AVRDC-The World Vegetable Center
Vegetable Breeding for ASEAN Countries

7th East Asia Plant Variety Protection Forum, Vientiane, Laos
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Tomato Breeder
Theme Leader-Breeding
AVRDC-The World Vegetable Center
Presentation Outline

• Brief introduction of AVRDC- the World Vegetable Center
• Overview of AVRDC Vegetable Breeding and Approach
• AVRDC breeding strategies and products by crop
• IPR and distribution of AVRDC lines
• Outlook
Founded in 1971 as the Asian Vegetable Research and Development Center

Our research and development is nonprofit

Our research outputs are global public goods

The World Vegetable Center has an expanding global role with a growing network of regional offices
Alleviate poverty and malnutrition in the developing world through increased production and consumption of safe vegetables
Theme Breeding: Goal

- Varieties that expand opportunities in tropical vegetable production
  - Increased productivity
  - Reduced farmer risk
  - Off-season production
  - Processing, value addition
AVRDC Global Vegetable Crops

- Tomato
- Bulb Allium
- Pepper
- Cucurbits
- Vegetable soybean
- Mungbean
- Crucifer
Locations: AVRDC Vegetable Breeding

Map showing locations in Mali, Cameroon, Tanzania, India, Thailand, and Taiwan.
Improved Inbred Lines: Major Output of AVRDC Breeding

Tropical Adaptation:
• Heat tolerance
• Multiple disease resistances
• High quality (firmness, color, taste
• Improved nutrient content (vitamins A & C, iron, protein, phytonutrients)
Approaches: multidisciplinary teamwork

- **Plant pathology**
- **Molecular breeding**
- **Nutrition**
Strategic Trait Development and Marker-Assisted Selection

- Trait development
- Design of marker protocols and marker-assisted selection

Screening for salinity tolerance

MAS to Pyramid Multiple Resistance Genes

AVTO1001 Ty1+Ty2+Ty3

MAS for disease resistance

Susceptible

Resistant
Introduce Novel Genes from Wild Relatives

- S. pennellii
- S. chilense
- S. habrochaites
- S. lycopersicum
- S. l. var. cerasiforme
- S. peruvianum
- S. pimpinellifolium

Infections:
- TYLCD
- Bacterial wilt
- Late blight
- Insects
- Tospovirus
- Nematodes
- TMV
- Fusarium wilt
- Early blight
- Bacterial wilt
Theory of Change: Theme Breeding

**Phytosanitary laws allow AVRDC seed import**

Superior cultivars developed
- Seed companies
  - NARS

Farmer demand creation (farmer field days, training)
Market Demand (distributors, retailers, consumers)

Superior cultivars tested & released
Seed companies
- NARS

Farmers grow improved cultivars

Strong Stakeholder Demand

Increased consumer demand

Increased vegetable supplies

Adequate seed supplies (seed companies, farmers’ groups, NGO’s)

Streamlined cultivar release procedures

- Breeder, foundation, commercial seed produced
- Cultivars maintained

Seed marketed & distributed

Theme Breeding
- Improved lines, hybrids
- Improved research capacity of partners
- Breeder seed produced

Government policies favor seed sector
Major AVRDC Tropical Tomato Product Profiles

- **Lowland Tropics**
  - Heat tolerance 32-34/ 23-25 °C
  - Tomato yellow leaf curl virus disease (TYLCD) and bacterial wilt resistances
  - Early blight, fusarium wilt, TMV
  - Determinate, dual purpose fresh market/processing

- **Highland and mid-altitude tropics**
  - Semi-determinate, indeterminate plant habits
  - Fresh market
  - Late blight, bacterial wilt, early blight resistances

- **Yield, fruit quality, and nutrient content important for all market types**
Tomato Yellow Leaf Curl Disease (TYLCD)

- Major tomato problem in the tropics including ASEAN
- 100% yield loss *from early infection*
- Prompts farmer over-use of pesticides
- Resistant cultivars the foundation of sustainable control
AVRDC Tomato Lines Resistant to TYLCD

- **AVTO1001**
  - Ty-2+Ty-3

- **AVTO1130**
  - Ty-2+Ty-3a

- **AVTO1122**
  - Ty-2+Ty-5

- **CHT2062**
  - Ty-3,
  - High β-carotene
Pepper (*Capsicum annuum*)

