Greenhouse Vegetable Production

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Potential Greenhouse Vegetables

Tomato
Pepper (?)
Cucumber
Leafy greens and lettuces
Strawberry – No!
Others?

Marketing and Economics

Marketing Options
- Wholesale
  - Spring Crop
  - Fall Crop
- Retail
  - Spring Crop
  - Fall Crop
- Greenhouse and Field
  - Long Season (April 1 to December 31)

Greenhouse Tomato Budgets
- Several Available
  - Mississippi State
  - British Columbia
  - ARE Report No. 18
- Best
  - ARE Report No. 18
  - Mississippi State
### Greenhouse Tomato Budgets

**New 24' X 96' GH plus Labor and Equipment**
- **Total Price**
  - $16,335
- **Depreciated**
  - $1,914 / year

**Annual Production Costs**
- **Operating**
  - $6,620
- **Capital**
  - $721
- **Misc.**
  - $2,240

**Annual Production Costs**
- **Total Price**
  - $16,335
- **Depreciated**
  - $1,914 / year

### Greenhouse Tomato Production

**Production Systems**
- **Soil Culture**
  - Most room for error
- **Bag Culture**
  - Moderate room for error
- **Nutrient Film Technique (NFT)**
  - No room for error

### Greenhouse Tomato Budgets (cont.)

**Gross Returns**
- **8,400 lb**
  - $1.57 / lb
  - $13,188
  - 840 lb @ $1.90 / lb
  - 5,880 lb @ $1.60 / lb
  - 1,680 lb @ $1.30 / lb

**Net Returns**
- **Existing House**
  - $3,607
  - Gross Returns
    - $13,188
  - Annual Costs
    - $9,581
- **New House**
  - $1,693
  - Establishment Costs
  - $1,914
### Cropping Systems – Approach 1

**Fall Crop**
- **Start Seed**  July 1<sup>st</sup>
- **Transplant**  August 15<sup>th</sup>
- **First Harvest**  Mid – October
- **End Crop**  Mid – late December

**Spring Crop**
- **Start Seed**  Thanksgiving - Christmas
- **Transplant**  Mid – January – mid – February
- **First Harvest**  Late March – mid – April
- **End Crop**  July 1<sup>st</sup>

### Cropping Systems – Approach 2

**10 Month Crop**
- **Start Seed**  July 1<sup>st</sup>
- **Transplant**  August 15<sup>th</sup>
- **First Harvest**  Mid – October
- **End Crop**  July 1<sup>st</sup>

### Soil Culture Production Practices

Very similar to field tomato production!

### Soil Preparation and Planting

- Remove and/or incorporate crop residue
- Work soil as deeply as possible
- Fumigate – Biofence?
- Form ridges or small beds
- Set plants
- Lay irrigation tubing
- Cover the middles with plastic

### Concerns
- Vine Health
- Fertility
- Diseases
- Insects
- Heat Bills
- Light Intensity

### Soil Culture Production Practices

- Remove and/or incorporate crop residue
- Work soil as deeply as possible
- Fumigate – Biofence?
- Form ridges or small beds
- Set plants
- Lay irrigation tubing
- Cover the middles with plastic
**Greenhouse / Soil Production**

**pH and Fertility**

- **pH**
  - Range of 6.0 – 6.8
  - 6.5
    - Good nutrient availability
    - Reduced incidence of Fusarium Wilt
  - Less than 5.5
    - Nutrient deficiencies
    - Nutrient toxicities
  - Greater than 6.8
    - Nutrients become unavailable

**Fertility – Bareground Tomatoes**

- **Nitrogen (N)**
  - 175 – 200 lb/A total
  - 25 – 60 lb/A at planting
  - 1 to 1.5 lb/A/day beginning 3 weeks after transplanting

- **Phosphate (P₂O₅)**
  - Low 240 lb/A  Medium 120 lb/A  High 60 lb/A

- **Potash (K₂O)**
  - Low 240 lb/A  Medium 120 lb/A  High 60 lb/A

**Fertility (30’ x 96’ = 2,880 ft²)**

- **Nitrogen (N)**
  - 16 – 20 lb/GH total
  - 3 – 6 lb/GH at planting
  - 0.06 to 0.1 lb/GH/day beginning 3 weeks after transplanting

