Large-Scale Rice Bulk Storage

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Contents

- Some basics on storage
- Storage technology options
- Summary
- Suggested next steps
- What IRRI can offer

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, 92 International Staff
200 ha experiment station in Los Baños, Philippines

Head office: Los Baños, Philippines
Country offices: Bangladesh, Cambodia, India, Indonesia, Laos, Myanmar, Thailand, Vietnam, Africa program in Burundi, Tanzania, Mozambique

IRRI: The Global Rice Science Partnership GRiSP

GRiSP R&D Themes

1. Genetic Resources
2. New Varieties
3. Production Systems
4. New Products & Value Chains
5. Targeting & Policy
6. Regional Delivery

Postharvest

Mechanization Systems

Outcome-driven innovation through interdisciplinary, product-oriented Research & Development and Capacity Building

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Rice Storage Systems

- **Considerations**
  - Volumes, economics of scale
  - Bulk or sack handling
  - Postharvest chain integration
  - Indoor or outdoor
  - Flexibility

- **Losses**
  - Quantity
  - Quality
    - Head rice recovery
    - Discoloration
    - Aroma, taste
    - Mycotoxins

CAP: Not a modern storage system!
Rain, rodents, high relative humidity most likely cause huge losses, estimates from Indian authors: 10%, most likely additional loss in quality (monetary loss).

Modern Storage Systems

- **Modern Storage Systems**
  - Fixed Installations
    - Warehouses
    - Indoor silos
    - Outdoor silos
    - Silo bags
    - Concrete
    - Metal
  - Flexible Storage

Modern Storage Systems

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Storage Problems

- **Insect pest development**
- **Microorganisms**
- **Moisture adsorption**
  - Equilibrium moisture content of rice at 14% at 75% relative humidity (RH)
  - Higher RH or rain → re-wetting

Source: FrigorTec GmbH

Storage Problems

- **Insect pest development**
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Source: Lacey J.

- **Other pests**
  - Rats, birds, (elephants)

Irri: Losses to rats in Myanmar up to 8% in farmers storage

Warehouse Storage in Bags

- **Advantage**
  - Flexible, suitable for small amounts
- **Disadvantages**
  - Large surface area
    - Pests
    - Humidity
  - 50% more floor area than bulk storage
- **But: Optimum for storing milled rice**
**Warehouse Storage in Bulk**

- 500-10,000 t
- Advantages
  - Flexible in volumes with separators
  - Maximum use of space compared to bag storage
  - Aeration possible
- Disadvantages
  - Bulk depth limited to 6m
  - Control of rodents, birds very difficult
  - Moisture control
  - Labor intensive handling

**Round Storage Silos**

- Advantages
  - Large scale, several thousand tons
  - Can be designed to customers needs
  - Complete protection from rodents, birds
  - Can be fully automated
- Disadvantages
  - Danger of condensation, hot spots
  - Cost
  - Once installed, not flexible in capacity

**Indoor Silos**

- Small scale applications (5-800t)
- Advantages
  - No condensation
  - Can be fully mechanized
  - Excellent pest control
- Disadvantages
  - Costly (warehouse plus silo)

**Potential Problems with Silos**

- Large temperature changes on side exposed to sun
- Air heats up, moves upwards, dries grain, gets saturated
- Condensation when it cools down (roof, other parts of the grain bulk)
- Hot spots, germination, molds
- Corrosion in some models

**Sources:**
- Schmidt-Seeger
- Mühlbauer
Some Measures to Prevent Problems

- Proper pre-cleaning
- Aeration to prevent hot spots (days, not hours)
- Monitoring of temperature, sensors, automatic aeration control
- Repeated aeration, if necessary
- Exhaust fan in roof to remove humid air
- Insulation (expensive)

Example: Reasons for Failure of Silo Storage in Vietnam

- Mostly management related
  - Too high moisture content
  - Too short aeration times
  - Mixing of different lots
  - Insufficient cleaning of paddy
  - Procurement and marketing patterns don’t match capacity
- Some technical
  - Corrosion
  - Incomplete system (e.g. no aeration facilities)

Silo Storage as a System

Has to be designed as a system, for the individual silos but also for the whole plant.

