Grafting Tomato to Overcome Salt Stress

Wuu-Yang Chen

World Vegetable Center

18 May 2016
Contents

• Salinity
• Grafting
• Grafting to Overcome Salt Stress
• Future Perspectives
Salinity
Salinity

• Salinity is one of the major abiotic factors threatening food security worldwide (Julkowska and Testerink 2015).

• More than 800 million hectares of land throughout the world are salt-affected (including both saline and sodic soils), corresponding to more than 6% of the worlds’ total land area (Colla et al. 2010).
Salinity

• Saline soil is defined as having a high concentration of soluble salts, high enough to affect plant growth

• Salt concentration in soil is measured by electrical conductivity (EC)

• The USDA Salinity Laboratory defines a saline soil as having an Ecₑ of 4 dS/m or more

• Ecₑ is the electrical conductivity of the ‘saturated paste extract,’ that is, of the solution extracted from a soil sample after being mixed with sufficient water to produce a saturated paste (Munns 2016)
Salinity: causes

Natural and human factors contributing to increased salinity of soils

- low rainfall
- high evaporation
- weathering of native rocks
- poor water management
- the indiscriminate use of huge quantities of chemical fertilizers (poor cultural practices)
Salinity

Plants transpire water

Water evaporates

Salts remain behind

Water and salts move upward from a high water table
Salinity

• Salinity is pervasive problem in a large proportion of irrigated agricultural land and are substantive hazards for tomato production.
• Some cultivated tomato have tolerance of varieties to slight salinity of up to 2.3-2.5 dS/m.
• Above this limit, substantial linear reduction in the number of fruits, average fruit weight and total yield was reported (Keatinge et al. 2014).
Salinity: Effect on Plants

A high concentration of salts implies:
→ high osmotic pressure of the soil solution (osmotic stress)

→ Lower water intake

→ Salt ions compete against essential plant nutrients and hinder their absorption.

→ Reduced growth

→ Depending on
  - Concentration
  - Specific ion (Na+, Cl-, ... )
  - Plant species

→ Ion toxicity (Ionic stress)
Salinity: Symptoms

- Spotty growth: barren spots and stunted plants
- Smaller leaves
- (Often) presence of white salt crusts on the soil surface
- If uniform throughout the field, soil salinity can go undetected! No apparent injuries, only restricted growth.

Mild salinity: blue-green tinge  
High salinity: burnt tissue
Salinity: Effect on Plants

Table 10 SOIL SALINITY CLASSES AND CROP GROWTH

<table>
<thead>
<tr>
<th>Soil Salinity Class</th>
<th>Conductivity of the Saturation Extract (dS/m)</th>
<th>Effect on Crop Plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non saline</td>
<td>0 - 2</td>
<td>Salinity effects negligible</td>
</tr>
<tr>
<td>Slightly saline</td>
<td>2 - 4</td>
<td>Yields of sensitive crops may be restricted</td>
</tr>
<tr>
<td>Moderately saline</td>
<td>4 - 8</td>
<td>Yields of many crops are restricted</td>
</tr>
<tr>
<td>Strongly saline</td>
<td>8 - 16</td>
<td>Only tolerant crops yield satisfactorily</td>
</tr>
<tr>
<td>Very strongly saline</td>
<td>&gt; 16</td>
<td>Only a few very tolerant crops yield satisfactorily</td>
</tr>
</tbody>
</table>

Salinity: Effect on Plants

Factors Influencing Salinity Tolerance

1. Growth stage
2. Environmental factors
3. Varietal differences
Factors Influencing Salinity Tolerance

1. Growth stage
   - Mostly sensitive at germination
   - Not necessarily a physiological reason: higher salt concentrations in the soil upper layer
   - Crops can be vulnerable at more than one stage!

