Overview of non-chemical disease management in apple and strawberry production in China

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Outline

Apple

• Current production situation
• Present Practice and on-going research
• Future Potential work

Strawberry

• Current production situation
• Present Practice and on-going research
• Future Potential work
Apple production in China

- Area 2140 ha
- Total Yield 33 million tons
- > 40% of world
- Export 1.5 million tons
- Processed 8 million tons
- Fresh 23 million tons

>70% is Fuji
Apple production in main provinces in China in 2007

<table>
<thead>
<tr>
<th>Region</th>
<th>Acreage ('000 ha)</th>
<th>(%)</th>
<th>Production (million tons)</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole China</td>
<td>191.3</td>
<td></td>
<td>2715.7</td>
<td></td>
</tr>
<tr>
<td>Shan'an'xi</td>
<td>48.4</td>
<td>25.3</td>
<td>701.6</td>
<td>25.8</td>
</tr>
<tr>
<td>Shandong</td>
<td>30.4</td>
<td>15.9</td>
<td>724.9</td>
<td>26.7</td>
</tr>
<tr>
<td>Hebei</td>
<td>25.0</td>
<td>13.1</td>
<td>247.9</td>
<td>9.1</td>
</tr>
<tr>
<td>Gansu</td>
<td>24.7</td>
<td>12.9</td>
<td>142.4</td>
<td>5.2</td>
</tr>
<tr>
<td>Henan</td>
<td>18.2</td>
<td>9.5</td>
<td>352.3</td>
<td>13.0</td>
</tr>
<tr>
<td>Shanxi</td>
<td>14.4</td>
<td>7.5</td>
<td>187.3</td>
<td>6.9</td>
</tr>
<tr>
<td>Liaoning</td>
<td>10.7</td>
<td>5.6</td>
<td>136.4</td>
<td>5.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>162.2</strong></td>
<td><strong>89.8</strong></td>
<td><strong>2129.8</strong></td>
<td><strong>91.7</strong></td>
</tr>
</tbody>
</table>
Shannxi is the top 1 apple production area in China, which covered 30% yield in China and 15% of the world.

Shannxi is also the biggest green apple production base in China, the certificated area is 180,000ha.

“Shannxi Apple” is the top 1 product of geographical indication in China.
Manin diseases ---- Apple canker （Valsa mali）

溃疡型和枝枯型两类症状。
The outbreak of Apple Canker in 2008 in different region

<table>
<thead>
<tr>
<th>Region</th>
<th>Trees</th>
<th>Infected trees</th>
<th>Infected rates (%)</th>
<th>Average infected rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liaoning</td>
<td>300</td>
<td>161</td>
<td>53.8</td>
<td>19.48</td>
</tr>
<tr>
<td>Beijing</td>
<td>150</td>
<td>80</td>
<td>53.3</td>
<td>20.87</td>
</tr>
<tr>
<td>Hebei</td>
<td>300</td>
<td>127</td>
<td>42.3</td>
<td>22.98</td>
</tr>
<tr>
<td>Shan’xi</td>
<td>725</td>
<td>364</td>
<td>50.3</td>
<td>11.22</td>
</tr>
<tr>
<td>Shandong</td>
<td>850</td>
<td>495</td>
<td>58.3</td>
<td>1.35</td>
</tr>
<tr>
<td>Shanxi</td>
<td>200</td>
<td>39</td>
<td>19.5</td>
<td>5.85</td>
</tr>
<tr>
<td>Gansu</td>
<td>700</td>
<td>283</td>
<td>40.5</td>
<td>18.35</td>
</tr>
</tbody>
</table>

Tree: 4-24 years, about 147 orchards, Average infected rates 52.5%
苹果轮纹病
（*Botryosphaeria berengeriana*）
## The outbreak of Apple Canker in 2008 in different region