**Chili**
- Adapted to tropics
- Pungent (hot)

**Sweet Pepper**
- Not tropically-adapted
- Highlands
Strategic goals: AVRDC Pepper breeding

Chili: high & stable yield via multiple disease, insect resistance
- Viruses: *Cucumber mosaic virus* (CMV), *Chili veinal mottle virus* (ChiVMV), begomoviruses, others
- Fungi: Phytophthora wilt, anthracnose
- Bacteria: bacterial wilt, bacterial spot
- Insects: mites, thrips, aphids

Sweet Pepper
- Heat tolerance
- Multiple disease resistance

Special trait
- Male sterility systems
### 22th International Chili Pepper Nursery (ICPN22)

<table>
<thead>
<tr>
<th>Line</th>
<th>Disease Resistance*</th>
<th>Fruit Traits</th>
<th>Capsaicin**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Length (cm)</td>
<td>Width (cm)</td>
</tr>
<tr>
<td>C05573</td>
<td>PVY (R), CVMV (R)</td>
<td>8.1</td>
<td>1.1</td>
</tr>
<tr>
<td>AVPP1105</td>
<td>PVY (R), BW (MR), Anthr (GR)</td>
<td>14.2</td>
<td>1.4</td>
</tr>
<tr>
<td>AVPP1106</td>
<td>CVMV(R), PVY(R), BW(R), Anthr (FR)</td>
<td>13.6</td>
<td>1.5</td>
</tr>
<tr>
<td>AVPP9813</td>
<td>PVY (R), BW (R)</td>
<td>9.4</td>
<td>1.9</td>
</tr>
<tr>
<td>AVPP1107</td>
<td>CVMV(R), PVY(R), BW(R), Anthr (FR)</td>
<td>14.0</td>
<td>1.8</td>
</tr>
<tr>
<td>AVPP1108</td>
<td>CMV(MR), CVMV (R), PVY (R), BW (R), PC (R)</td>
<td>11.3</td>
<td>1.9</td>
</tr>
<tr>
<td>AVPP9905</td>
<td>PVY (R), CVMV (R)</td>
<td>15.5</td>
<td>2.6</td>
</tr>
<tr>
<td>AVPP1109</td>
<td>PVY (R), PC(R)</td>
<td>10.6</td>
<td>1.2</td>
</tr>
<tr>
<td>AVPP1110</td>
<td>CVMV (R), PVY (R), BW (R), Anthr (FR)</td>
<td>13.5</td>
<td>1.6</td>
</tr>
<tr>
<td>AVPP1111</td>
<td>CVMV (MR), PVY (R), BW (MR)</td>
<td>12.9</td>
<td>1.4</td>
</tr>
</tbody>
</table>

* CVMV=chili veinal mottle virus, PVY=potato virus Y, BW=bacterial wilt, CMV=cucumber mosaic virus, Anthr= Anthracnose (GR= green fruit resistance; FR= field tolerance), PC=Phytophthora blight race3; R=resistant, MR=moderately resistant  
** 100g fresh weight edible portion.
### 11th International Sweet Pepper Nursery (ISPN11)

<table>
<thead>
<tr>
<th>Line</th>
<th>Resistance*</th>
<th>Shape</th>
<th>Color</th>
<th>Weight (g)</th>
<th>Length (cm)</th>
<th>Width (cm)</th>
<th>Wall thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVPP1112</td>
<td>PVY (MR)</td>
<td>Bell</td>
<td>Light green-red</td>
<td>160</td>
<td>8.7</td>
<td>8.5</td>
<td>4.8</td>
</tr>
<tr>
<td>AVPP1113</td>
<td>CVMV (R), PVY (R), BW (MS), PC1 (MR), BS (Hor.R)</td>
<td>Bell</td>
<td>Green-red</td>
<td>105</td>
<td>9.1</td>
<td>7.0</td>
<td>4.8</td>
</tr>
<tr>
<td>AVPP1114</td>
<td>PVY (R)</td>
<td>Bell</td>
<td>Green-yellow</td>
<td>191</td>
<td>7.8</td>
<td>9.2</td>
<td>5.9</td>
</tr>
<tr>
<td>C05483</td>
<td>PVY (MR), PC1 (MR), (check)</td>
<td>Bell</td>
<td>Green-red</td>
<td>98</td>
<td>9.9</td>
<td>7.0</td>
<td>5.0</td>
</tr>
<tr>
<td>AVPP1115</td>
<td></td>
<td>Bell</td>
<td>Green-yellow</td>
<td>148</td>
<td>7.1</td>
<td>8.7</td>
<td>5.9</td>
</tr>
</tbody>
</table>