- **Phosphate (P₂O₅)**
  - Low 24 lb/GH  Medium 12 lb/GH  High 8 lb/GH

- **Potash (K₂O)**
  - Low 24 lb/GH  Medium 12 lb/GH  High 8 lb/GH
Fertility – Example (Medium)

- Apply 6 – 12 – 12 prior to transplanting
  - 100 lb of 6 – 12 – 12 / GH
  - 50 lb of 12 – 24 – 24 / GH
- Three weeks after transplanting begin applying N, Ca, and K₂O every week (2 to 3 – 4 lb/A/day)
  - 5 – 15 lb of Calcium Nitrate / GH
  - 5 – 15 lb of Potassium Nitrate / GH
  - 5 – 15 lb of Soluble 20 – 20 – 20 / GH
    - Alternate the 3 products

Too Much Nitrogen or Low Light

Nitrogen Deficiency

Potassium Deficiency
Phosphorus Deficiency

Calcium Deficiency

Magnesium Deficiency

Varieties

Determinate
- ‘BHN 589’
- ‘BHN 871’
- ‘Biltmore’
- ‘Carolina Gold’
- ‘Empire’
- ‘Rocky Top’ (?)

Indeterminate
- ‘Big Beef’
Practical Guide to Variety Selection

Identify a variety that satisfies your market requirements.
Learn how to grow that variety to maximize yield and quality.
- Researchers
- Extension
- Other growers
- Your own records

Plant Population

30’ x 96’ GH
Use 30’ x 90’
- 9 – 10 rows
- 60 plants / row @ 18” spacing
540 – 600 plants

Tomato Plant Spacing

Between-Row
- Dictated by the equipment used
- As close as you can stand them
- 3 ft. – 4 ft.
- 3.5 ft. (42 in.)

In-Row
- Dictated by:
  Variety
  Training System
- Determinate variety pruned to 2 stems
  1.5 ft. – 2 ft.
- Indeterminate variety pruned to a single stem
  12 in. – 18 in. (15 in.)

Pruning / Training

Determinate
- Leave the first sucker below the first fruit cluster
- Remove most or all other suckers as the plant matures
- When plants extend above the stakes, break out the growing point

Indeterminate
- Prune to a single stem
- Remove all suckers up the plant
- Do not over-sucker the top of the plant
- Make sure the plant doesn’t terminate
Irrigation

When first transplanted, tomatoes require about 1 in. of water / A / week. When developing fruit, tomatoes require between 2 and 2.5 in. of water / A / week.

30’ x 96’ Greenhouse
- 1,000 gallons/week at transplanting
- 2,000 to 2,500 gallons/week at ‘full load’

Growing Media / Containers

Media
- Perlite
- Ground Pine Bark
- Misc. Materials
  - Coconut Hull
  - Cotton Gin Trash

Containers
- Upright Bags
- Flat Bags
- Buckets
- Pots

Bag Culture / NFT

Varieties

Recommended
- ‘Trust’
- ‘Match’
- ‘Switch’
- ‘Blitz’
- ‘Cobra’
- ‘Bigdena’ (trial)
- ‘Brightina’ (trial)
- ‘Panzer’ (trial)
- ‘Big Beef’ (?)
Tomato Plant Spacing

- **Between Row**
  - Double row configuration on 5 ft. centers
  - Approximately 1 ft. between each double row

- **In-row**
  - Fall Crop 16 in.
  - Spring Crop 14 in.
  - Compromise 15 in.
  - Depends on the container used!

