IRRI Training Module

Rice Storage

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Los Baños, Philippines

First Version: Joe Rickman, IRRI Bangkok, Thailand
With some materials form Prof. Werner Mühlbauer, Hohenheim University, Germany

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600 Year old Traditional German Warehouse

Sources: W. Muehlbauer
Participants will learn about

- Need for storage
- Rice and interactions with the environment
- Present situation and problems
  - On farm storage
  - Commercial storage
- Best practice storage management
  - Technology
  - Management
- Hermetic storage
Rice Production in 2011

- World – 700 million tons
- Asia - 650 million tons
- Bag storage - 500 million tons

(Total world cereal and pulse production 2,300 million tons)

Sources: FAO, USDA
Present Situation

Between 25-50% of the total grain value (quantity + quality) is lost between harvest and consumption in developing countries.
Postharvest Losses and Food Security

“It is not so important to know whether the exact figures for postharvest losses are 15% or 25%. If we can just reduce them by just 5% we can make a huge difference.”

Project partner from Vietnam during a joint field trip when asking about the magnitude of postharvest losses in Vietnam.

Rice production and milled rice export in 2008 in million t
(Source: World Rice Statistics)

<table>
<thead>
<tr>
<th></th>
<th>CAM</th>
<th>PHI</th>
<th>VTN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual paddy production</td>
<td>8.3</td>
<td>15.8</td>
<td>40.0</td>
</tr>
<tr>
<td>Milled rice production</td>
<td>5.4</td>
<td>10.3</td>
<td>26.0</td>
</tr>
<tr>
<td>5% loss equivalent</td>
<td>0.3</td>
<td>0.5</td>
<td>1.3</td>
</tr>
<tr>
<td>Net milled rice export</td>
<td>1.0</td>
<td>-1.5</td>
<td>7.0</td>
</tr>
</tbody>
</table>
# Quantity Losses in Cambodia
(88 on farm studies)

<table>
<thead>
<tr>
<th>Post-harvest stage</th>
<th>Mean (%)</th>
<th>Range (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutting</td>
<td>3.0</td>
<td>2.2 – 3.8</td>
</tr>
<tr>
<td>Transportation</td>
<td>3.6</td>
<td>2.0 – 5.2</td>
</tr>
<tr>
<td>Threshing</td>
<td>1.6</td>
<td>1.0 – 2.2</td>
</tr>
<tr>
<td>Drying</td>
<td>2.0</td>
<td>1.0 – 2.0</td>
</tr>
<tr>
<td>Storage</td>
<td>10.7</td>
<td>3.5 – 18.0</td>
</tr>
<tr>
<td>Milling</td>
<td>14.7</td>
<td>7.5 – 22.0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>35.6</td>
<td>17.2 - 53.2</td>
</tr>
</tbody>
</table>

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Average Postharvest Losses in Southeast Asia

Physical losses in traditional postharvest chain

- Cutting, handling: 1-5%
- Manual threshing: 1-5%
- Sun drying: 3-5%
- Open storage: 5-10%
- Village milling: 20-30%
- Small retailers

Quality losses resulting in 10-30% loss in value

- Machine threshing: 1-5%
- Combine harvesting: 1-5%
- Mechanical drying: 1-2%
- Sealed storage: 1-2%
- Commercial milling: 5-30%
- Large retailers

Physical losses in mechanized postharvest chain
Simulated farmers practice compared to best practice postharvest management

**Indications:**
Aflatoxin might be a problem in smallholder postharvest operations

**Ongoing follow-up:**
Quantification in selected villages
Low-cost detection method
Other mycotoxins

Source: IRRI - C. Balingbing, 2008
Rice Grains and their Interactions with the Environment
Save Moisture Contents (MC) Depends on Purpose

