ORGANIC AGRICULTURE IN JAPAN AND PERSPECTIVES ON ORGANIC VEGETABLE PRODUCTION IN GREENHOUSES

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Tsukuba, Ibaraki, Japan
Organic shop in Taipei
Topics

1) Organic in Japan
2) Organic farming and Sustainable farming
   IGM: Integrated greenhouse management
   = Plant factory
3) IFM: Integrated fertilizer management
4) IPM: Integrated pest management
5) Seeding
6) Scientific Certification of organic
7) ICT and organic
Diversity of Agriculture in Japan
Position of agriculture systems

Artificial

Intensive Farming

Organic Agriculture

Extensive Agriculture

Alternative Environmentally conscious

Conventional

Protected Precision

Plant Factory

Concern for Bio-diversity

5. Low price, 6. Sustainable, 7. Passion
Fig. 1  Open field cultivation and Protected cultivation
From farm to table, Agricultural products distribution

Farmer

Environmentally conscious Agriculture
Organic farming

IPM

Physical control
Chemical control
Biological control
Agronomic control

Preparation
Growing period
Post harvest

Preparation for shipment

GAP: Good Agricultural Practice
(Regulation of physical, Chemical and Biological risks)

Agricultural related materials

Fertilizer
Agricultural chemical
Medicine and feed for animals

Intermediate wholesalers

Preparation
Disposal
Re-Package

Example of food production process

material
preparation
filling
packing
heat sterilization
cooling
encasement

Food manufacturer

HACCP method
Hazard Analysis every each stage
and setting of Critical Control Point

Monitoring, improvement, record management

Quick action to problem

Retail dealer

Consumer
Food import and Food mileage

Japan, Korea, USA, Germany

Average traveled distance (km)

Food import (kt)
Amount of Organic certified products in Japan and Imported Organic products

Certified abroad: Imported (without sugar cane)

Certified in Japan

Organic products ($10^4$ ton)

Year

2001 2002 2003 2004 2005 2006 2007
## Total production amount and organic certified agricultural product (2007)

<table>
<thead>
<tr>
<th>Product</th>
<th>Total Production $\times 10^4$ t in Japan</th>
<th>Organic Certified</th>
<th>Organic Ratio %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetables</td>
<td>1,627</td>
<td>3.28</td>
<td>0.20</td>
</tr>
<tr>
<td>Fruits</td>
<td>349</td>
<td>0.22</td>
<td>0.06</td>
</tr>
<tr>
<td>Rice</td>
<td>871</td>
<td>1.08</td>
<td>0.12</td>
</tr>
<tr>
<td>Wheat</td>
<td>110</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>Soybean</td>
<td>23</td>
<td>0.10</td>
<td>0.43</td>
</tr>
<tr>
<td>Green tea</td>
<td>9</td>
<td>0.17</td>
<td>1.81</td>
</tr>
<tr>
<td>Others</td>
<td>14</td>
<td>0.42</td>
<td>3.00</td>
</tr>
<tr>
<td><strong>total</strong></td>
<td><strong>3,004</strong></td>
<td><strong>5.34</strong></td>
<td><strong>0.18</strong></td>
</tr>
</tbody>
</table>
### Area and ratio of organic agriculture (10^3ha)

<table>
<thead>
<tr>
<th>Region</th>
<th>2007</th>
<th>2011</th>
<th>2007 Ratio</th>
<th>2011 Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Asia</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Korea</td>
<td>10</td>
<td>19</td>
<td>0.50%</td>
<td>1%</td>
</tr>
<tr>
<td>China</td>
<td>1553</td>
<td>1900</td>
<td>0.30%</td>
<td>0.40%</td>
</tr>
<tr>
<td>Japan(^a)</td>
<td>7</td>
<td>9</td>
<td>0.10%</td>
<td>0.20%</td>
</tr>
<tr>
<td><strong>Europe and America</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>865</td>
<td>1016</td>
<td>5.10%</td>
<td>6.10%</td>
</tr>
<tr>
<td>Italy</td>
<td>1150</td>
<td>1097</td>
<td>9</td>
<td>8.6</td>
</tr>
<tr>
<td>France</td>
<td>557</td>
<td>975</td>
<td>1.90%</td>
<td>3.60%</td>
</tr>
<tr>
<td>USA</td>
<td>1640(^b)</td>
<td>1949</td>
<td>0.50%</td>
<td>0.60%</td>
</tr>
</tbody>
</table>