Plant Population

- **30’ x 96’ GH**
  - Use 30’ x 85’
    - 5 double rows (10 rows)
    - 72 plants/row @ 14”
    - 64 plants/row @ 16”
    - 640 – 720 plants
    - 3.5 – 4 ft²/plant

Planting Configuration

- X X X X X X X X X X X X X X X X X X X X X X X X X
- X X X X X X X X X X X X X X X X X X X X X X X X X
- X X X X X X X X X X X X X X X X X X X X X X X X X
- X X X X X X X X X X X X X X X X X X X X X X X X X

Training / Pruning

- **Indeterminate**
  - Prune to a single stem
  - Remove all suckers up the plant
  - Do not over-sucker the top of the plant
  - Make sure the plant doesn’t terminate

- **Cluster Pruning**
  - Reduces the number of fruit / cluster
  - Increases the size and quality of fruit
  - Increases uniformity of fruit ripening
  - Typically 4 to 5 (6) good fruit/cluster
Cluster Pruning

Support
- Greenhouse itself
- Separate frame
- Provide overhead support - wire
- Nylon twine
  - Clipped to base of the plant
  - Tied to a wire or cable

Cluster Pruning – Example

Nutrient Solution – Modified Steiner (ppm)

<table>
<thead>
<tr>
<th>Element</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>171</td>
</tr>
<tr>
<td>P</td>
<td>48</td>
</tr>
<tr>
<td>K</td>
<td>304 (+10% ‘Trust’)</td>
</tr>
<tr>
<td>Ca</td>
<td>180</td>
</tr>
<tr>
<td>Mg</td>
<td>48</td>
</tr>
<tr>
<td>Fe</td>
<td>3</td>
</tr>
<tr>
<td>Mn</td>
<td>1 – 2</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
</tr>
<tr>
<td>Zn</td>
<td>0.4</td>
</tr>
<tr>
<td>Cu</td>
<td>0.2</td>
</tr>
<tr>
<td>Mo</td>
<td>0.1</td>
</tr>
</tbody>
</table>
## Percentage of Modified Steiner

<table>
<thead>
<tr>
<th>Season</th>
<th>Transplanting Details</th>
<th>% Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fall Crop</strong></td>
<td>Transplant to 1st bloom on 4th cluster, 40 – 50% and above to end of crop, 85 – 90%</td>
<td>40 – 90%</td>
</tr>
<tr>
<td><strong>Spring Crop</strong></td>
<td>Transplant to 1st bloom on 4th cluster, 40 – 50% but above to 1st bloom on 5th cluster, 85 – 90%</td>
<td>40 – 90%</td>
</tr>
</tbody>
</table>

## pH

The pH of the fertilizer solution should be between 5.6 and 5.8 for:
- Nutrient availability
- To prevent the formation of calcium phosphate

### pH Adjustment

- Most water is above pH 6
- Acid to lower the pH to:
  - Sulfuric
  - Nitric
  - Hydrochloric
  - Phosphoric

## Mixing Fertilizer

### Bulk Tank

- All components are diluted and added to a bulk tank
- The tank has the appropriate concentration of each nutrient
- Solution is used directly and not diluted further

### Multiple Injectors

- Each component is mixed in a concentrated solution
- As the plants are watered, the concentrate is diluted and mixed

## Fertilizer Components

### Tank A

- Complete Fertilizer
  - N
  - P
  - K
- Micro-Nutrients
- Epson Salts (?)

### Tank B

- Calcium Nitrate
- Potassium Nitrate (?)
**Injection System**

**Sources of Water Soluble Fertilizers**

- **Complete**
  - Hydro-Gardens Chem-Gro Tomato Formula
    - 4 – 18 – 38
  - Champion GH Tomato
    - 3 – 15 – 28
  - TotalGro Bag Culture Tomato Special
    - 3 – 13 – 29

- **Greenhouse Grade Calcium Nitrate**
  - Hydro-agri (Viking Ship)

- **Potassium Nitrate**
  - Champion
  - Hiafa

- **Epson Salts**

**Two Important Equations**

**Bulk Tank**

- \[ ppm = \left(\frac{\% \text{ fertilizer}}{100}\right) \times (\text{lb added to tank}) \times \left(\frac{16 \text{ oz/lb}}{1 \text{ lb}}\right) \times 0.75 \times \left(\frac{100}{\text{gal of bulk tank}}\right) \]