2. Environmental factors
3. Varietal differences
Factors Influencing Salinity Tolerance

1. Growth stage

2. Environmental factors
   - Temperature

3. Varietal differences

Table 15 RESPONSE OF THREE CROPS TO SALINITY IN SAND CULTURES AT TWO LOCATIONS

<table>
<thead>
<tr>
<th>Crop</th>
<th>Solution salinity at which 25% yield reduction was observed dS/m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cool location</td>
</tr>
<tr>
<td>Bean pods</td>
<td>1 4.0</td>
</tr>
<tr>
<td>Garden beetroot</td>
<td>2 11.1</td>
</tr>
<tr>
<td>Onion bulbs</td>
<td>3 12.5</td>
</tr>
</tbody>
</table>

Factors Influencing Salinity Tolerance

1.- Growth stage
2.- Environmental factors
   - Humidity

Table 16 EFFECT OF SEASON ON THE RELATIVE RICE YIELDS (Murthy and Janardhan, 1971)

<table>
<thead>
<tr>
<th>Salinity of root zone dS/m (approximate range)</th>
<th>Relative yield</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wet Season</td>
<td>Dry Season</td>
</tr>
<tr>
<td>Control (non saline)</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>2-4</td>
<td>93</td>
<td>81</td>
</tr>
<tr>
<td>4-8</td>
<td>63</td>
<td>53</td>
</tr>
<tr>
<td>10-12</td>
<td>39</td>
<td>11</td>
</tr>
</tbody>
</table>

Note: Relative yields are comparable only within the same season.


   - Air pollution may increase the apparent salt tolerance of many crops
3.- Varietal differences
Factors Influencing Salinity Tolerance

1. Growth stage

2. Environmental factors

3. Plant-specific factors
   - Tolerance differs between species and varieties
   - Research on genes for tomato: AVRDC - Biotechnology
   - Screening for species with high tolerance: AVRDC - GRSU
     → Grafting
How to Reduce Salinity Effects?

Strategies to reduce the negative impact on crop yield:

- application of chemical amendments
- use of drainage techniques to drain salts away from plant roots
- exogenous application of plant growth regulators
- grafting of high-yielding cultivars on salt-tolerant rootstocks
Salinity and Electric Conductivity

Saline soils are those which have an electrical conductivity (EC) of the saturation soil extract of more than $4 \text{ dS/m}$ at $25^\circ\text{C}$.

Saturated Paste Extract

Method
“Soluble Salts by the Saturated Paste Method”
US Salinity Laboratory Staff - 1954

Equipment
- No. 10 (2 mm opening) sieve
- 150 mL beaker
- 250 mL vacuum flask with Buchner funnel
- Vacuum pump
- Filter paper, Whatmann No. 5 or equivalent (slow speed, fine)
- Deionised water
- EC meter
Saturated Paste Extract

1. Dry and sieve the soil.
2. Fill the beaker up to approximately $\frac{2}{3}$ of its volume.
Saturated Paste Extract

3. **GRADUALLY** add water while stirring thoroughly.
Saturated Paste Extract

Desired texture:
- The soil glistens, reflecting the light,
- It flows slightly when the container is tipped, and
- The paste slides cleanly off the spatula (except for clayish soils).
Saturated Paste Extract

4. Equilibration: Let the paste stand for AT LEAST 1h.
   - Peat and muck soils require an overnight wetting period!

5. Re-check, and when necessary re-adjust, the saturation:
   - No water on the surface
   - No stiffening or loss of its glistening appearance

→ In case of need, more soil or water can be added. Equilibrate again after re-adjusting.
Saturated Paste Extract

6. Transfer the saturated paste to a Buchner funnel with the filter paper in place and humidified with some drops of water. Activate the pump and collect the saturated paste extract in the vacuum-flask. In humid environments, cover the funnel with plastic film to prevent absorption of air humidity.
Saturated Paste Extract

**Advantages**
- It is the most representative measurement of total soluble salts in the soil solution.
- All recommendations are based in SP measurements.

**Disadvantages**
- Very time consuming
- Temperature-dependent
- Cannot be performed in field conditions
- Determining the “saturation point” is rather subjective
  → High variability between analysts: human error
Grafting
What is Grafting?