<table>
<thead>
<tr>
<th>MC</th>
<th>Purpose</th>
<th>Possible problems in storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 14%</td>
<td>Unsafe, dry within 24h after harvesting</td>
<td>Rapid temperature increase, yellowing</td>
</tr>
<tr>
<td>&lt; 14%</td>
<td>Weeks to a few months of storage</td>
<td>Molds, respiration loss, insect damage, moisture adsorption</td>
</tr>
<tr>
<td>&lt; 13%</td>
<td>8 to 12 months storage</td>
<td>Insect damage</td>
</tr>
<tr>
<td>&lt; 12%</td>
<td>Farmers’ seeds</td>
<td>Loss of seed viability</td>
</tr>
<tr>
<td>&lt; 9%</td>
<td>Storage for more than 1 year</td>
<td>Loss of seed viability</td>
</tr>
</tbody>
</table>

- **Red** indicates a high risk of problems.
- **Green** indicates a low risk of problems.
- **Yellow** indicates a medium risk of problems.
- **Out of range** indicates that the moisture content is outside the recommended range.
Equilibrium Moisture Content (EMC)

Paddy and rice are “hygroscopic”

**A. Drying**

**B. Re-wetting**

Moisture adsorption

EMC is the moisture content the grain has after its water content has equilibrated with the water content of the surrounding air.
<table>
<thead>
<tr>
<th>Relative Humidity</th>
<th>Storage Temperature, ºC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>22</td>
</tr>
<tr>
<td>50</td>
<td>11.2</td>
</tr>
<tr>
<td>55</td>
<td>11.7</td>
</tr>
<tr>
<td>60</td>
<td>12.3</td>
</tr>
<tr>
<td>65</td>
<td>12.7</td>
</tr>
<tr>
<td>70</td>
<td>13.5</td>
</tr>
<tr>
<td>75</td>
<td>14.3</td>
</tr>
<tr>
<td>77</td>
<td>14.6</td>
</tr>
<tr>
<td>79</td>
<td>14.9</td>
</tr>
<tr>
<td>81</td>
<td>15.3</td>
</tr>
<tr>
<td>83</td>
<td>15.7</td>
</tr>
<tr>
<td>85</td>
<td>16.1</td>
</tr>
<tr>
<td>87</td>
<td>16.6</td>
</tr>
<tr>
<td>89</td>
<td>17.2</td>
</tr>
<tr>
<td>91</td>
<td>17.9</td>
</tr>
</tbody>
</table>

Final paddy MC in Percent

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Equilibrium Moisture Content in Vietnam

Average Weather Data, Ho Chi Minh City

Source: http://www.saigon.climatemps.com/

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Reasons for Post Harvest Losses

1. Poor product coming into storage (improper harvesting and drying)

2. Poor storage management

3. Poor quality paddy + poor milling techniques
Present On-farm Storage Situation and Problems in Asia
Traditional Bag Storage
(Indonesia)
Granaries
(Cambodia, Myanmar, Lao, Indonesia)
Woven Bamboo Basket
(Cambodia and Myanmar)
Other Farm Level Storage Systems

- **Clay pots** (Bangladesh)
- **Wooden containers**
- **Steel drums**
- **Bulk storage at home** (Lao PDR)

**Storage**
- Need
- Rice grain
- Problems
  - Farm level
  - Commercial Technology Management
  - Hermetic Storage
- Pests

**Milling**

**Packaging**

**Marketing**
Concrete Bin
(Bhutan)
Household Steel Silos

- Protects from rodents, birds
- Expensive
- Does not control insects
- Although some information materials say the silos are hermetic, this is NOT hermetic storage

Source: FAO, 2008

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Summarizing Existing On-farm Storage Situation

- Grain is stored in open systems in bags or open granaries
- Grain is exposed to insect, rodent and bird attacks
- High equilibrium moisture content >14.0 under tropical conditions
- Grain is not always protected from rain
Farmers Present Storage Practices

1. Sell excess immediately after harvest (indebted or poor storage)
2. Take grain out and re-dry during storage period
3. Store seed in “sealed” containers
Present Commercial Storage Situation and Problems in Asia
Commercial Bag Storage Systems