**Injector System**

- \[ ppm = \left(\frac{\% \text{ fertilizer}}{100}\right) \times (\text{lb added to tank}) \times \left(\frac{16 \text{ oz/lb}}{1 \text{ lb}}\right) \times 0.75 \times \left(\frac{100}{\text{gal of concentrate}}\right) \times \left(\frac{1}{\text{ratio of injector}}\right) \]

**Bulk Tank Example**

(0.5 lb of 3 – 15 – 28)

\[ \text{ppm} = 3\% \times 0.5 \text{ lb} \times 16 \text{ oz/lb} \times 0.75 \times \frac{100}{100} \]

\[ \text{ppm} = 18 \]
**Injector System Example**

(25 lb of 3 – 15 – 28)
50 gallons of concentrate
Injector ratio of 1:100
(N)
- ppm = (% fertilizer) x (lb added to tank) x (16 oz/lb) x (0.75) x (100 / gal of concentrate) x (1 / ratio of injector)
- ppm = 3% x 25 lb x 16 oz/lb x 0.75 x 2 x 1/100
- ppm = 18

**Two Things to Keep in Mind**

\[ P \]
- \[ P \times 2.291 = P_2O_5 \]
- \[ P_2O_5 \times 0.437 = P \]

\[ K \]
- \[ K \times 1.205 = K_2O \]
- \[ K_2O \times 0.83 = K \]

There is no exact “recipe” greenhouse tomato production
- Each crop is different
  - Light intensity
  - Temperature
  - Etc.

**Fertilizer Mixing Example(s)**

<table>
<thead>
<tr>
<th>Fertilizer Mix</th>
<th>Desired Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 – 18 – 38</td>
<td>N 154 177</td>
</tr>
<tr>
<td></td>
<td>P 43 65</td>
</tr>
<tr>
<td></td>
<td>K 304 314</td>
</tr>
<tr>
<td>Calcium Nitrate</td>
<td>Ca 162 171</td>
</tr>
<tr>
<td>12 oz / 100 gallons</td>
<td>Mg 43 46</td>
</tr>
<tr>
<td>Magnesium Sulfate</td>
<td>Fe 2.7 3.3</td>
</tr>
<tr>
<td>6 oz / 100 gallons</td>
<td>Mn 1.0 1.6</td>
</tr>
<tr>
<td>Bulk Tank</td>
<td>B 0.9 1.6</td>
</tr>
<tr>
<td>Per 100 gallons</td>
<td>Zn 0.4 0.4</td>
</tr>
<tr>
<td></td>
<td>Cu 0.2 0.4</td>
</tr>
<tr>
<td></td>
<td>Mo 0.09 0.08</td>
</tr>
</tbody>
</table>

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<thead>
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<th>Desired Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 – 13 – 29</td>
<td>N 100 110</td>
</tr>
<tr>
<td></td>
<td>P 64 104</td>
</tr>
<tr>
<td>Calcium Nitrate</td>
<td>K 214 232</td>
</tr>
<tr>
<td>14 lb / 30 gallons</td>
<td>Ca 105 105</td>
</tr>
<tr>
<td>Magnesium Sulfate</td>
<td>Mg 28 43</td>
</tr>
<tr>
<td>Concentrate Mix</td>
<td>Fe 1.8 2.7</td>
</tr>
<tr>
<td>30 gallons</td>
<td>Mn 0.8 0.8</td>
</tr>
<tr>
<td>Injectors</td>
<td>B 0.6 0.8</td>
</tr>
<tr>
<td>1:100</td>
<td>Zn 0.2 0.4</td>
</tr>
<tr>
<td></td>
<td>Cu 0.1 0.8</td>
</tr>
<tr>
<td></td>
<td>Mo 0.06 0.08</td>
</tr>
</tbody>
</table>
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</tr>
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<tr>
<td>– 3 – 15 – 28</td>
<td>N 171 P 48 K 304 Ca 180 Mg 48 Fe 3 Mn 1.2 B 1 Zn 0.4 Cu 0.2 Mo 0.1</td>
</tr>
<tr>
<td>– 37.5 lb / 50 gallons</td>
<td></td>
</tr>
<tr>
<td>– Calcium Nitrate</td>
<td></td>
</tr>
<tr>
<td>– 25 lb / 50 gallons</td>
<td></td>
</tr>
</tbody>
</table>

Concentrate Mix

– 50 gallons

Injectors

– 1:100

Tissue Testing

Since there is no exact recipe and each crop is different, periodic tissue testing should be utilized.