<table>
<thead>
<tr>
<th>Region</th>
<th>Orchards</th>
<th>trees</th>
<th>Infected trees</th>
<th>Infected rates (%)</th>
<th>Infected index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liaoning</td>
<td>5</td>
<td>125</td>
<td>105</td>
<td>84.0</td>
<td>61.8</td>
</tr>
<tr>
<td>Beijing</td>
<td>5</td>
<td>125</td>
<td>113</td>
<td>90.4</td>
<td>70.2</td>
</tr>
<tr>
<td>Heibei</td>
<td>21</td>
<td>525</td>
<td>410</td>
<td>78.0</td>
<td>51.9</td>
</tr>
<tr>
<td>Shan’xi</td>
<td>9</td>
<td>225</td>
<td>155</td>
<td>69.0</td>
<td>35.3</td>
</tr>
<tr>
<td>Shandong</td>
<td>23</td>
<td>575</td>
<td>575</td>
<td>100.0</td>
<td>87.2</td>
</tr>
<tr>
<td>Total</td>
<td>63</td>
<td>1575</td>
<td>1358</td>
<td>86.2</td>
<td>/</td>
</tr>
</tbody>
</table>
苹果斑点落叶病（*Alternaria mali*）
苹果褐斑病（*Marssonina mali*）
• Bio-fungicide
• Bio-fungicide: 苏云金杆菌（*Bacillus huringiensis*）、白僵菌（*Beauveria spp.*）等

• Plant-fungicides: 苦皮藤素（Celangulins）、苦参碱（*Matrine Injection*）等

• Mineral Fguid: 机油乳剂（*Machine oil mulsion*）、石硫合剂（*Lime Sulphur*）、波尔多液（*Bordeaux Mixture*）等
• Recent study on “Technology integration and demonstration on Fruit Canker disease control” with the public service programme supported by MOA

• Mainly on apple, pear and orange
Future work
biodiversity enhance:

From IPM to IBM (Integrated Biodiversity Management)
起垄、生草、覆盖苹果园

Ridging, cover crop in apple Orchard
Functional biodiversity
Comprehensive Utilizing of Biogas Residue and biogas slurry
Strawberry in China: largest and growing rapidly

- Cultivation areas: 90.1 thousand ha (2009), 3.3 thousand ha (1985)
- Total production: 2206 thousand tons (2009), covered 35.7% of the world production

<table>
<thead>
<tr>
<th>country</th>
<th>Production 2009 (thousand tons)</th>
<th>% of the total world</th>
<th>Area (thousand ha)</th>
<th>Average yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>2206</td>
<td>35.7</td>
<td>90.1</td>
<td>24484.5</td>
</tr>
<tr>
<td>USA</td>
<td>1271</td>
<td>20.6</td>
<td>22.1</td>
<td>57646.5</td>
</tr>
<tr>
<td>Turkey</td>
<td>292</td>
<td>4.7</td>
<td>12.1</td>
<td>24033.0</td>
</tr>
<tr>
<td>Spain</td>
<td>264</td>
<td>4.3</td>
<td>7.1</td>
<td>37141.5</td>
</tr>
<tr>
<td>Mexico</td>
<td>233</td>
<td>3.8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

‘off-season’ vegetable crops
Major producing provinces

- Top three producers: Hebei, Shandong, and Liaoning
- >60% of China’s total strawberry production.
>1000 acres strawberry regions

Figure 1. Major Chinese Strawberry Production Regions
Strawberry in China

- 85 percent of China’s fresh strawberries are locally consumed; the remaining 15 percent are delivered to processing facilities.

- Fresh strawberries are available on the local market between December and June, with the peak consumption period occurring from December to March.

- Imported varieties dominate China’s fresh strawberry production. Japanese varieties such as Toynoka, Benihoppe Akihime, and Tochiotome are very popular for fresh consumption.

- China produces organic fresh strawberries in the suburbs of Beijing, Shanghai, Chengdu and Dandong with prices ranging from $5 to $6.5 per kg.
Diversity Cultivation Patterns

Outdoor cultivation (field-grown, 20%)

Outdoor Strawberry in winter in Guangdong
Diversity Cultivation Patterns

Protective cultivation (plastic-covered, 80%)
Many Chinese-style solar greenhouses

Steel frame Plastic greenhouse

Smaller wood framed plastic greenhouse

Chinese-style sunshine greenhouses
## Protective cultivation

- high-tech multi-span greenhouses

<table>
<thead>
<tr>
<th>styles</th>
<th>Input/output ratio</th>
<th>Purified Income (yuan/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>outdoor</td>
<td>1:1.8~1:2</td>
<td>45 000~60 000</td>
</tr>
<tr>
<td>Spring plastic greenhouse</td>
<td>1:2~1:2.5</td>
<td>90 000</td>
</tr>
<tr>
<td>Solar greenhouse</td>
<td>1:3~1:4</td>
<td>150 000</td>
</tr>
</tbody>
</table>
Challenges of Strawberry production in China

As a kind of berry fruit, strawberry is eat fresh. The biggest problem is getting high-quality, disease-free plants. Three of the most pressing challenges facing organic strawberry growers are:

• soil fertility
• soil borne diseases
• pests
Major diseases

There are more than 20 different diseases in China, strawberry growers face significant disease problems.

