Mechanization of rice production and challenges in China

Zhu Defeng
China National Rice Research Institute (CNRRI)
1 Status of rice production
2 Requirement of Mechanization
3 Mechanization of rice prod.
4 Rice planting methods
5 Rice planting by machine
6 Challenges
1 Status of rice production
Percentage of provincial rice planting area over Chinese national rice area (2001)
Area, yield and production

![Graph showing area, yield, and production trends over time. The x-axis represents years from 1949 to 2009, and the y-axis represents an index (1949=100). The graph includes lines for production (Prod), yield (Yield), and area (Area).]
Rice cropping system

[Graph showing the percentage of planting area over years for single rice and double rice]

- **Percentage of planting area (%)**
- **Year**: 1950 to 2010
- **Legend**:
  - Blue circles: Single rice
  - Red squares: Double rice
Hybrid rice
Contribution of hybrid rice to rice production in China

![Graph showing the contribution of hybrid rice to rice production in China from 1975 to 2010. The graph displays the production (in Mt) and the percentage increase due to hybrid rice.]
Hybrid area distribution in China

Hybrid Area Distribution(%):
- 13.5 - 16.5 (2)
- 10.3 - 13.5 (2)
- 7.1 - 10.3 (2)
- 3.9 - 7.1 (3)
- .7 - 3.9 (6)
### Change of plant type of variety

#### Traits of Japonica varieties released in Jiangsu

<table>
<thead>
<tr>
<th>Period</th>
<th>Growth duration (day)</th>
<th>Plant height (cm)</th>
<th>Panicle (no/m²)</th>
<th>Total grain (no/panicle)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980-1985</td>
<td>143</td>
<td>69</td>
<td>396</td>
<td>92</td>
</tr>
<tr>
<td>1986-1990</td>
<td>145</td>
<td>69</td>
<td>396</td>
<td>93</td>
</tr>
<tr>
<td>1991-1995</td>
<td>149</td>
<td>71</td>
<td>370</td>
<td>101</td>
</tr>
<tr>
<td>1996-2000</td>
<td>152</td>
<td>98</td>
<td>363</td>
<td>109</td>
</tr>
<tr>
<td>2000-2002</td>
<td>152</td>
<td>99</td>
<td>321</td>
<td>122</td>
</tr>
</tbody>
</table>
Plant height of Indica varieties released in region of Changjiang river

![Bar chart showing plant height (cm) in different years for Early rice, Single rice, and Late rice varieties, categorized by release period: 1986 to 1990, 1991 to 1995, and 1996 to 2002.](chart.png)
## Panicle character of Indica varieties released in region of Changjiang river

<table>
<thead>
<tr>
<th>Season</th>
<th>Period</th>
<th>Panicle (no/m²)</th>
<th>Grain number (no/panicle)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early rice</td>
<td>1986 to 1990</td>
<td>421 (100)</td>
<td>75.9 (100)</td>
</tr>
<tr>
<td></td>
<td>1991 to 1995</td>
<td>393 (93)</td>
<td>81.0 (106)</td>
</tr>
<tr>
<td></td>
<td>1996 to 2002</td>
<td>360 (85)</td>
<td>101.3 (133)</td>
</tr>
<tr>
<td>Single rice</td>
<td>1986 to 1990</td>
<td>354 (100)</td>
<td>104.5 (100)</td>
</tr>
<tr>
<td></td>
<td>1991 to 1995</td>
<td>310 (87)</td>
<td>130.7 (125)</td>
</tr>
<tr>
<td></td>
<td>1996 to 2002</td>
<td>260 (73)</td>
<td>155.2 (148)</td>
</tr>
<tr>
<td>Late rice</td>
<td>1986 to 1990</td>
<td>343 (100)</td>
<td>87.8 (100)</td>
</tr>
<tr>
<td></td>
<td>1991 to 1995</td>
<td>337 (98)</td>
<td>96.9 (110)</td>
</tr>
<tr>
<td></td>
<td>1996 to 2002</td>
<td>288 (83)</td>
<td>120.1 (136)</td>
</tr>
</tbody>
</table>
2 Requirement of mechanization
2.1 Labor shortage and higher labor cost

- Agri labor transfer
- Higher labor cost
- Delay management
- Time
- Effect on profit
- Strong requirement
2.2 Larger scale rice farm

- Large-scale rice farm through land shift
- Low rice profit from small rice farm
- Rice cooperative farm
- Rice management contract (social service)
### 2.3 Lower labor productivity

<table>
<thead>
<tr>
<th>Country</th>
<th>Labor time (hrs/ha)</th>
<th>Relative percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>960</td>
<td>100</td>
</tr>
<tr>
<td>Japan</td>
<td>19</td>
<td>2.0</td>
</tr>
<tr>
<td>Korea</td>
<td>20</td>
<td>2.1</td>
</tr>
<tr>
<td>USA</td>
<td>15</td>
<td>1.6</td>
</tr>
</tbody>
</table>
3  Mechanization of rice production
3.1 Mechanization percentage of rice production in country

The bar chart shows the percent of mechanization for the following stages:
- **Tillage**: 82%
- **Planting**: 20%
- **Harvest**: 65%
3.2 Percentage of rice area and machine planting in rice zones
3.3 Mechanization percent of tillage and harvest in rice zones