– Routine
– Problem Solving

How to sample for a Leaf Tissue Analysis

– Collect at least 6 to 8 (10 – 12) leaves from different plants.
– Collect the leaf just above a 2” diameter fruit (golf ball size).
– Higher of lower will not be accurate

Three Important “Tools”

pH Meter

– Buffer solution to calibrate

EC Meter

– Standard to calibrate

Tissue Test

– Take the leaf just above a fruit that is 2 inches in diameter (golf ball size)

Labs

– Mississippi State University
  Soil Testing and Plant Analysis, P.O. Box 9610, Mississippi State, MS 39762

– Private Labs
  Micro-Macro, Athens, GA
  A & L, Memphis, TN

Elemental Concentrations of Tomato Leaf Tissue

| N 4.0 – 5.5 % | Fe 100 – 250 ppm |
| P 0.3 – 1.0 % | Zn 30 – 150 ppm |
| K 4.0 – 7.0 % | Mn 40 – 300 ppm |
| Ca 1.0 – 5.0 % | Cu 5 – 25 ppm |
| Mg 0.4 – 1.5 % | B 35 – 100 ppm |
|               | Mo 0.15 – 5 ppm |
Watering Schedule

Depending on size, temperature, humidity, etc.
Plants will use from:
- 2 oz / day
- 3 quarts / day
- 2 quarts / day is often enough

Rule of Thumb
- 10 – 20% of bags draining after watering

Automated to apply small amounts of water many times / day.
- Time
  - 30 seconds every hour
- Light accumulation
  - 30 seconds every 0.8 mhos of light

Humidity Control

Humidity control
- A full canopy of a tomato or cucumber crops will produce significant amounts of moisture through transpiration
- A closed GH maintains that moisture

Humidity control fan in the top of the house works very well.

Temperature Control

Soil Culture
- Minimum night temperature
  - 50 – 55°F
- Minimum day temperature
  - 60 - 65°F
- Maximum temperature
  - 80 - 85°F

Bag / NFT Culture
- Minimum night temperature
  - 60 – 65°F
- Minimum day temperature
  - 70 - 75°F
- Maximum temperature
  - 80 - 85°F

Humidity Control (cont.)

As low as possible
- Optimum
  - 60 – 70%
- Realistic
  - 80 – 90%

Humidity control fan
- Switch
- Timer
- Humidistat
Pollination

Greenhouse tomatoes should be pollinated every other day.
- Hand
- Electric pollinator
- Bees

Low humidity is important

Disease Control

Disease Management
- Biological
- Cultural
  - Humidity Control
  - Temperature Control
  - Fertilization
  - Pruning
- Sanitation
- Chemical
  - Fungicides
  - Bactericides

Major Diseases
- Botrytis Gray Mold
- Leaf Mold
- Early Blight
- Powdery Mildew
- Target Spot
- Pythium Root Rot
- Fusarium crown and Root Rot
- Bacterial Pith Necrosis
- Tomato Mosaic Virus
- Tomato Spotted Wilt Virus
- Timber Rot

Pest Control

Weed Control
- Soil Culture
  - Black Plastic Mulch
  - Roundup – empty house only
  - Sencor DF and Select
- Bag / NFT Culture
  - Should be no weeds

Disease Control

Disease Management
- Biological
- Resistant Varieties
- Cultural
  - Humidity Control
  - Temperature Control
  - Fertilization
  - Pruning
- Sanitation
- Chemical
  - Fungicides
  - Bactericides

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Profitable Greenhouse Production of Local Produce
Allen Straw, Virginia Cooperative Extension