- Open to atmosphere
  - moisture uptake,
  - pest problems
- Store in batches
- Often no headways and walkways
- Relatively easy to fumigate
Commercial Bulk Storage: Warehouse

- Flexible, can be used for other purposes
- 500-10,000 tons
- Divisions can separate for different sizes
- Aeration facilities available
- Automation difficult, labor intensive
- Cheaper than silos
- Control of rodents, birds and insects is very difficult

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Commercial Bulk Storage: Indoor Silos

- Not common in Asia
- Automatic loading and unloading using conveyors
- Compartments for different varieties / lots
- High investment per ton
Commercial Bulk Storage: Outdoor Silos

- Not popular in Asia, but new installations
- Management problems -> Condensation
- Efficient use of space
- Automatic loading, unloading
- Aeration
- Easy to control pests, sealed for fumigation
- Less problems with rodents and birds

Concrete and steel silos

Silo Complex in Vietnam

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Best Practice Storage Management
Pre-condition: Proper Drying

• Dry immediately after harvest to safe moisture content (with 24 hours to 14% moisture or less)

• Avoid any re-wetting of dried grains

• Avoid mixing grains of different lots with different MC.
Example Vietnam
Storage assessment in 2012

Visit to three representative processors
1. Saigon – “Satake” Food enterprise, HCMC (indoor silo for paddy storage)
2. Song Thuan Rice Mill (indoor silo for brown rice / milled rice storage)
3. Tra Noc (outdoor) Silo Complex at Song-Hau Food Company, Can Tho City

Results
- Small sample size, not conclusive
- Only #1 currently stores paddy, produced high quality milled rice
- High moisture content, all store at 15% or higher
  -> yellowing, shifting to other silos to extend storage time
- High percentage of impurities: 4-5%
  After cleaning still 1-2%
- Many varieties in rice production
- Investment by the private sector is happening
- Limited know-how on best practice and technology options
- High cost of credit for commercial operation (not for food security)
- Very little quantification / measurements
Best practice according to IRRI for minimal loss and optimum quality

Combine harvesting → Cleaning → Drying → Paddy storage → Milling (husking+polishing) → Milled rice storage

Optimum maturity 22-24%

within 24 hours

Safe for storage 14% or less (13% Muyang)

Single pass, multi stage

Current Situation in Vietnam with “reverse processing” or “re-processing”

Harvesting → Pre drying? → Husking → Temporary storage? → Transport brown rice

≈ 18-20%

≈ 16-18%

Temporary storage → Cleaning → Whitening, Polishing → Drying → Milled rice storage

≈ 15-16%

14-15%
What is required of a good storage system

- Prevention of moisture re-entering the grain after drying
- Protection from insects, rodents and birds
- Ease of loading and unloading.
- Efficient use of space
- Ease of maintenance and management.
Granary Improvements

- Insulation material for protection against heat and condensation
- Wire mesh for ventilation and protection against birds and rats
- Tarpaulin as outer wall for protection against rain, especially when walls are made from bamboo or wire mesh.
- Lifted floor to exclude ground moisture and provide the grain with ventilation
- Long eaves for enough shade and protection against rain.
- Rat barrier

Storage
- Need
- Rice grain
- Problems
  - Farm level
  - Commercial
  - Technology
  - Management
- Hermetic
- Pests

Milling
- Packaging
- Marketing
Open Storage: Storage Hygiene

- Keep storage areas clean.
- Clean storage rooms after they are emptied.
- Placing rat-traps and barriers in drying and storage areas. Cats deter and help control rats and mice.
- Inspect storage room regularly to keep it vermin proof.
- Inspect the stored seeds once a week for signs of insect infestation.
Silo Storage

- Uniform drying and cleaning of the paddy
- Buy the silo as a system (silo, conveyors for loading and unloading, aeration equipment…)
- Level the top
- Use a roof exhaust (humidity controlled)
- Use aeration as recommended
- Cleaning and sanitation between uses
Pest Control

See separate presentation
Hermetic Storage
Hermetic Sealed Storage Systems

Principle
- Special plastic - low oxygen permeability
- Biological activity reduces oxygen level quickly
- Insects die at low oxygen level
- Plastic prevents moisture adsorption
What Consumes the Oxygen?