\(^a\): only organic JAS (the Japanese Agricultural Standard) certified, \(^b\): 2005
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Organic Farming

Sustainable production
1) Effective Utilization of Resources using organic fertilizer without environment pollution
2) Without harmful chemicals environmentally friendly

Organic Farming
Supported by advanced technology

IGM: Integrated greenhouse management = Plant factory
1) IFM: Integrated fertilizer management
2) IPM: Integrated pest management
Basic of IFM

Organic fertilizer

Humus

Ammonium Ion (NH₄⁺)

Nitrate Ion (NO₃⁻)

Ammonia (gas)

Nitrogenous gas (N₂、N₂O)

Volatilization

Denitrification

Mineralization

Nitrification

Immobilization

Humification

Ground Water

Leaching
Concern for environment
Grand water pollution by nitrate from manure

NO$_3$-N (mg L$^{-1}$) in soil solution below 1m of grand level

Maeda et al. 2007
Excessive fertilization in protected cultivation (greenhouse)
In the open field

**Effect of Mulch**

1) to suppress temperature rise
2) to keep the soil water
3) to reduce Salt accumulation
4) To reduce leaching
5) Mulch make the root shallow.

*Nutrient use efficiency.*
Minimum tillage and use of living mulch

Diagram showing rows of plants with labels for tillage, non-tillage, and living mulch. Distances marked as 45cm between rows.
Organic fertilizer is not balanced nutrients
Organic Liquid fertilizer from Sugar production process

Starch from corn

Manufacture of Sugar

Beer ingredient: corn starch

Bi products: CSL (corn steep liquor)

Selling in a home center
As a fertilizer
CSL (corn steep liquor) as a liquid fertilizer

<table>
<thead>
<tr>
<th></th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (g·m⁻¹)</td>
<td>1.22</td>
</tr>
<tr>
<td>Water content (%)</td>
<td>50.8</td>
</tr>
<tr>
<td>Total Nitrogen (%)</td>
<td>3.31</td>
</tr>
<tr>
<td>NH₄-N</td>
<td>0.33</td>
</tr>
<tr>
<td>NO₃-N</td>
<td>0.04</td>
</tr>
<tr>
<td>amino nitrogen</td>
<td>0.98</td>
</tr>
<tr>
<td>protein and peptide nitrogen</td>
<td>1.96</td>
</tr>
<tr>
<td>P₂O₅</td>
<td>3.40</td>
</tr>
<tr>
<td>K₂O</td>
<td>3.15</td>
</tr>
<tr>
<td>CaO</td>
<td>0.04</td>
</tr>
<tr>
<td>MgO</td>
<td>1.11</td>
</tr>
<tr>
<td>Reducing sugar</td>
<td>1.57</td>
</tr>
<tr>
<td>Lactic acid</td>
<td>11.5</td>
</tr>
<tr>
<td>Ash</td>
<td>8.09</td>
</tr>
<tr>
<td>Starch and others</td>
<td>16.9</td>
</tr>
</tbody>
</table>

Added deficit element

e.g. Calcium
We developed Organic Fertigation with soil (medium)

①Top dressing little by little with in the decomposition ability of soil microbe

②Added deficit element e.g. Calcium in advance

Organic Liquid Fertilizer

Amino acid or Protein N

Ammonium N

Nitrate N

Minerals

Composite was proceeded in the soil or media

e.g. Oyster shell Calcium or manure
Manure and Organic Liquid fertilizer play complementary roles on plant nutrition organically.
IFM
integrated fertilizer management

Higher efficiency
Fertilizer for Long-term tomato cultivation by JA

<table>
<thead>
<tr>
<th>N(8%)</th>
<th>P2O5(3%)</th>
<th>K2O(8%)</th>
<th>MgO(2%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic</td>
<td>Coated Fertilizer</td>
<td>Organic</td>
<td>Citric acid soluble</td>
</tr>
<tr>
<td>4.0</td>
<td>4.0</td>
<td>1.7</td>
<td>1.3</td>
</tr>
</tbody>
</table>

Organic materials come from Feather meal, Processed fish cake and Rice bran. Coated urea: LPS120 and LPS160 were blended for long term tomato cultivation. Over the half amount of ingredient comes from organic materials. This fertilizer is suitable for specially cultivated agricultural products.
Nitrogen use efficiency will improved by fertigation and environment control.
Sanding system (Fertigation)

Spain, Murcia

Plastic house for organic tomato production. From Inochio Agri Co.