*PVY=potato virus Y, PC1= Phytophthora race 1, CVMV=chili veinal mottle virus, BW=bacterial wilt, BS= bacterial spot (Hor.R=Horizontal resistant), R=resistant, MR=moderately resistant, MS=moderately susceptible,

### Nutrient Contents (mg /100 g fresh weight edible portion)

<table>
<thead>
<tr>
<th>Line</th>
<th>Ascorbate</th>
<th>Capsanthin</th>
<th>Zeaxanthin</th>
<th>Lutein</th>
<th>β-Cryptoxanthin</th>
<th>β-Carotene</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVPP1112</td>
<td>162</td>
<td>1.21</td>
<td>0.06</td>
<td>0.10</td>
<td>0.02</td>
<td>0.03</td>
</tr>
<tr>
<td>AVPP1113</td>
<td>175</td>
<td>3.16</td>
<td>0.40</td>
<td>0.51</td>
<td>0.17</td>
<td>0.34</td>
</tr>
<tr>
<td>AVPP1114</td>
<td>183</td>
<td>0.00</td>
<td>0.10</td>
<td>0.46</td>
<td>0.04</td>
<td>0.16</td>
</tr>
<tr>
<td>C05483</td>
<td>200</td>
<td>3.02</td>
<td>0.14</td>
<td>0.57</td>
<td>0.11</td>
<td>0.17</td>
</tr>
<tr>
<td>AVPP1115</td>
<td>132</td>
<td>0.00</td>
<td>0.05</td>
<td>0.27</td>
<td>0.02</td>
<td>0.12</td>
</tr>
</tbody>
</table>
Crucifer Breeding

• Focus on leafy crucifers
  – East Asia secondary center of brassica diversity
  – Short duration, lower production costs
• Selection for high yield, vigor, earliness, nutrition
AVRDC Leafy Brassica OP’s for Distribution

Pak choi
- CR020
- CR101

Kailaan
- CR046

Choysum
- CR007
- CR073
Cucurbit Improvement

- Research at regional station for AVRDC-East and SE Asia in Thailand and AVRDC-Taiwan
- Priority crops
  - Bitter gourd (*Momordica charantia*)
  - Pumpkin (*C. moschata*)
**Bittergourd**
- Yield, earliness, gynoecy
- Fruit quality: shelf life and low fruit cracking
- Disease/ insect resistance
- Nutritional/medicinal components

**Pumpkin**
- Yield, earliness
- Fruit quality
- Disease resistance
- Carotenoids

**Common approach and strategy**
- Evaluate GRSU accessions, commercial hybrids
- Select superior inbreds from segregating hybrids, GRSU accessions
- Develop genetically diverse populations for targeted market segments for inbred development
- Hybrids from genetically superior inbreds
High yielding, high quality AVRDC bitter gourd lines

AVBG 1304 (36 t/ha*)
AVBG 1310 (33 t/ha)
AVBG 1311 (39 t/ha)
AVBG 1314 (41 t/ha)
AVBG 1323 (33 t/ha)
AVBG 1325 (37 t/ha)

*Yields based on a 2013 May trial conducted in Kamphengsaen, Thailand
Promising Pumpkin Selections

TD-2-5-10

ED-8-8

LE-5-2-3

PKH251-3-3

12THCM33-09S-5
## Nutrient Contents of Indigenous Vegetables Noted for Heat/Flood Tolerance

