Current Status of Protected Horticulture in Korea

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Protected Horticulture Research Institute, NIHHS, RDA

Organization
- 4 specialized laboratories: Greenhouse structure & materials, Greenhouse Energy saving, Hydroponic culture, Greenhouse ICT
- 16 researchers, 5 technician, and 50 research assistant members

History
- Founded in 1953 as Central Institute of Horticulture Technique
- Changed in 1962 as Branch Station of Horticulture Research Station, RDA
- Changed in 2015 as Protected Horticulture Research Institute, NIHHS, RDA

Main Missions
1) Research on development and use for greenhouse structures, equipment, structural safety assessment system for greenhouse crops
2) Development of energy saving techniques for protected horticulture to cope with high fuel costs
3) Research on hydroponics and fertigation systems for greenhouse crops
4) Development of precise control techniques of the greenhouse microclimate and root zone environment for high quality horticultural crop production

Introduction

Greenhouse farming in Korea has developed very quickly since 1990s.

- Greenhouse area: 762 ha (1970) ⇒ 54,945 ha (2015), 0.4ha / farm
- Mostly plastic greenhouse: 99% (single-span 88%)
- Heated: 73% (by air heater) • Automatically controlled (30%)
- Hydroponic culture: 3,295ha (6.0%)
Introduction

Yearly change of greenhouse area in Korea

Ratio of greenhouse types in 2015

Greenhouse vegetable cultivation in 2015

<table>
<thead>
<tr>
<th>Crop</th>
<th>Growing area (ha)</th>
<th>Production (1,000 ton)</th>
<th>Major crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>63,815</td>
<td>2,715</td>
<td>Total vegetable growing area : 246,725 ha</td>
</tr>
<tr>
<td>Root</td>
<td>1,105</td>
<td>44</td>
<td>radish</td>
</tr>
<tr>
<td>Leaf</td>
<td>10,640</td>
<td>342</td>
<td>Chinese cabbage, lettuce, chives, spinach, water parsley, watermelon, strawberry, tomato, green pepper, paprika, cucumber, oriental melon, squash, melon</td>
</tr>
<tr>
<td>Fruit</td>
<td>46,693</td>
<td>2,165</td>
<td></td>
</tr>
<tr>
<td>Condiment</td>
<td>2,022</td>
<td>51</td>
<td>Welsh onion</td>
</tr>
<tr>
<td>Others</td>
<td>3,355</td>
<td>112</td>
<td>cauliflower, red cabbage</td>
</tr>
</tbody>
</table>

Major greenhouse fruit vegetable cultivation in 2015

<table>
<thead>
<tr>
<th>Crop</th>
<th>Total</th>
<th>Watermelon</th>
<th>Tomato</th>
<th>Strawberry</th>
<th>Green pepper</th>
<th>Paprika</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenhouse area (ha)</td>
<td>31,439</td>
<td>12,572</td>
<td>6,976</td>
<td>6,306</td>
<td>4,878</td>
<td>707</td>
</tr>
<tr>
<td>Production (ton)</td>
<td>1,442,887</td>
<td>544,605</td>
<td>456,982</td>
<td>192,776</td>
<td>175,574</td>
<td>72,950</td>
</tr>
<tr>
<td>Yield (kg/m²)</td>
<td>4.6</td>
<td>4.3</td>
<td>6.6</td>
<td>3.0</td>
<td>3.6</td>
<td>10.3</td>
</tr>
</tbody>
</table>

History of Protected Horticulture in Korea

Glasshouse in Korea

1450's
- Clay, oil paper, ondol

1950's
- First started in Gimhae
- Wood, bamboo, PVC

1970's
- Iron pipe, soft film, single-span

1980's
- Iron pipe, soft film, heat insulation, scale up

1990's
- Automation, labor saving
- Increase area of protected horticulture

2000's
- Large scale and multi-span

2010's
- Improving structure
- Precise environment control

Future
- Applying ICT and BT
- Plant factory

Glasshouse in Korea

Construction cost : 2.4-3.0 million US$ /ha
Long-term loan with one percent annual interest for glasshouse construction from government
Greenhouse structure

**Plastic greenhouse in Korea**

- Single-span type
- Multi-span type
- Tunnel type
- Mammoth type

**Climatic disasters in plastic greenhouse**


- Typhoon: 46.8%
- Heavy snow: 17.22%
- Heavy rain: 3.0%

**Regional standard of design wind velocity**

<table>
<thead>
<tr>
<th>Region</th>
<th>Design Wind Velocity (m/s)</th>
<th>Rainfall (mm)</th>
<th>Construction Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seoul</td>
<td>20</td>
<td>500</td>
<td>Medium</td>
</tr>
<tr>
<td>Gyeonggi</td>
<td>30</td>
<td>750</td>
<td>High</td>
</tr>
<tr>
<td>South Jeolla</td>
<td>40</td>
<td>1000</td>
<td>Very high</td>
</tr>
</tbody>
</table>

**Regional standard of design snow depth**

<table>
<thead>
<tr>
<th>Region</th>
<th>Snow Depth (cm)</th>
<th>Snow Cover (cm)</th>
<th>Construction Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seoul</td>
<td>12</td>
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<td>South Jeolla</td>
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<td>40</td>
<td>Very high</td>
</tr>
</tbody>
</table>

