system in MRD (2013)
IRRI-Downdraft Rice Husk Furnace for paddy drying

Renewable energy, carbon neutral, high efficiency, low pollution

- High efficiency (80%)
- Commercialized in the Philippines (>100 units sold as of July 2016)
- Transferred to Indonesia and Cambodia
- Improved air-cooled grate, patent application pending

Source: IRRI-Ripple, 2015
Rice straw management

IRRI-BMZ funded Rice Straw Management Project (2016-2019)

IRRI-SUPERGEN (UK) Rice Straw Energy Project (2013-2016)

Related publications:

- Energy efficiency, greenhouse gas emissions, and cost of rice straw collection in the Mekong river delta of Vietnam
  
- Generating a positive energy balance from using rice straw for anaerobic digestion

Sources: IRRI-BMZ Project, 2015; IRRI-SUPERGEN Project 2014

Book chapter: Processing rice husks and straw
Off-field option ➔ Straw collection

Barriers:

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

Solved in MRD of Vietnam

Demonstration in Vietnam and Cambodia, 2016 (CORIGAP & IRRI-BMZ Project)
Off-field straw management

Demonstration of straw baler in Cambodia, 2016

Demonstration of straw baler in Vietnam, 2016

Non-energy

Energy

Digester (Grainsafe bag: 180 kg)
Crop modeling and monitoring using drone and remote sensing system

Implemented under IRRI-BMZ-Rice Straw Management Project
Modelling rice crop productivity using advanced information technologies to define indicators of crop growth status for better nutrient management.

- Ground measurements
- Advanced technologies
- Field work: Straw management
- Soil + N management
- Scenarios analyses
- Crop calendar
- Climate change
- Crop growth pattern
- Crop growth signal

Source: IRRI, 2016
Sustainability analysis

Economic (investment, profit, ..)

Environment, energy

Social (livelihood, labor,..)

Quantified by Sustainability/ Lifecycle assessment ➔ Best practices
Case study: LCA of rice production with different straw management practices

Annual GHGE (Mg CO₂-eq/ha/year)

- Complete removal
- Partial removal
- Straw burning
- Straw retained

- Mushroom production
- In-field burning straw
- Direct field emission
- Mechanized operations
- Herbicide
- Fertilizer
- Seeds

Source: Nguyen Van Hung, et al., 2016
LCA of rice production with different straw management practices

Annual paddy yield, level 1 = 10.2 Mg

Grain quality (head rice recovery), level 1 = 55.4%

Human toxicity, level 1 = 0.19 Mg 1,4 DB

GHGE, level 1 = 7.3 Mg CO2-eq

Net energy balance, level 1 = 4.7

- Partial removal (control = 1)
- Complete straw removal
- In-field burning
- Straw retained and incorporated

Source: Nguyen V Hung et al., 2016
Supporting tools/factors

1. PPP model – Case study of IRRI solar bubble dryer

From concept to commercialization: 2 years

Verification and dissemination

Institutions

Optimization

Adaptation

Donors

IRRI

GIZ

GrainPro, Inc.

Farmers, NARES

Gummert, GIZ – SBD project, 2015
2. Learning Alliance platform

- **Technology transfer** in NARES countries (e.g. reversible airflow dryer transferred by NLU to SEA)

- **Capacity building** of manufacturers, operators, and users on dryers and enhanced knowledge on assessing rice quality

- **Developed business models**

- **Stakeholder networks**

Source: IRRI, 2016
IRRI - Mechanization / Postharvest Projects

Learning from the past

• ADB Postharvest projects (2006-2013)
• Combine market study (2014)

Ongoing

• IRRI-CORIGAP project 2013-2020
• ACIAR-IRRI project in Myanmar: 2012-2017
• BMZ-IRRI rice straw management project
• RICE CRP (2017-2021)
  – FP3: Mechanization
  – FP2: Value chain support services and Postharvest
• Capacity building, curriculum development
  – Vocational training (e.g. Don Bosco, Cambodia)
  – Training courses at IRRI with certification
Summary and recommendations

- **Trends of agricultural mechanization ➔ sustainability**: quality and losses, energy use efficiency, environment, cost-benefits, labor-shortage, and social aspect.

- **Some advanced/mechanized-technologies for sustainable rice production**: Laser leveling, seed drills, transplanter, fertilizer spreader, combine harvester, dryers using renewable energy, hermetic storage, digital and remote sensing crop management (drones, GSM based, etc...)

- **No “one solution fits all” ➔ strategy**: identify and develop good (suitable) practices corresponding to the specific rice production value chain/context.

- **Looking at the whole value chain**, not just on single technology component.

- **PPP, LA, joint-research platform, capacity building**
Thank you

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Other related information: [http://postharvestla.irri.org/](http://postharvestla.irri.org/)

IRRI joint-research group: Climate change – agronomy – mechanization - sustainability

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