- Insect infestation
- Microorganisms, especially in wet rice
- Oxidation and lipases of the oil in the rice bran
- Seed respiration, but little because dry seed does not respire much
What happens at low $O_2$, high $CO_2$ Atmosphere?

- $O_2 < 3\%$ is lethal to insects at all stages of development
- At higher $O_2$ levels insect activity gets reduced and even if they are not killed, they don’t multiply
Hermetic Storage: Research Findings

- Works for 3kg – 50 ton Cubes
- Controls insects without pesticides
- Maintains grain moisture content
- Approximately doubles the life of seeds
- Maintains milling quality
- Protects grain from rodents and some birds
Parameters Evaluated

1. In store atmosphere (02)
2. Grain moisture content
3. Seed germination
4. Insects
5. Grain quality
6. Farmer uptake
Intergranular Atmosphere

Findings:
1. Normal plastic is not hermetic
2. Don’t open!
3. Insect population increases over time, but is controlled by the system
Maintains Moisture Content

- 8 months of storage
- 4 varieties
- Hermetic: IRRI super bags
- Control: Woven PVC bags

Data from 2005, Bac Lieu Seed Center, Vietnam
Provides Insect Control

- 8 months of storage
- 4 varieties
- Hermetic: IRRI super bags
- Control: Woven PVC bags

Data from 2005, Bac Lieu Seed Center, Vietnam
Maintains Germination

- 8 months of storage
- 4 varieties
- Hermetic: IRRI super bags
- Control: Woven PVC bags

Data from 2005, Bac Lieu Seed Center, Vietnam
Higher Returns in Milling

- 8 months of storage
- 4 varieties
- Hermetic: IRRI super bags
- Control: Woven PVC bags

Data from 2005, Bac Lieu Seed Center, Vietnam
Benefits of Hermetic Storage

Insect control

<table>
<thead>
<tr>
<th>Variety</th>
<th>Initial sample</th>
<th>After 8 months hermetic storage</th>
<th>After 8 months traditional storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tai Nguyen</td>
<td>40</td>
<td>60</td>
<td>20</td>
</tr>
<tr>
<td>Mot Bui Do</td>
<td>20</td>
<td>40</td>
<td>0</td>
</tr>
<tr>
<td>Jasmin 85</td>
<td>20</td>
<td>60</td>
<td>0</td>
</tr>
<tr>
<td>OM 2717</td>
<td>20</td>
<td>40</td>
<td>20</td>
</tr>
</tbody>
</table>

High germination rates

<table>
<thead>
<tr>
<th>Variety</th>
<th>Initial sample</th>
<th>After 8 months hermetic storage</th>
<th>After 8 months traditional storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tai Nguyen</td>
<td>80</td>
<td>100</td>
<td>60</td>
</tr>
<tr>
<td>Mot Bui Do</td>
<td>60</td>
<td>100</td>
<td>60</td>
</tr>
<tr>
<td>Jasmin 85</td>
<td>80</td>
<td>100</td>
<td>60</td>
</tr>
<tr>
<td>OM 2717</td>
<td>60</td>
<td>100</td>
<td>60</td>
</tr>
</tbody>
</table>

Higher milling returns

<table>
<thead>
<tr>
<th>Variety</th>
<th>Initial sample</th>
<th>After 8 months hermetic storage</th>
<th>After 8 months traditional storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tai Nguyen</td>
<td>20</td>
<td>40</td>
<td>0</td>
</tr>
<tr>
<td>Mot Bui Do</td>
<td>20</td>
<td>40</td>
<td>0</td>
</tr>
<tr>
<td>Jasmin 85</td>
<td>20</td>
<td>40</td>
<td>0</td>
</tr>
<tr>
<td>OM 2717</td>
<td>20</td>
<td>40</td>
<td>0</td>
</tr>
</tbody>
</table>