↑ Gravel on the surface is spread to prevent drying.

Goat dung manure (2cm)

Sand (10cm)

Soil dressing (20cm)

Natural soil (Clay 40%)
Lettuce production in open field with fertigation from NARO Ahn et al.
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**Light control**
e.g. UV cut film: pest control
Heat cut film: higher yield

**Screen**
e.g. Insect screen, red screen

**UV irradiation**
e.g. to induce resistance to pathogen

**Environmental control**
e.g. Temperature and humidity control to prevent fungi propagation

**Microbial pesticide**
e.g. Some strain of *Bacillus subtilis*

**Natural enemy**
e.g. Stinkbug to whitefly

**Grafting**
e.g. Disease-resistant

**Varieties**
e.g. Disease-resistant

**Insect repellant**
e.g. Acetylated Glyceride (food additives), Whitefly repellant

**Plant activator**
e.g. L-Histidine to the Bacterial pathogen

**Soil solarization**
e.g. pathogen free after cultivation

**Isolated culture**
e.g. drain bed

**Physical control**

**Chemical control**

**Biological control**

**Agronomic control**

**Environmental control**
e.g. Temperature and humidity control to prevent fungi propagation

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**Soil solarization**
e.g. pathogen free after cultivation

**Isolated culture**
e.g. drain bed
Diagrammatic representation of arthropod pest management strategies for organic crops. Priority is given to preventative strategies, which are considered first, followed by more direct measures if preventative strategies are not sufficient.
To protect seedlings from cutworms and other crawling pests, effective for young seedlings

(P) : Physical control

Protective disks

Protective collar
Floating row cover

Kitchen garden in Japan

Experiment of floating row cover in Thai land

(P): Physical control

Effective for controlling of insects and micro-climate
1 % Ethanol

Root-gall of cucumber (root-knot nematode)
Steam sterilization in Korea

Dutch style greenhouse
Production of chrysanthemum
Virtuous cycle in production system

- Seedling medium
- Soil “meidification”
- Steam sterilization

- Good physical property
  (*air permeability and water holding capacity)
- Good physical property make steam sterilization more effective.
Decrease plant disease by UV-B lighting

**Disease (%)**

- **Sooty mold**
- **Powdery mildew**


**Panasonic**
Temperature and humidity control effective to reduce the fungi disease.

Cheaper and more easy system

UECS (Ubiquitous Environmental Control System)

All of the equipment have been incorporated computer.

Anywhere can monitoring and environmental control by networkable machine.

UECS (Ubiquitous Environmental Control System)
Stinkbug
Natural enemy to white fly

Increasing natural enemy on verbena
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苗半作: Nae han saku

A seedling is 50% of harvest.
Interpretation: Please note the making of good seedlings.
Good seedling (pest free and good taking root) will promise good harvest.
Closed system, Artificial light PF
Nae terrace: Seedling terrace

- Thermal insulation
- Air conditioned (temperature, humidity and circulation)
- Energy effective lighting (e.g. LED AI)
- CO₂
- Hydroponics
Raising tomato seedling in plant factory
(A) : Agronomic control

CSL+ covered with smoked rice hull

Cont. (only CSL)
Yield of lettuce


Feb. 4th transplanting, Apr. 15th harvest
LED Alternating Irradiation

Seedling production
In closed plant factory
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Identification of fertilization and geographical origin
Organic or Conventional?
Which country?