• Grafting is the union of two plant parts, a root stock and a scion.
• The rootstock provide a stronger root system of the grafting union while the scion producing the harvestable yield (Genova et al. 2013).
• Vegetable Grafting
  – Solanaceae grafting
  – Cucurbit grafting
Benefits of Grafting

- Effectively control soil-borne diseases
- Overcome abiotic stress such as high salinity, flooding and soil temperature extremes
- Extension of the growing season, increased yield and quality
- Reduce application of chemicals (fumigant, pesticide, and fertilizer)
- Create income by selling extra grafted seedlings to neighboring communities
On-farm trial of integrated management of tomato bacterial wilt
Grafted Tomatoes Under Flooding
Rootstocks

- World Vegetable Center recommended rootstocks for tomato grafting

- Resistant to:
  - Bacterial wilt
  - Fusarium wilt
  - Root-knot nematode
  - Flooding

<table>
<thead>
<tr>
<th>Rootstock</th>
<th>Resistance</th>
<th>ID Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>TS03</td>
<td>⬤</td>
<td>VI034845</td>
</tr>
<tr>
<td>EG190</td>
<td>⬤ ⬤ ⬤</td>
<td>VI046101</td>
</tr>
<tr>
<td>EG195</td>
<td>⬤ ⬤</td>
<td>VI046103</td>
</tr>
<tr>
<td>EG203</td>
<td>⬤ ⬤ ⬤</td>
<td>VI045276</td>
</tr>
<tr>
<td>EG219</td>
<td>⬤ ⬤ ⬤</td>
<td>VI046104</td>
</tr>
<tr>
<td>HW7996</td>
<td>⬤ ⬤</td>
<td>VI043614</td>
</tr>
</tbody>
</table>
Grafting Procedure

- Tomato/Eggplant or Tomato/Tomato (scion/rootstock)
Grafting Demonstration
Grafting to Overcome Salt Stress
# Plant Materials

<table>
<thead>
<tr>
<th>Genetic Material</th>
<th>AVRDC Genebank Accession Number</th>
<th>Abbreviation</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tomato ‘Yu-Nu’ (<em>Solanum lycopersicum</em>)</td>
<td>(commercial hybrid)</td>
<td>YN</td>
<td>Cherry tomato. Tolerant to Fusarium wilt, Race 1.</td>
</tr>
<tr>
<td>Tomato FMTT 1728 (<em>S. lycopersicum</em>)</td>
<td>(AVRDC experimental hybrid)</td>
<td>GS</td>
<td>Green shoulder salad tomato. TYLCD resistant, strains 1, 2 and 3. Heat tolerant.</td>
</tr>
<tr>
<td>Eggplant EG195 (<em>S. melongena</em>)</td>
<td>VI047335</td>
<td>EG1</td>
<td>Resistant to flooding, bacterial wilt (<em>Ralstonia solanacearum</em>), and root-knot nematode (<em>Meloidogyne incognita</em>)</td>
</tr>
<tr>
<td>Eggplant EG203 (<em>S. melongena</em>)</td>
<td>VI045276</td>
<td>EG2</td>
<td>Resistant to flooding, bacterial wilt (<em>R. solanacearum</em>), root-knot nematode (<em>M. incognita</em>), and tomato fusarium wilt.</td>
</tr>
<tr>
<td><em>S. pimpinellifolium</em></td>
<td>VI007002</td>
<td>SP1</td>
<td>Salinity tolerant</td>
</tr>
<tr>
<td><em>S. pimpinellifolium</em></td>
<td>VI008107</td>
<td>SP2</td>
<td>Salinity tolerant and low leaf Na+ content</td>
</tr>
<tr>
<td><em>S. sisymbriifolium</em></td>
<td>VI039590</td>
<td>SS</td>
<td>Resistant to root-knot nematodes, and moderately resistant to <em>Pseudomonas</em> and <em>Verticillium</em> bacterial wilt.</td>
</tr>
<tr>
<td><em>S. quitense</em></td>
<td>VI034876</td>
<td>SQ</td>
<td>Relatively unexplored. Potential resistance to bacterial wilt.</td>
</tr>
</tbody>
</table>
Grafting Survival Rate (%)