No pesticides / fumigation (farmers often store inside the house to avoid theft)

Farmers in SE Asia use around 80% own seeds and use high seed rates to compensate for low germination -> more grains to sell

More grain to sell
Also controls moisture content -> protection from mycotoxins

Source: IRRI - Bac Lieu Seed Center, Vietnam collaboration
Eight months of storage, 4 varieties, comparing IRRI Super bag with farmers practice
Works with other crops
Technical Evaluation of Hermetic Storage

- Through Irrigated Rice Research Consortium Partners in Vietnam, Philippines, Indonesia, Cambodia, Myanmar, Lao PDR, Thailand from 2004 to 2012

- In collaboration with research partners and by other partners also in Sri Lanka, India, Bangladesh

- Technically feasible
Hermetic storage options
Transfer a principle..

Locally available containers

Ferro cement bin in Sri Lanka

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..or a technology, “Super bags”

- Capacity: 50kg
- Cost: US$ 1-5
- Generation 1: Sealing by twisting
- Generation 2: Sealing by zip lock
Super Grain Bag, High Capacity (SGB-HC), for use with Big Bag

- Capacity: 1t
- Cost: US$ 58
- Storage in bulk,
- Disadvantage: Not UV stabilized, thin material (like Super bag)
GrainSafe II and GrainSafe III

- Capacity: 1t
- Cost: US$ 175 (II), US$ 150 (III)
- Storage in bulk (Grainsafe II) or in sacks (GrainSafe III)
- GrainSafe II: Sprout on bottom to take grain out without disturbing the atmosphere

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## Cocoon

### Section 1A -- Organic GrainPro Cocoon

<table>
<thead>
<tr>
<th>Code</th>
<th>Capacity</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPC-005</td>
<td>5 Tonne*</td>
<td>$1,250.00</td>
</tr>
<tr>
<td>GPC-010</td>
<td>10 Tonne*</td>
<td>$1,500.00</td>
</tr>
<tr>
<td>GPC-020</td>
<td>20 Tonne*</td>
<td>$2,500.00</td>
</tr>
<tr>
<td>GPC-2-050</td>
<td>50 Tonne*</td>
<td>$4,650.00</td>
</tr>
<tr>
<td>GPC-3-050</td>
<td>50 Tonne*</td>
<td>$4,450.00</td>
</tr>
<tr>
<td>GPC-100</td>
<td>100 Tonne*</td>
<td>$8,050.00</td>
</tr>
<tr>
<td>GPC-150</td>
<td>150 Tonne*</td>
<td>$9,200.00</td>
</tr>
<tr>
<td>GPC-300</td>
<td>300 Tonne*</td>
<td>$14,000.00</td>
</tr>
</tbody>
</table>

*Capacity is approximate and subject to change.*

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Tasks: Storage activities

- Determine density of paddy, husk, milled rice, bran
- Evaluate seed storage systems at IRRI
- Load and sealing 5 t hermetic storage system (2 groups)
- Make small seed storage system (1 per group)
- Sample seed store and set up germination test
- Sample stored grain and identify insects
- Seal grain storage system ready for fumigation
# Evaluating a seed store

<table>
<thead>
<tr>
<th>Store</th>
<th>Store 2</th>
<th>Store 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grain Protection</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moisture content</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rodents</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birds</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>In store Hygiene</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage above floor (pallets)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clearways (0.5m)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batch storing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Management strategies</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Store cleaning after season</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bags cleaned, dipped</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fumigation options</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Paddy under MA conditions:

- No change in MC
- No weight loss/increase
- Infestation controlled due to low O2/high CO2 (<3% O2 is lethal to all stages of insect development)
- Molds are controlled
- Better head rice/ less broken
Milled rice

• No infestation
• No weight loss
• Storage up to one year
• No change in physical appearance
• Fragrance/aroma retained
• If no MA build up within a short time (4 weeks) plastic liner is at risk due to activity of lesser grain borer (*rhyzoperta dominica*)

Source: GrainPro
Brice (brown rice)