- 病毒病（SMYEV; SCrV; SVBV）
- 根腐病 Root rot （*Fusarium* sp.; *Phytophthora* sp.; *Pythium* sp.; *Rhizoctonia solani*）
- 炭疽病 Anthracnose （*Colletotrichum fragariae*）
- 枯萎病（*Fusarium oxysporum f. sp. fragariae*）
- 白粉病 Powderly mildew （*Sphaerotheca aphanis*）
- 叶斑病 LEAF SPOT （*Ramularia tulasnei*; *Mycosphaerella fragariae*）
- 轮斑病（*Phyllosticta gradimaculans*）
- 灰霉病 GRAY MOLD （*Botrytis cinerea*）
- 叶枯病（*Gnomonia fructicola*）
- 灰斑病（*Phyllosticta fragaricola*）
- 黑腐病（*Alternaria tenuis*）
- 革腐病（*Phytophthora cactorum*）
- 果腐病（*Fusarium* sp.; *Phytophthora* sp.; *Pythium* sp.）
- 芽枯病（*Rhizoctonia solani*）
- 丛枝病（*Phytoplasma Disease*）
- 根腐线虫（*Pratylenchus sp.*）
On-going Research
Green Technical Specifications and Quality Standards of Strawberry Cultivation

Source control

Seeding

Air

Surface of greenhouse

Soil

Dead or senescent plant material

Chemical-free control approach

Clearing greenhouse

Seedbed disinfection

Seedling dipping treatment

Soil fumigation

Integrated physical and biological control

Destruction of dead or senescent plant material

防控策略

全面控制病虫源头

种苗

棚室表面

病残体

土壤

根据病虫特点规律，针对性非化学防控

防控规程

整体田间清洁

苗床消毒，种苗防控

种苗蘸根处理

棚室表面消毒

物理、生物综合防控

残体快速无害处理

无病虫定植

土壤处理

Greenhouse surface disinfection

Physical control

- High temperature stuffy greenhouse
  In summer (July or Augouts) before transplanting strawberry,
  - crops residues or manures 1 500〜2 000 kg/mu
  - 50〜60 kg/mu lime
  - Covered by plastic, irrigation and closed the greenhouse, keep soil temperature to 40〜50 °C for 15〜20d.
Sulfur fumigation

- Sulfur fumigation
Rotation

overcome continuous cropping obstacles

• If possible, avoid sites where potatoes, tomatoes, eggplants, or brambles have recently been grown and, to a lesser extent, squash, cucumber, pepper, or melons.

• Rotating tonon-susceptible grasses and cereals (5-8 year rotation) will reduce the amount of Verticillium inoculum in infested soil,

• Brassica crop rotations (mustards, broccoli, Brussels sprouts) are recommended
Protect before outbreak

protection of plants from pathogen infection and pest damage.

- Plant strawberry varieties that are disease resistant or less susceptible to diseases of concern.
- Avoid excessive nitrogen fertilization
- Keep fruit from contacting soil by use of mulch under and around the plants.
- Applications of fungicides, insecticides, or miticides may protect susceptible tissues from disease and insect damage.
Biocontrol (spray)

• 0.5% Berberine AS 500
• 1.1% Catechin WP 400～600
• $1 \times 10^6$ spore/g *Pythium oligandrum* WP 500
• $1 \times 10^{11}$ spore/g *Bacillus subtilis* WP 600
• 2% *agricultural antibiotic* AS 200
• 2% Wuyi streptozotocin AS 200
Future Work

• Resistant varieties breeding
• The ways to optimize soil fertility with organic soil inputs and cover crops
• compare various crop rotations to measure the effects on soil microorganisms and crop nutrients
• controlling soilborne plant pathogens with organic measures
• Induced defense by arbuscular mycorrhizae fungi (AMF).
• Small-scale and large-scale or field-grown and plastic-covered strawberry chemical-free produce approach
Small-scale Diversified Production

Crop Rotation / Diversified Farm-scape
(temporal diversity/spatial diversity)
(soil microbial diversity/arthropod diversity)

Manage Diseases/Pests

No or Reduced Use of Pesticides

- Less Environmental Impacts
- Conserving Biodiversity
- Reduced Human Health Risk
- Less Use of Non-renewable Energy
- No Development of Pest Resistance
Thanks!