**Disaster-resistant facilities for horticultural and special crops by government (MAFRA)**

- 1st notice: April 2007
- 5th notice (the latest edition): July 2014

**Greenhouse models in standards**

- Plastic greenhouse
  - Multi-span (5), Single-span (19), Mammoth (5), Fruit (3), Mushroom (2)
- Shading structure for ginseng
  - Iron (5), Wood (15)
- Private development model
  - Multi-span (5), Single-span (19), Mammoth (5)
Greenhouse model (Multi-span)

Greenhouse structure

< 07-Multi-1 >
< 08-Multi-1 >
< 12-Multi-1 >

Greenhouse model (Single-span)

Greenhouse structure

< 10-Single-1 >
< 10-Single-6 >

Evaluation of greenhouse performance

Greenhouse modeling program (GHModeler)

* Download
http://www.mngsaro.go.kr/portal/bpsc/pool/vinyHousInfo.js?menuId=PS03995

Energy saving technology

Greenhouse heating
- Heating costs ratio to operating expenses: 27% (2015)
- Heating fuel: oil (84%), coal (9%), wood (8%), electricity (6%)
- Renewable energy: geothermal (214 ha), Solar thermal (68 ha)

< Hot air heater > < Hot water boiler > < Coal boiler >
< Electric heater > < Electric heater with lamp > < Fan coil unit >
**Energy saving technology**

### Insulation curtain types
- Multi-layered insulation curtain
- Outside covering multi-layered insulation curtain
- Two-layered non-woven fabric
- Automatic tunnel covering in greenhouse

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**Multi-layered insulation curtain (multi-span)**
- Crop: green pepper
- Experimental plot: Non-woven (control), multi-layered
- Fuel: decreased by 46%, yield: increased by 27%

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**Multi-layered insulation curtain (single-span)**
- Crop: cucumber
- Experimental plot: 3 layered covering (control), Rolling up, Sliding
- Fuel decreased by: Rolling up 41%, Sliding 43%
- Yield increased by: Rolling up 10%, Sliding 12%

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### Package technology for energy saving in glasshouse
- Crop: paprika
- Package configuration: Geothermal source heater, Aluminum multi-layered curtain, root zone heating
- Fuel: decreased by 85%, yield: increased by 12% (control: oil heater)

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### Environment control

#### Cooling
- Aluminum screen for shading
- Paint spray for shading
- Fan&Pad system
- Fog system

**Temperature drop: 5~7℃**
**Humidification**
**Low installation and operation cost**

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### Artificial lighting
- **Status**
  - Lighting
    - Long-day treatment
    - Low illumination, night break
  - Supplementary lighting
    - Accelerating photo-synthesis
    - High pressure sodium lamp, LED
- **Goal**
  - High effects of Supplementary lighting
  - Cost down
**Environment control**

- **CO₂ enrichment**
  - Status
    - Fruit vegetables → paprika
    - 1,000ppm → high yield (20-30%)
  - Problems
    - Liquid CO₂ → high cost
    - Supply without standard
    - Imperfect combustion

- **CO₂ enrichment in tomato cultivation**
- **Liquefied CO₂**
- **Kerosene**
- **Solid type**

**Automatic irrigation**
- Timer: 1-2L/plant/day, 4-12t/week
- Solar radiation sensor
- Lysimeter
- Moisture sensor (Tensiometer, FDR, TDR)

**Smart farm**

- **Concept**
  - A farm where information and communication technology (ICT) technology is applied to greenhouses, animal sheds, orchards, etc., to remotely and automatically manage the climate, environment control of crops and livestock properly.

  - Through smart farm, improving agriculture competitiveness, and overcoming limitation of small farm scale by increasing the yield and quality, decreasing input of fertilizer, water, and energy.

**Application effect**

- **Hwasun, Tomato (multi-span, 1.3ha)**
  - Yield increase: 65kg/3.3m² → 101kg, 55%↑
  - Labor saving: 6hrs/day → 4hrs, 50%↓
  - Energy saving: 35%↓

- Increase yield through modernization of the greenhouse, installation of smart farm and consulting by experts.
“Farm work more comfortable by smart technology”
Relieve out of tied time and space to control greenhouse environment

“Increasing productivity and quality by smart technology”
Upward leveling of farming skills by analysis of big-data and advanced prescription

“Developing agriculture industry by Korean smart greenhouse”
Entering global market by adjusting international standards

Measuring crop growth by thermal camera
- leaf temp., fruit temp.

Measuring crop growth by micro sensor
- Sap flow, EC in tomato stem

Optimally control energy of smart greenhouse system and robot farm work

Automation system for measuring crop growth by 3D camera
- leaf area, leaf temp., flower cluster, No. of internode, No. of fruit

< 3D camera>  < S/W for image analysis >  < Measurement Data >
Conclusions

Protected horticulture industry in Korea has developed rapidly in recent three decades with government support and efforts of farmers.

Recently, Korean agriculture has faced difficulties both internally and externally. The profitability and competitiveness of agriculture is deteriorating due to the small scale of management, labor shortage, rising wages, and agricultural products import opening.

To cope with such changes in agricultural conditions, much effort have been made regarding modernization of greenhouse, labor saving and automation devices, energy saving technology using natural energy, and development of smart farm using ICT technology.

Thank you for your attention!!

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