Principle of Grain Cooling
Advantages of Grain Cooling

- Comprehensive conservation of any grain in bulk storage against respiration, weevil and fungi through out the storage time by one time application which leads to simplification of storage management
- Operation of grain cooling is weather independent unlike aeration
- No need for fumigation or mycotoxin inhibitors and therefore protection of organic grain as well
- Drying of moist grain up to 2% and reduction of drying cost thereby increase of head rice recovery from paddy
- Conservation of seeds and their germination strength
- Extension of save storage time according to the moisture content and the low storage temperature

Source: RigorTec GmbH

Scale and Cost of Grain Cooling

- Grain cooling is suitable for bulk storage
- Minimum storage capacity should be 1,000 Mt per site
- Grain coolers are flexible and movable and can be used for several sites per season
- Average power consumption of the initial cooling of grain is around 6 to 8 kWh per ton of grain under tropical climate
- A second cooling maybe necessary when temperature of the grain increases by the ambient condition after several months of storage which will consume about 3% of the energy of the initial cooling
- Amortization of the investment is achieved after 2 to 3 years when used at least once a year
- Grain cooling is applied world wide under various climate condition since more than 50 years

Source: RigorTec GmbH

Hermetic Storage, Principle

- Enclose grains in an airtight container
  - Protection from water, humidity
  - Keeps rodents out
- Respiration and biological activity
  - Decrease of $O_2$
  - Increase of $CO_2$
- Insect control without pesticides

Benefits of Hermetic Storage

- Insect control
- High germination rates
- Higher milling returns

Source: IRRI - Bac Lieu Seed Center, Vietnam collaboration
Eight months of storage, 4 varieties, comparing IRRI Super bag with farmers practice

Oxygen contents overt time in sealed containers containing paddy, hermetic storage bags (blue) and ordinary PE bags (red)
**Hermetic Storage Cocoons™**

- Bag handling
- Capacity from 5t – 1050t
- Option for fumigation (CO$_2$)
- Can be installed indoors or outdoors
- No electricity needed

**Silo Bags**

- 12ft diameter, 60-100m long, around 2,200 t per acre
- Similar to Hermetic Storage
- Bulk handling
- Machines for loading, unloading
- Introduced in India since 2012, Madhya Pradesh, order for 1.3 million t storage capacity.
- IRRI has not worked with them, can’t give an objective assessment

