Next Generation of Vegetable Grafting Utilization Under Biotic and Abiotic Stress for Vegetable Production in Thailand

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Thailand’s agricultural land use between 2008 and 2012

- Classified by commodities:
  - Paddy field (47.06%);
  - Field crops such as corn, sugar cane, cassava and etc. (21.00%);
  - Orchards (23.12%);
  - Vegetable and floriculture (0.91%);
  - Other crops (7.92%).

Fig 1  Land use by commodity

Productivity/Income

- Although the area of vegetable production in Thailand is smaller than paddy field and field crops
- The productivity and income of vegetable production is about 10 times higher
The average of vegetable land use is 218,389 hectares.

These areas are planted to chili, watermelon, cucumber, eggplant, tomato, and pumpkin (major fruit vegetables).

<table>
<thead>
<tr>
<th>Crop</th>
<th>Hectare</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chili</td>
<td>32,782</td>
<td>15</td>
</tr>
<tr>
<td>Watermelon</td>
<td>11,121</td>
<td>5.09</td>
</tr>
<tr>
<td>Cucumber</td>
<td>10,268</td>
<td>4.7</td>
</tr>
<tr>
<td>Eggplant</td>
<td>7,201</td>
<td>3.29</td>
</tr>
<tr>
<td>Tomato</td>
<td>3,300</td>
<td>1.51</td>
</tr>
<tr>
<td>Pumpkin</td>
<td>3,055</td>
<td>1.4</td>
</tr>
</tbody>
</table>
Problems of agriculture land use in Thailand

- In 2016, agriculture in Thailand faces severe drought disaster
  - Very short rainy season in 2015 and very little rainfall amount
  - In addition in 2016, the rainy season late coming
  - that caused drought, especially in the Chao Phraya basin area, which is the main area of vegetable production in Thailand
Fig 2 Chao Phraya basin area

http://www.ayutthaya-history.com/images/

http://rachadathaicuisines.com/
Fig 3 Drought disaster in 2015-2016
Problems of agriculture land use in Thailand

- Because of drought,
  - the seawater diffuses to the underground river and the other agricultural water sources
  - which caused high salinity problems in that area
- Normal, fresh water for vegetable production should not higher than 0.5 - 0.75 g/l

Fig 4 Salinity measurement

http://www.bangkokpost.com/
Nonthaburi, where a huge vegetable production area

- Nonthaburi, 3.47 g/l salinity level
  March 30 – April 5, 2016
  (http://www.agriinfo.doae.go.th/)

Fig 5 High salinity level in Nonthaburi

https://en.wikipedia.org/wiki/Nonthaburi_Province#
Environmental stress

- Environmental stress not only affect the crop yield and quality, but also induce other problems to vegetable production in Thailand,
  - such as disease and insect

- New tolerance/resistance varieties are keys to solve these problems
  - However, Take time to release a new varieties
The good performance of rootstocks for grafted vegetables is an important technique to prevent soil-borne diseases and environmental stress such as drought and salinity. This trend has become popular among Thai farmers, especially in fruit vegetable crops that tolerate environmental or abiotic stress.
Example, the recent utilization of grafting technique

The fruit breeding team improves and released

- New guava variety called “KU guard # 1” that is root-knot nematode resistance
- Used as rootstocks for guava production widely in Thailand

http://hort.ku.ac.th
Fig 6  Root-knot disease from nematode infection

http://hort.ku.ac.th
Fig 7  KU Guard # 1 (nematode resistance)
The vegetable breeding team focuses on pumpkin and eggplant, with several proposals:

- Pumpkin improvement on
  - High beta-carotene with high yield
  - Disease resistance and environmental stress

- Furthermore, pumpkin and eggplant germplasm evaluation be continued, using morphological traits and molecular markers
  - Especially, environmental stress tolerance in eggplant
• Germplasm unit
  
  o TVRC (Tropical Vegetable Research Center) Germplasm Unit
  
  o 34 vegetable types and 13,364 numbers of accession, landrace and commercial varieties