<table>
<thead>
<tr>
<th>Crop</th>
<th>Protein (g)</th>
<th>Lutein (mg)</th>
<th>β-carotene (mg)</th>
<th>Vit. C (mg)</th>
<th>Ca (mg)</th>
<th>Fe (mg)</th>
<th>Folate (μg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tropical violet</td>
<td>4.68</td>
<td>7.38</td>
<td>5.68</td>
<td>50</td>
<td>180</td>
<td>2.05</td>
<td>27</td>
</tr>
<tr>
<td>Malabar spinach</td>
<td>2.25</td>
<td>3.12</td>
<td>3.40</td>
<td>57</td>
<td>65</td>
<td>1.21</td>
<td>88</td>
</tr>
<tr>
<td>Jute mallow</td>
<td>5.17</td>
<td>7.02</td>
<td>5.10</td>
<td>124</td>
<td>300</td>
<td>5.74</td>
<td>92</td>
</tr>
<tr>
<td>Purslane</td>
<td>1.23</td>
<td>...</td>
<td>2.96</td>
<td>9</td>
<td>36</td>
<td>0.53</td>
<td>...</td>
</tr>
</tbody>
</table>

100g edible portion on fresh weight

Courtesy: AVRDC Nutrition
AVRDC Breeding Line Distribution: http://www.avrdc.org
AVRDC Seed Shop

Hot Pepper
Capsicum annum

Lines developed at AVRDC – The World Vegetable Center

PP0537-7559

Pedigree: Jin’s Joy/Kulai*3/PBC932.

Tested as ICPN18-10, this line is a product of our anthracnose resistance breeding program. With moderate pungency and relatively high yield potential, the line carries resistance to four diseases (Cucumber Mosaic Virus, Potato Virus Y, Bacterial wilt, and Anthracnose). It has strong red color when mature, and good flavor. It has shown good combining ability in hybrid test crosses.

<table>
<thead>
<tr>
<th>Descriptor</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Maturity</td>
<td>Early</td>
</tr>
<tr>
<td>Plant size</td>
<td>Medium</td>
</tr>
<tr>
<td>Plant stature</td>
<td>Medium</td>
</tr>
<tr>
<td>Days to flower</td>
<td>78.5</td>
</tr>
<tr>
<td>Fruit type</td>
<td>Chili</td>
</tr>
<tr>
<td>Fruit shape</td>
<td>Elongated</td>
</tr>
<tr>
<td>Fruit shape at blossom end</td>
<td>Pointed</td>
</tr>
<tr>
<td>Fruit length (cm)</td>
<td>10.65</td>
</tr>
<tr>
<td>Fruit width (cm)</td>
<td>1.85</td>
</tr>
<tr>
<td>Fruit fresh weight (g)</td>
<td>13</td>
</tr>
<tr>
<td>Fruit position</td>
<td>Intermediate</td>
</tr>
<tr>
<td>Fruit pungency</td>
<td>Medium</td>
</tr>
<tr>
<td>Immature fruit color</td>
<td>Green</td>
</tr>
<tr>
<td>Fruit color intensity at immaturity</td>
<td>Medium</td>
</tr>
<tr>
<td>Mature fruit color</td>
<td>Red</td>
</tr>
<tr>
<td>Fruit color intensity at maturity</td>
<td>Medium</td>
</tr>
<tr>
<td>Plant habit</td>
<td>Compact</td>
</tr>
</tbody>
</table>

Disease resistance *

<table>
<thead>
<tr>
<th>Disease</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cucumber Mosaic Virus (CMV)</td>
<td>MS</td>
</tr>
<tr>
<td>Chili Veinal Mottle Virus (CVMV)</td>
<td>S</td>
</tr>
<tr>
<td>Potato Virus Y (PYY)</td>
<td>R</td>
</tr>
<tr>
<td>Tomato Mosaic Virus (ToMV)</td>
<td>S</td>
</tr>
<tr>
<td>Bacterial spot (Xanthomonas)</td>
<td>-</td>
</tr>
<tr>
<td>Bacterial wilt (Ralstonia)</td>
<td>R</td>
</tr>
<tr>
<td>Phytophthora blight</td>
<td>MS</td>
</tr>
<tr>
<td>Anthracnose (Colletotrichum)</td>
<td>FR</td>
</tr>
</tbody>
</table>

* Laboratory evaluations conducted at AVRDC Taiwan, where R = resistant (0-100% symptom free), MR = moderately resistant (50-79% symptom free), MS = moderately susceptible (10-49% symptom free) and S = susceptible (<10% symptom free). Performance at other sites may vary.