- Self-grafted
- EG1
- EG2
- HW
- SP1
- SP2
- SQ
- SS

YN | GS

- Self-grafted: YN 90, GS 85
- EG1: YN 95, GS 90
- EG2: YN 90, GS 85
- HW: YN 90, GS 80
- SP1: YN 70, GS 75
- SP2: YN 80, GS 70
- SQ: YN 60, GS 55
- SS: YN 100, GS 90
# Soil EC Analysis

<table>
<thead>
<tr>
<th>EC (dS/m)</th>
<th>0 DAT</th>
<th>35 DAT</th>
<th>95 DAT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CK</strong></td>
<td>2.47</td>
<td>-</td>
<td>2.49</td>
</tr>
<tr>
<td><strong>Salt treatment</strong></td>
<td>3.55</td>
<td>3.82</td>
<td>5.39</td>
</tr>
</tbody>
</table>

*a EC was measured by saturated paste method  
b Target EC is 4 dS/m  
c DAT: days after transplanting
Vegetative Growth
Vegetative Growth

Plant Height (NS YN)

Plant Height (S YN)
# Days to First Flowering

<table>
<thead>
<tr>
<th>Plant ID</th>
<th>Non-Saline</th>
<th>Saline</th>
</tr>
</thead>
<tbody>
<tr>
<td>GS_NG&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>12.0</td>
<td>12.7</td>
</tr>
<tr>
<td>GS_SG&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>17.3</td>
<td>19.1</td>
</tr>
<tr>
<td>GS_EG1&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>16.7</td>
<td>16.8</td>
</tr>
<tr>
<td>GS_EG2&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>12.9</td>
<td>13.0</td>
</tr>
<tr>
<td>GS_HW&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>17.6</td>
<td>18.2</td>
</tr>
<tr>
<td>GS_SP1&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>16.9</td>
<td>14.6</td>
</tr>
<tr>
<td>GS_SP2&lt;sup&gt;*&lt;/sup&gt;</td>
<td>19.0</td>
<td>20.9</td>
</tr>
<tr>
<td>GS_SS&lt;sup&gt;**&lt;/sup&gt;</td>
<td>21.9</td>
<td>22.0</td>
</tr>
<tr>
<td>YN_NG&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>11.6</td>
<td>11.4</td>
</tr>
<tr>
<td>YN_SG&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>13.8</td>
<td>14.0</td>
</tr>
<tr>
<td>YN_EG1&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>18.0</td>
<td>18.2</td>
</tr>
<tr>
<td>YN_EG2&lt;sup&gt;**&lt;/sup&gt;</td>
<td>28.3</td>
<td>18.1</td>
</tr>
<tr>
<td>YN_HW&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>18.3</td>
<td>18.6</td>
</tr>
<tr>
<td>YN_SP1&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>18.9</td>
<td>17.4</td>
</tr>
<tr>
<td>YN_SP2&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>16.3</td>
<td>18.3</td>
</tr>
<tr>
<td>YN_SS&lt;sup&gt;**&lt;/sup&gt;</td>
<td>21.9</td>
<td>20.3</td>
</tr>
</tbody>
</table>

Unit: Days After Transplanting (DAT)
## Yield

<table>
<thead>
<tr>
<th>Plant ID</th>
<th>Fruit No. (No./plant)</th>
<th>Yield (g/plant)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Non-saline</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-saline</td>
</tr>
<tr>
<td>GS_NG</td>
<td>9.4</td>
<td>488.8</td>
</tr>
<tr>
<td>GS_SG</td>
<td>12.8</td>
<td>549.7</td>
</tr>
<tr>
<td>GS_EG1</td>
<td>8.7</td>
<td>543.8</td>
</tr>
<tr>
<td>GS_EG2</td>
<td>10.0</td>
<td>491.3</td>
</tr>
<tr>
<td>GS_HW</td>
<td>9.4</td>
<td>479.4</td>
</tr>
<tr>
<td>GS_SP1</td>
<td>6.6</td>
<td>429.5</td>
</tr>
<tr>
<td>GS_SP2</td>
<td>7.6</td>
<td>436.4</td>
</tr>
<tr>
<td>GS_SS</td>
<td>6.6</td>
<td>417.0</td>
</tr>
<tr>
<td>YN_NG</td>
<td>17.8</td>
<td>169.8</td>
</tr>
<tr>
<td>YN_SG</td>
<td>13.9</td>
<td>118.0</td>
</tr>
<tr>
<td>YN_EG1</td>
<td>5.2</td>
<td>45.9</td>
</tr>
<tr>
<td>YN_EG2</td>
<td>11.2</td>
<td>110.4</td>
</tr>
<tr>
<td>YN_HW</td>
<td>5.8</td>
<td>55.9</td>
</tr>
<tr>
<td>YN_SP1</td>
<td>16.0</td>
<td>123.2</td>
</tr>
<tr>
<td>YN_SP2</td>
<td>14.6</td>
<td>147.1</td>
</tr>
<tr>
<td>YN_SS</td>
<td>7.1</td>
<td>54.1</td>
</tr>
</tbody>
</table>
# Quality