**Comparison**

<table>
<thead>
<tr>
<th></th>
<th>Warehouses</th>
<th>Indoor silos</th>
<th>Outdoor silos</th>
<th>Hermetic storage</th>
<th>Silo bags</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Handling</strong></td>
<td>Bags, bulk</td>
<td>Bulk</td>
<td>Bulk</td>
<td>Bags</td>
<td>Bulk</td>
</tr>
<tr>
<td><strong>Investment</strong></td>
<td>High</td>
<td>Very high</td>
<td>High</td>
<td>Very low</td>
<td>Low</td>
</tr>
<tr>
<td>(Numbers from other countries, to be treated with care)</td>
<td>High</td>
<td>Very high</td>
<td>High</td>
<td>Very low</td>
<td>Low</td>
</tr>
<tr>
<td>Blasted steel silo</td>
<td>130-240US$/t</td>
<td>47US$/t for 300t cocoon</td>
<td>47US$/t for 300t cocoon</td>
<td>47US$/t for 300t cocoon</td>
<td>47US$/t for 300t cocoon</td>
</tr>
<tr>
<td><strong>Storage cost</strong></td>
<td>7.5 US$/t</td>
<td>12-13 US$/t</td>
<td>(? )</td>
<td></td>
<td>(? )</td>
</tr>
<tr>
<td><strong>Major operating cost items</strong></td>
<td>Loading, unloading, aeration</td>
<td>Loading, unloading, aeration</td>
<td>Loading, unloading, aeration</td>
<td>Labor f. loading and unloading</td>
<td>Labor, energy f. loading and unloading</td>
</tr>
<tr>
<td><strong>Flexible volumes, small lots</strong></td>
<td>Frontloader, conveyors</td>
<td>Conveyors</td>
<td>Conveyors</td>
<td>Manual</td>
<td>Loading device</td>
</tr>
<tr>
<td><strong>Insect control</strong></td>
<td>Fumigation, grain cooling</td>
<td>Fumigation, grain cooling</td>
<td>Fumigation, grain cooling</td>
<td>Included (++)</td>
<td>Included (++)</td>
</tr>
<tr>
<td><strong>Rodent protection</strong></td>
<td>?</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>(+?)</td>
</tr>
<tr>
<td><strong>Microorganisms</strong></td>
<td>Grain cooling</td>
<td>Grain cooling</td>
<td>Grain cooling</td>
<td>++</td>
<td>(++)</td>
</tr>
<tr>
<td><strong>Major issues</strong></td>
<td>Pest control difficult</td>
<td>Needs site AND warehouse, expensive</td>
<td>Condensation, hot spots, if poorly managed</td>
<td>Proper management of empty cocoons</td>
<td>(?)</td>
</tr>
</tbody>
</table>

**Important: Milled Rice Quality depends on Paddy Quality**

- “Garbage in – garbage out” principle
- Reducing quality losses need to go hand in hand with improving production, processing, especially drying
- In Myanmar and Vietnam IRRI works with governments and rice industry with farmers on rice production and postharvest to improve paddy quality
  - Varieties, seed quality
  - Rice production improvements
  - Harvesting, drying, storage at village level

**Examples:**

- Best practice rice production for production of good quality paddy
  - Timely harvesting
- Immediate and proper drying, either on village level or in rice industry
Learning from Existing Plants

- IFC, Punjab Silos, 50,000 t silo storage, last reports from 2013
- Tilda Rice Inc.: Visited in 2011, had both, CAP and modern, computer controlled silos on one site.
- Grain Cooling, already used in India, -> FrigorTec
- Hermetic storage and Silo bags already used in India

Summary

- Storage in the open under tarpaulins is not a modern storage system, losses due to humidity, rain and pests are most likely extremely high
- There are several modern storage technologies available
- IRRI does not believe in a “one solution fits all” approach, technologies should be tailored to the procurement volumes, handling systems, labor situation / need for mechanization, etc. or the value chain in general
- To improve the existing system, hermetic storage has huge potential, it is proven, flexible, inexpensive and provides insect control without pesticides. It requires little change of bag handling systems. They can handle smaller amounts of different varieties. Ideal for “floating storage”, buffer stock…
- We don’t have experience with silo bags, already commercialized in India.
- Round Metal Silos are now successfully used in the tropics, they need to be part of a system (not just technology) and managed properly. They allow full mechanization and might need a shift to bulk handling and uniform crop / varieties. Silo systems need to be very carefully tailored to the needs.
- Grain cooling is a technically viable option to preserve grains in bulk. Needs at least 1,000 t capacity. This could be an an addition to Silos to address some of the problems they have.

Suggested Next Steps

- Capture lessons learned from previous installations
- Further specify the needs for the storage systems
- Identify additional technology providers, include them in the discussions
- Organize a seminar with technical experts, end users, involved institutions and industry representatives on Grain Bulk Storage (ADB could support the Seminar)

What could IRRI Contribute?

- Assist with and participate in the Seminar
- Link to international experts and technology providers
  - Grain cooling
  - Silos
  - Hermetic storage
  - International storage experts
- Link to other IRRI programs, accompanying measures in the rice value chain to ensure that paddy of high quality reaches the storage facilities
Thank You

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