Japan learned rice cultivation from China.
China has the world record of unit yield.
Today, I want to introduce a story of modern Japanese rice production.
Now, fertilizer use efficiency of Japanese rice cultivation has been improved however Japan was a heavy fertilizer user.
• Change of fertilizer use efficiency in Japan
  – Statistics of Japanese rice production
  – Change of fertilizing methods
• Why Japan could reduce fertilizer?
  – Accumulation of phosphorus and potassium
  – Returning rice straw without composting
  – Studies for the nitrogen use efficiency
• The most advanced farmer’s practices

Change of fertilizer use efficiency in Japan
• Statistics of Japanese rice production
• Change of fertilizing methods

Japan International Research Center for Agricultural Sciences
Rice yields and nitrogen application in Japan (1960–2007)

From Atsuko Tanaka 2010

Population move and mechanization

From Atsuko Tanaka 2010
Mechanization Fulfilled Basic Technologies

- Good Seedling
- Good Leveling
- Shallow Transplanting

Decrease of N application

1967 achieved self-sufficiency
1985 started focusing on taste

- Preventing lodging of "Koshihikari"
- Decrease N content in rice grain for taste

From Atsuko Tanaka 2010
Nitrogen application efficiency (1960–2007)

From: Atsuko Tanaka 2010

- 1985 started focusing on taste
- Ecological regulation
- 2008 fertilizer prices rose

Fertilizer use efficiency

<table>
<thead>
<tr>
<th>(%)</th>
<th>Uptake in Rice</th>
<th>Remains in Soil</th>
<th>Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface*</td>
<td>17</td>
<td>35</td>
<td>49</td>
</tr>
<tr>
<td>Incorporate*</td>
<td>28</td>
<td>48</td>
<td>25</td>
</tr>
<tr>
<td>Side dressing*</td>
<td>36</td>
<td>25</td>
<td>29</td>
</tr>
<tr>
<td>Side dressing with controlled-release**</td>
<td>64</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Single application in a nursery box**</td>
<td>77</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

* Kankyouhozengata nougyojiten 2005
** Kaneda 1996
### Single application in a nursery box

<table>
<thead>
<tr>
<th>Method</th>
<th>Fertilizer*</th>
<th>N Kg/ha</th>
<th>%</th>
<th>Yield t/ha</th>
<th>Grain grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side-dressing fertilizers</td>
<td>LPSS100</td>
<td>80</td>
<td>100</td>
<td>6.9</td>
<td>No.1</td>
</tr>
<tr>
<td>Single application in a nursery box</td>
<td>N400-LPS120</td>
<td>48</td>
<td>40</td>
<td>7.0</td>
<td>No.1</td>
</tr>
</tbody>
</table>

*controlled-release fertilizers

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**Why Japan could reduce fertilizer?**

- Accumulation of phosphorus and potassium
- Returning rice straw without composting
- Studies for the nitrogen use efficiency
Accumulation of phosphorus and potassium

mg /100g soil

<table>
<thead>
<tr>
<th>Year</th>
<th>Phosphorus</th>
<th>Potassium</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983</td>
<td>~79</td>
<td>~99</td>
</tr>
<tr>
<td>1988</td>
<td>~84</td>
<td>~94</td>
</tr>
<tr>
<td>1993</td>
<td>~89</td>
<td>~94</td>
</tr>
<tr>
<td>1998</td>
<td>~94</td>
<td>~99</td>
</tr>
<tr>
<td>2003</td>
<td>~99</td>
<td>~99</td>
</tr>
</tbody>
</table>

53% fields were excess
29% fields were excess

Available Phosphorus
Exchangeable Potassium
Excess limit

Average of paddy fields soil

2009 MAFF

Compost and rice straw

Compost application
Rice straw return

<table>
<thead>
<tr>
<th>Year</th>
<th>Compost application</th>
<th>Rice straw return</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>2.5</td>
<td>19 kg N</td>
</tr>
<tr>
<td>1990</td>
<td>2.15</td>
<td>3.77</td>
</tr>
<tr>
<td>1995</td>
<td>0.84</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>0.5</td>
<td></td>
</tr>
</tbody>
</table>

Why you don’t use ‘compost’?
1. Aging farmers cannot afford the hard work; 83%
2. Rice price doesn’t cover the cost of compost; 57%
3. Getting compost is difficult; 37%
4. Effects of compost is not clear; 28%
5. Relation with livestock farming is not enough; 20%
6. Chemical fertilizer price raising decreased the use of compost; 17%
7. Compost quality has problems; 15%

Use of combine increased rice straw return

2009 MAFF
Fertilizing method and the efficiency

- Surface vs Incorporate = 35% vs 51%
- However the total absorbed nitrogen is same!
- The effect of nitrogen is very short

Hasegawa et al. 1981

The most advanced farmer’s practices

Japan International Research Center for Agricultural Sciences
Nitrogen proportion of rice

<table>
<thead>
<tr>
<th></th>
<th>Dry Weight t ha⁻¹</th>
<th>N Content %</th>
<th>N uptake Kg ha⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straw</td>
<td>7</td>
<td>0.5</td>
<td>35</td>
</tr>
<tr>
<td>Paddy</td>
<td>8(6.4)**</td>
<td>1.0</td>
<td>80</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>0.77</td>
<td>115</td>
</tr>
</tbody>
</table>

* Japanese Society of Soil science and plant nutrition, 1984
** ( ) as grain

In 1984, Japanese average yield was 6 t
→ 110 kg N was applied

Single application in a nursery box yield is 7 t
→ 48 kg N is applied

Epilogue (Next stage with eco agriculture)

The practices of Keiji Ohotsuki, one of the most advanced farmer.

Seedling decides 90% of the yield
- 1 plant per hill
- Adjusting the machine planted seedling by hand
- 20 cm depth ponding until harvesting
- Oedogonium provides nutrition for rice (?)

Photos by Taichi Yamamoto 2012
Conclusions

- Fertilizer use efficiency was improved from 40 to 80 kg grain per kg nitrogen application in Japan.
- Japanese compost application decreased, on the other hand, rice straw return increased.
- Improvement of nitrogen use efficiency is not change the total nitrogen absorption of rice.
- The most advanced technology (I recommend) is ‘single application in a nursery box. (145 kg grain per kg nitrogen application)’.
- Some farmer achieved higher nitrogen use efficiency, therefore further studies are needed.