- Marketing is a problem due to short shelf life
- Enzymatic lipases which starts after the husk is removed, causes a rancid taste in the oil of the bran layer
- Lipases combined with infestation will cause a rapid modified atmosphere enabling long term storage
- MC will be stable

Source: GrainPro
Rice Bran

• Valuable additive for feedmills due to high oil and protein content
• Used for rice oil extraction (leftover is pelletized and sold to feedmills)
• Cannot be stored for more than a few days due to infestation and rancidity

Source: GrainPro
Storage of (hybrid) seeds

- Seeds stored in regular warehouses will deteriorate in 3-6 months
- MA storage replaces successfully cold and air conditioned stores
- Acceptable germination rates are kept for one year or more
- Seeds can be stored outdoor
- Seeds are without insect damage

Source: GrainPro
Hermetic Super Bag Storage, Sulawesi

<table>
<thead>
<tr>
<th>Village/ Treatment</th>
<th>Germination, %</th>
<th>Moisture content, %</th>
<th>Insect count/100g</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial</td>
<td>Final</td>
<td>Initial</td>
</tr>
<tr>
<td><strong>Awolagading</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IRRI Super Bag</td>
<td>95.6</td>
<td><strong>91.2</strong></td>
<td>11.9</td>
</tr>
<tr>
<td>Ordinary plastic sack</td>
<td>91.2</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>4.66</td>
<td>1.84</td>
<td>0.27</td>
</tr>
<tr>
<td><strong>Ujung Tanah</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IRRI Super Bag</td>
<td>90.8</td>
<td><strong>88.2</strong></td>
<td>11.9</td>
</tr>
<tr>
<td>Ordinary plastic sack</td>
<td>86.6</td>
<td>30.8</td>
<td>12.4</td>
</tr>
<tr>
<td>LSD</td>
<td>4.81</td>
<td>8.25</td>
<td>0.95</td>
</tr>
</tbody>
</table>

Source: IRRI ACIAR/SMAR project

n = 5 farmers in each village
LSD = least significant difference.
** Means are significantly different at 5% level of significance (P<0.05).
Case study example: Super bag trials by Romeo Junasa (farmer)

- End-user type: Farmer
- Stored seeds, 3 mos (May-July)
- Stored 40kg in SuperBag and 80kg in 2 Polypropylene bags
- Business model: Grows rice 2 seasons/yr, on 1-ha area, buys 120kg seeds per season and stores them until needed (3 months usually).
<table>
<thead>
<tr>
<th>Current practice: (PP bag):</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of seed currently used by end-user per season</td>
<td>120 kgs</td>
</tr>
<tr>
<td>Germination rate of seed with current practice</td>
<td>60-70%</td>
</tr>
<tr>
<td>Seed rate</td>
<td>120 kg/ha</td>
</tr>
<tr>
<td>No. of seasons in a year paddy is grown</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Seed stored in Super bags</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Germination rate (GR)</td>
<td>Close to 100%</td>
</tr>
<tr>
<td>New seed rate given this GR (better than current practice)</td>
<td>40 kg/ha</td>
</tr>
<tr>
<td>Amount of seed saved</td>
<td>80 kg</td>
</tr>
<tr>
<td>Market price of seeds</td>
<td>P1200/40kg</td>
</tr>
<tr>
<td>Total additional profit</td>
<td>P2400</td>
</tr>
<tr>
<td>Cost per season (Cost of Super bag X No. of Super bags)</td>
<td>P100 X 1 bag</td>
</tr>
<tr>
<td>Additional net profit per season</td>
<td>P2300 (55USD)</td>
</tr>
<tr>
<td>Additional net profit if SB is used for 2 seasons</td>
<td>P4600 (110USD)</td>
</tr>
</tbody>
</table>
Outlook: Brown rice storage

- Brown rice has a very short shelf life
- Aflatoxin and FFA development is a problem
- Initial results indicate that the Super bag can slow down aflatoxin development
- (minimum detection level: 4 ppb)
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