Fig 8  Germplasm unit at Dept. of Horticulture
Germplasm of some fruit vegetables

- pumpkin 349 acc
- eggplant 844 acc
- tomato 520 acc
- chili 3,469 acc
- Cucurbitaceae 192 acc
Germplasm Evaluation

- They are evaluated for their agronomic performance and molecular markers

- Then, we make crossing and selection to release new cultivars such as, varieties with
  - High yield, beta-carotene (pumpkin)
  - Salt/drought and heat stress tolerance (pumpkin & eggplant)

- At present, we are evaluating them to find out
  - the high performance rootstocks with tolerance to abiotic stress for a future fruit vegetable production
For example in Thailand,

- Most commercial pumpkin cultivars in a market belong to *Cucurbita moschata* while some commercial cultivars of *C. maxima* called Japanese pumpkin are premium pumpkins.

- The area of Japanese pumpkin production is only in northern Thailand (in the mountains).

- It cannot be grown in the central region, especially at Kamphaeng Saen area due to bacterial wilt diseases.

- Evaluation of our pumpkin germplasm to find out the rootstock that tolerance/resistance to bacterial wilt is necessary.
Fig 9 The problem of Japanese pumpkin production at Kasetsart University, Kamphaeng Saen campus (a) *C. moschata*; (b) young plant of *C. maxima*; and (c) *C. maxima* at 3 weeks after pollination.
Eggplant germplasm evaluation

- Eggplant is classified as non-saline tolerant vegetable that
  - Cannot be grown on soils with salinity higher than 1.2 g/l (Arunin, 1996)
- Almost the breeding program in Thailand has released
  - a new eggplant cultivar including round eggplant, long eggplant with white, green, and purple skin
- But no variety that can be grown in salt stress/saline soils
  - Whereas the salt stress/saline soils or drought become the severe problems at present and future

50 eggplant cultivars were evaluated for salinity tolerance at low to very high salinity levels.

We got 24 and 1 salinity tolerant eggplant cultivars under 5 g/l and 11 g/l salinity levels, respectively.

We continued to evaluate 11 eggplant cultivars from 24 5 g/l salinity tolerant cultivars, results showed 2 cultivars can tolerate salinity of up to 7.5 g/l.

<table>
<thead>
<tr>
<th>Salinity Level</th>
<th>Concentration (g/l)</th>
<th>Conductivity (dS/m)</th>
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<tbody>
<tr>
<td>Low</td>
<td>1.2</td>
<td>2</td>
</tr>
<tr>
<td>Medium</td>
<td>2.5</td>
<td>4</td>
</tr>
<tr>
<td>High</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Moderate High</td>
<td>7.5-11</td>
<td>12-16</td>
</tr>
<tr>
<td>Very High</td>
<td>&gt;11</td>
<td>&gt;16</td>
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</tbody>
</table>
Fig 10 Eggplant evaluation for salt stress in greenhouse
(a) eggplant were grown at 11 g/l compared with control and (b) the eggplant that can be tolerance to salinity at 5 g/l
Vegetable grafting

- Even though using of grafting vegetable is not popular in Thailand
- But it is very useful to obtain vegetables that are resistant/tolerate to both biotic and abiotic stress by using a rootstock
- However, some fruit vegetable farms, always use the grafting seedling or young plant, especially
  - Eggplant, tomato, cucurbit, pumpkin, bitter gourd, etc.
Fig 11  Grafted tomato
Fig 12  Grafted eggplant
Fig 13  Grafting vegetable nursery (from left; eggplant, bitter gourd, tomato)
Vegetable grafting

- We expect that grafting will become a common technique applied in both solanaceous and cucurbit crops in Thailand
Conclusion

- Grafting is a key technique used to solve vegetable production problems in Thailand, both
  - Biotic stress (disease resistance)
  - Abiotic stress (drought and salt tolerance)
- Grafting technique is more important and valuable to Thai farmers
Thank you for your attention