<table>
<thead>
<tr>
<th>Scion</th>
<th>Root-stock</th>
<th>pH</th>
<th>Soluble solid (°Brix)</th>
<th>Acidity (% citric acid)</th>
<th>Color (a/b)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>NS</td>
<td>S</td>
<td>NS</td>
<td>S</td>
</tr>
<tr>
<td>GS</td>
<td>NG</td>
<td>4.2</td>
<td>4.0</td>
<td>6.2</td>
<td>8.4</td>
</tr>
<tr>
<td>GS</td>
<td>SG</td>
<td>4.0</td>
<td>4.0</td>
<td>6.3</td>
<td>8.7</td>
</tr>
<tr>
<td>GS</td>
<td>EG1</td>
<td>4.1</td>
<td>4.1</td>
<td>7.3</td>
<td>8.6</td>
</tr>
<tr>
<td>GS</td>
<td>EG2</td>
<td>4.1</td>
<td>4.1</td>
<td>6.8</td>
<td>8.6</td>
</tr>
<tr>
<td>GS</td>
<td>HW</td>
<td>4.0</td>
<td>4.0</td>
<td>6.2</td>
<td>8.3</td>
</tr>
<tr>
<td>GS</td>
<td>SP1</td>
<td>4.0</td>
<td>4.0</td>
<td>6.2</td>
<td>7.9</td>
</tr>
<tr>
<td>GS</td>
<td>SP2</td>
<td>4.1</td>
<td>4.1</td>
<td>6.0</td>
<td>8.2</td>
</tr>
<tr>
<td>GS</td>
<td>SS</td>
<td>4.1</td>
<td>4.0</td>
<td>5.8</td>
<td>8.7</td>
</tr>
<tr>
<td>YN</td>
<td>NG</td>
<td>4.4</td>
<td>4.3</td>
<td>7.4</td>
<td>9.8</td>
</tr>
<tr>
<td>YN</td>
<td>SG</td>
<td>4.4</td>
<td>4.3</td>
<td>8.0</td>
<td>9.1</td>
</tr>
<tr>
<td>YN</td>
<td>EG1</td>
<td>4.4</td>
<td>4.4</td>
<td>8.9</td>
<td>10.6</td>
</tr>
<tr>
<td>YN</td>
<td>EG2</td>
<td>4.4</td>
<td>4.3</td>
<td>8.3</td>
<td>9.6</td>
</tr>
<tr>
<td>YN</td>
<td>HW</td>
<td>4.4</td>
<td>4.3</td>
<td>6.4</td>
<td>7.1</td>
</tr>
<tr>
<td>YN</td>
<td>SP1</td>
<td>4.5</td>
<td>4.3</td>
<td>6.4</td>
<td>9.4</td>
</tr>
<tr>
<td>YN</td>
<td>SP2</td>
<td>4.3</td>
<td>4.3</td>
<td>7.0</td>
<td>9.7</td>
</tr>
<tr>
<td>YN</td>
<td>SS</td>
<td>4.4</td>
<td>4.3</td>
<td>7.1</td>
<td>9.4</td>
</tr>
</tbody>
</table>
Discussion