![Bar chart showing percent of tillage and harvest by machine in different rice zones. The chart includes specific values for each region (N, NE, NW, S, SW, YR).]
3.4 Tillage

- Rotation
- Harrow and level
3.5 Ditch digging
3.6 Fertilization

- Basal fertilization
- Dress fertilization
Transplanter with fertilization
3.7 Pesticide and herbicide spraying

- Tractor
- Plane
diversified type of sprayers

- Personal sprayer
- Higher pressure spraying
3.8 Harvest
Combine harvester with straw cutting
4 Rice planting methods
4.1 Planting types

1. Hand transplanting
2. Seedling throwing
3. Direct seeding
4. Machine transplanting
5. Ratoon rice
Hand transplanting

- High cost
- Low efficiency
- Delay planting time
Seedling throwing

- Labor saving
- Higher efficiency
- Enough basic seedling per unit
Direct seedling

- Low labor cost
- Growth season limited
- Higher cost of weed control
- Unstable seedling establishment
- Lodging
- Early senescence
Machine transplanting

- Strong requirement
- Seedling mat transplanting
- Introduced from Japan and Korea
Ratoon rice
Hand harvest to protect stubble

Hand harvest

Machine harvest
4.2 Change of planting methods

The graph shows the percentage of machine transplanting (MT) and hand transplanting (HT) over the years from 2000 to 2010. The blue line represents machine transplanting, which decreases from approximately 30% in 2000 to around 10% in 2010. The red line represents hand transplanting, which increases from about 10% in 2000 to around 60% in 2010.
Percentage of main rice planting methods

- HT: 47%
- STH: 22%
- MT: 20%
- DS: 11%
5  Rice planting by machine
5.1  Rice transplanting by machine
Development of machine TR

- Washed seedling transplanting by machine
  - Developed in 50’s

- Seedling mat transplanting by machine
  - Developed in 70’s
Types of Machine TR

- Mat Seedling transplanted by machine developed in Japan
- Pot seedling putted by machine developed in Japan
- Pot-mat Seedling transplanted by machine developed in China
## Comparison among type of Machine TRs

<table>
<thead>
<tr>
<th>Type</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Mate seedling</td>
<td>☑ Easy management</td>
<td>☑ Severe damage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>☑ Uneven</td>
</tr>
<tr>
<td></td>
<td></td>
<td>☑ Long recover</td>
</tr>
<tr>
<td>2 Pot seedling</td>
<td>☑ Less TR shock</td>
<td>☑ Low efficiency</td>
</tr>
<tr>
<td></td>
<td>☑ Uniform</td>
<td>☑ Higher cost</td>
</tr>
<tr>
<td></td>
<td>☑ Short recover</td>
<td>☑ Diff. in seedling</td>
</tr>
<tr>
<td>3 Pot-mat seedling</td>
<td>☑ Less TR shock</td>
<td>☑ More time to pulling</td>
</tr>
<tr>
<td></td>
<td>☑ Uniform</td>
<td></td>
</tr>
<tr>
<td></td>
<td>☑ Short recover</td>
<td></td>
</tr>
</tbody>
</table>
sowing

Pot-mat seedling

transplanting
- Short green-returning period
- Uniform seedling per hill
- Early tillering
Sowing machine

- Machine sowing system
- Field sowing by machine
Seedbed

- Paddy field
- Upland
Machine transplanting

- High speed transplanter
- Hand hold transplanter
Growth stage of rice transplanted by machine

Grain filling

20DAT  40DAT
Machine transplanting

- Main rice planting method **in China**
- Other rice planting methods, including **hand transplanting**, **direct seeding** (also machine seeder), **seedling throwing**, used in specific rice area
- Different kinds of machine transplanting to be developed to adapt to rice systems and conditions
- Seedling raising method is key point in machine transplanting
5.2 Rice direct seeding by machine
Dry seeding

- High speed seeder
- Hand tractor seeder
Wet or water seeding
Direct seedling -- drill
No water rice direct seeding

- High seed rate per unit
- Low seedling establishment rate, 30%
- High percentage of hybrid, 60%
- Small rice filed
Main limitation of direct seeding

5 limiting factors

- Growth season limitation
- Unstable seedling establishment
- Higher cost of weed control
- Lodging
- Early senescence
6 Challenges
6.1 Hybrid seed production
6.2 Machine transplanting

- Large amount of seeds per unit, high cost of seed for hybrid
- Short seedling age to limit growth duration of CV
- Few varieties used for to late rice in double rice system
- Lower seedling quality and short suitable transplanting period, normally 2-4d
- Requirement of large amount of seedling soil
6.3 Integration of agronomy and mechanization

- Machine design **based on agronomic requirement**
- Machine planting
  - Seedling raising, CV traits, Management
- Special machine **needed**
  - Machine for hybrid seed production
  - Ditch digger
  - Seeder in field for MT
  - Combine harvester with straw cutting
  - Ratoon rice
6.4 Research Priority

- Suitable variety and its traits
- Cropping system
- Seedling raising

- Suitable row distance of MT adaptable to rice seasons, CV type, hybrid seed production
- Crop management, fertilizer, water, pest control and natural disaster mitigation
Thank you