To order seed, please email: seedrequest@worldveg.org
A handling fee will be charged.
For seed distribution policies, please visit the AVRDC website: www.avrdc.org

AVRDC – The World Vegetable Center
Box 42
Shanhua, Tainan 74199
TAIWAN
AVRDC Breeding Lines: International Public Goods

- Available to public, private sectors for research, breeding
- No royalty charges
- Recipients asked to:
  - Inform AVRDC if a line is released as a variety, used as hybrid parent line
  - Provide trial performance data
  - Publicly acknowledge AVRDC

Acknowledgement of AVRDC in East-West seed catalog
AVRDC Varieties released worldwide
Seed Companies Critical for Vibrant Horticulture Sector

• Superior cultivars, high quality seed are essential for increased productivity
• Competitive seed company R&D produces a stream of improved cultivars
• Seed companies succeed by repeat sales and service to their farmer customers
• AVRDC assistance to seed companies, especially regional companies benefits farmers and consumers
### AVRDC Seed Shipments* to ASEAN Countries (2004-2013)

<table>
<thead>
<tr>
<th>Country</th>
<th>Tomato</th>
<th>Pepper</th>
<th>Legume (mungbean)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brunei</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Cambodia</td>
<td>30</td>
<td>17</td>
<td>5</td>
</tr>
<tr>
<td>Indonesia</td>
<td>11</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>Japan</td>
<td>48</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>Laos</td>
<td>4</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Malaysia</td>
<td>1</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Myanmar</td>
<td>10</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Philippines</td>
<td>33</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>Singapore</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Thailand</td>
<td>87</td>
<td>66</td>
<td>9</td>
</tr>
<tr>
<td>Vietnam</td>
<td>75</td>
<td>62</td>
<td>9</td>
</tr>
</tbody>
</table>

*Each shipment usually includes multiple crops and lines*
## Major Seed Company Recipients of AVRDC Tomato Lines (1993-2013)

<table>
<thead>
<tr>
<th>Company</th>
<th>Countries</th>
<th>Shipments</th>
<th>No. Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>East West + Hortigenetics</td>
<td>SE/S Asia</td>
<td>35 + 5</td>
<td>325 + 23</td>
</tr>
<tr>
<td>Limagrain/Marco Polo/Harris Moran</td>
<td>Thailand/USA/Italy</td>
<td>19</td>
<td>158 + 77 + 78</td>
</tr>
<tr>
<td>Southern Seed</td>
<td>Vietnam</td>
<td>17</td>
<td>147</td>
</tr>
<tr>
<td>Seminis (+Peto)</td>
<td>USA</td>
<td>16</td>
<td>113 + 122</td>
</tr>
<tr>
<td>Chia Tai</td>
<td>Thailand</td>
<td>16</td>
<td>156</td>
</tr>
<tr>
<td>Takii</td>
<td>Japan</td>
<td>15</td>
<td>97</td>
</tr>
<tr>
<td>Namdhari</td>
<td>India</td>
<td>15</td>
<td>126</td>
</tr>
<tr>
<td>Kagome</td>
<td>Japan/Taiwan</td>
<td>15</td>
<td>165</td>
</tr>
<tr>
<td>Bejo Zaden</td>
<td>India</td>
<td>15</td>
<td>118</td>
</tr>
<tr>
<td>Known You</td>
<td>Taiwan</td>
<td>14</td>
<td>144</td>
</tr>
<tr>
<td>Enza Zaden</td>
<td>Holland</td>
<td>11</td>
<td>81</td>
</tr>
<tr>
<td>BHN</td>
<td>USA</td>
<td>12</td>
<td>68</td>
</tr>
</tbody>
</table>
Outlook: AVRDC Breeding

- Expect rapid growth and sophistication of the horticultural and vegetable seed sectors in ASEAN
- Will continue to provide advanced breeding lines of global vegetable crops to ASEAN NARS and seed companies and build capacity in classical and new breeding approaches, especially molecular markers
- More indigenous vegetable research and improvement for crop diversification
- Greater AVRDC emphasis on strategic and complex traits such as heat and salinity tolerance, insect resistance, multiple disease resistance, and nutrient content
Thanks for your kind Attention