Isotope Ratio Mass Spectrometer
# Natural abundance

<table>
<thead>
<tr>
<th></th>
<th>Natural Abundance</th>
<th></th>
<th>Natural Abundance</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$^1\text{H}$</td>
<td>99.985</td>
<td>$^2\text{H}$</td>
<td>0.015</td>
<td></td>
</tr>
<tr>
<td>$^{12}\text{C}$</td>
<td>98.892</td>
<td>$^{13}\text{C}$</td>
<td>1.108</td>
<td></td>
</tr>
<tr>
<td>$^{14}\text{N}$</td>
<td>99.6337</td>
<td>$^{15}\text{N}$</td>
<td>0.3663</td>
<td></td>
</tr>
<tr>
<td>$^{16}\text{O}$</td>
<td>99.759</td>
<td>$^{17}\text{O}$</td>
<td>0.0374</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$^{18}\text{O}$</td>
<td>0.2039</td>
<td></td>
</tr>
<tr>
<td>$^{32}\text{S}$</td>
<td>95.018</td>
<td>$^{34}\text{S}$</td>
<td>4.215</td>
<td></td>
</tr>
<tr>
<td>$^{88}\text{Sr}$</td>
<td>82.58</td>
<td>$^{86}\text{Sr}$</td>
<td>9.86</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$^{87}\text{Sr}$</td>
<td>7.00</td>
<td></td>
</tr>
</tbody>
</table>
$^{15}\text{N}$ and $^{14}\text{N}$
Nitrogen circulation and $^{15}\text{N}$ discrimination

Inorganic nitrogen $\text{NH}_4\text{-N,NO}_3\text{-N}$

Denitrification

Rainfall Fertilization

$\text{NH}_3$ volatilization

Decomposable organic matter

Leaching

Micro organisms

Immobilization

$\text{NO}_3\text{-N}$

$\text{NH}_4\text{-N}$

Big discrimination

Small discrimination
Isotope discrimination

\[
\text{NH}_4 \rightarrow \text{NO}_3^- \rightarrow \text{NO} \rightarrow \text{N}_2\text{O} \rightarrow \text{N}_2
\]
\[ \delta (\text{%o}) = \left[ \frac{R_{\text{sample}}}{R_{\text{standard}}} - 1 \right] \times 1000 \]

**Example**

\[ ^{14}\text{N} 99.6337\% \quad ^{15}\text{N} 0.3663\% \]

↑ Air: huge nitrogen pool

Sample \(^{15}\text{N}=0.3693\%\)

\[ \delta (\text{%o}) = \left[ \frac{0.3693}{0.3663} - 1 \right] \times 1000 = 8.2\% \]
Isotope Ratio Mass Spectrometer

Sample

Combustion column

Separation column

Electromagnet

Mass spectrometer

\[^{15}\text{N}_2\]

\[^{15}\text{N}^{14}\text{N}\]

\[^{14}\text{N}_2\]
Tomato in protected cultivation

Chemical only

Organic only

$\delta^{15}N$ values of tomato fruits ($\% \circ$)

$\delta^{15}N$ values of soil ($\% \circ$)

(Nakano, 2003)
Summary of relationship between fertilization and $\delta^{15}$N Value

(Nakano, 2010)
Paprika geographical origin by Sr

![Graph showing Paprika geographical origin by Sr](image-url)

- **Diamonds** represent Japan.
- **Triangles** represent Korea.
- **Crosses** represent New Zealand.
- **Circles** represent the Netherlands.

The graph plots Sr Concentration (ppm) against the ratio $^{87}\text{Sr}/^{86}\text{Sr}$.
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Program for preventing falsely labeling

Identification of production method
- organic farming
- conventional farming
- hydroponics

Identification of geographical origin
- Japan, USA, China, Korea, and so on.

Environment information
Distribution information
- Shipment prediction
- cold chain

 Scientifi  cally certified “Organic” products
- mineral contents
- vitamin contents
- production area
- production method

- Non-destructive
- ICT, AI technology

IoT
Computer connected “Organic” food
Temperature and humidity control effective to reduce the fungi disease.

Cheaper and more easy system
UECS (Ubiquitous Environmental Control System)

All of the equipment have been incorporated computer.

Anywhere can monitoring and environmental control by networkable machine.

UECS (Ubiquitous Environmental Control System)
Conclusions

IGM is package strategy. Integration of advanced technologies promote Sustainable agriculture: Organic farming from plant factory