- Salt stress → osmotic/ ionic/ oxidative stress → reduced photosynthesis/ growth
  - → reduced yield
  - → quality change on pH, soluble solid, acidity, color, etc.
- Some studies suggest that grafting provides an alternative way to improve salt tolerance by:
  - Reducing the ionic stress
  - Improving the photosynthesis performance
  - Improving the antioxidant systems
Discussion

- In this study, there is no significant effect of rootstock in reducing yield loss under salt stress.
- Further study is needed, as different result may be obtained depending on:
  - Shoot and root genotype
  - Salt levels
  - Exposure time of the grafted plants
- Careful screening for optimal rootstocks in a key question, as the yield & quality of the shoot depends on the root system
Future Perspectives
Future Perspectives

• Develop a quick, clean, accurate protocol for evaluation of salinity tolerance such as:
  – Hydroponics: initial selection of salinity tolerant accessions as potential rootstocks;
  – Fertigation: second assessment of the rootstocks. Test graft compatibility and rootstock-salinity interactions. Pathogens could also be inoculated or incorporated in the substrate;
  – Pot experiment: soil from saline fields, sterilized or not;
  – Field trial: final “in situ” evaluation. Full exposure to real conditions.

• Develop a suitable SCORING SYSTEM to evaluate the compatibility of scion and rootstock combinations.
Germplasm Resources for Screening Rootstocks

- **AVRDC GeneBank**: the largest vegetable germplasm collection over the world
  - *Solanum* (Eggplant): 3,727
  - *Solanum* (Tomato): 8,566
  - *Capsicum* (Pepper): 8,263
  - *Cucurbita*: 1,116

[Vegetable germplasm maintained in AVRDC-GRSU (as of 30 Apr. 2016)]
Screening for Salt Tolerant Rootstock

- Hydroponic system
  - Aeration pumps and tubes
  - Nutrient solution
  - NaCl (0, 25, 50, 75 mM)
Screening for Salt Tolerant Rootstock

Hydroponic

A nutrient solution with known EC is applied
- Advantages: accurate, clean, fast
- Disadvantages: costly, requires expertise
Compatibility Test and Rootstock-salinity Interactions

Fertigation

A nutrient solution with known EC is applied on an inert substrate.

- Advantages: accurate, clean, fast, versatile
- Disadvantages: costly, requires expertise
Compatibly Test and Rootstock-salinity Interactions

Pot experiments: irrigation with a saline solution

A saline solution of known concentration or EC is applied on pots.

- Advantages: relatively less costly
- Disadvantages:
  - Requires a deep understanding of the soil dynamics
  - Very irregular distribution of the salt in the soil
  - Regular irrigation “by hand” is necessary
  - Strong influence of the soil composition
    →Difficult to determine the soil solution EC
  - Risk of sodification!
Screening for Salt Tolerance of *Solanum pimpinellifolium*

- 172 Accessions of *Solanum pimpinellifolium*
- Irrigated with 200 mM NaCl solution every second day
- Salt susceptible check: *S. lycopersicum* (CLN2498E and CA4)
- Salt tolerant check: CLN2498E and CA4 grafted on to salt tolerant eggplant (*S. melongena*) rootstock (VI039523 and VI041752)
Screening for Salt Tolerance of *Solanum pimpinellifolium*

Irrigated with 200 mM NaCl solution

Plant growth showed drastic difference under saline and standard conditions

Salt treatment  Water CK
Compatibility & Yield Trial

• **Pot experiment in greenhouse:**
  – Compatibility trial with/without salt treatment
  – Plant growth/performance: stem diameter, height, biomass, etc.
  – Fruit yield, quality, nutrient content, organoleptic test
Screening for Salinity Tolerance

*In situ* screening

Direct transplant in saline soils.

- Advantages: real situation, low cost
- Disadvantages: need for land, difficult to control EC, location-dependent
Videos on the Web

• World Vegetable Center: avrdc.org
• YouTube: www.youtube.com

– Tomato and Eggplant Grafting: Tube splice method
– Cucurbit grafting
– How to Build a Grafting Chamber
Documents on the Web

http://avrdc.org/
Thanks for Your Attention!

Wuu-Yang Willie Chen
Willie.chen@worldveg.org