**Botrytis Gray Mold Control**

- **Humidity Control**
  - Below 90%

- **Temperature**
  - Above 70°F

- **Chemical Control**
  - Chlorothalonil
    - Exotherm Termil 20%
    - 3.5 oz can / 1,000 ft²
  - Botran 75WP @ 1 lb / 100 gal
  - Endura @ 9 to 12.5 oz/A
  - Scala @ 7 fl oz/A

**Leaf Mold Control**

- **Resistant Varieties**

- **Chemical Control**
  - Chlorothalonil
    - Exotherm Termil 20%
    - 3.5 oz can / 1,000 ft²
  - Maneb 80WP @ 1.5 – 2 lb/100 gal
  - Mancozeb 80WP @ 1.5 – 2 lb/100 gal

**Leaf Mold**

- Images of tomato leaves with leaf mold

**Early Blight**

- Images of tomato leaves with early blight
Early Blight Control

Chemical Control
- Chlorothalonil
  Exotherm Termil 20% 3.5 oz can / 1,000 ft²
- Maneb 80WP @ 1.5 – 2 lb/100 gal
- Mancozeb 80WP @ 1.5 – 2 lb/100 gal
- Kocide 2000 @ 1.5 – 2.25 Tbsp/1,000 ft²
- Scala @ 7 fl oz/A

Powdery Mildew Control

Chemical Control
- Nova @ 2.5 to 4 fl oz/A (?)
- Quadris (?)
- Cabrio (?)

Powdery Mildew

Target Spot
Target Spot Control

Chemical Control
- Chlorothalonil Exotherm Termil 20%
  3.5 oz can / 1,000 ft²
- Quadris

Pythium Root Rot Control

Cultural Control
- Proper Watering
- Good Drainage
  “Too heavy of growing media”
Temperature
- Above 70°F
Chemical Control
- Ridomil (?)
- Terramaster

Terramaster 4 EC (VA only)

For control of Pythium and Phytophthora Root Rot of GH Tomatoes
- Apply 6 to 7 fl oz /A in 0.01% Solution
- 6.5 fl oz/500 gallons of water
- Do not apply within 3 weeks of transplanting
- Do not apply within 3 days of harvest
- Do not exceed 27.4 fl oz/A/season

Fusarium Crown and Root Rot Control

Cultural
- Remove infected plants
- Resistant varieties (?)
Temperature
- Above 70°F
Chemical
- Quardis (?)
- Cabrio (?)
**Bacterial Pith Necrosis Control**

**Cultural Control**
- Proper Fertilization
  - Do not over fertilize with Nitrogen
- Avoid excess salts that could burn the roots

**Chemical Control**
- Kocide 2000 @ 1.5 – 2.25 Tbsp/1,000 ft²
- Kocide DF @ 2 – 4 Tbsp/1,000 ft²

**Tomato Mosaic Virus Control**

**Cultural**
- Remove Infected Plants ASAP
  (Yesterday)!

**Tomato Spotted Wilt Virus**

**Deformed, Necrotic Tissue**
Plant Necrosis

Western Flower Thrip

Fruit Discoloration

Tomato Spotted Wilt Virus
Control

Cultural
- Reflective mulches
- Resistant varieties
  - Experimental
  - Greenhouse Varieties
- Control alternate hosts
- Good sanitation in greenhouses
- Buffer strips around greenhouses

Chemical
- Insecticide in transplant water or through the drip irrigation repels thrips
  - Admire
  - Platinum
  - Venom
- Weekly insecticide sprays
  - Spintor
  - Thiodan
**Timber Rot (White Mold)**

*Sclerotinia sclerotiorum*

- Cultural Control
  - Avoid overwatering
- Chemical Control
  - Nothing labeled
  - Possibilities
    - Quadris (?)
    - Cabrio (?)
    - Endura (?)

**New Bactericide – IR-4**

Proposed Trade Name
- Kasumin

Proposed Common Name
- kasugamycin

Antibiotic
- No cross-resistance with streptomycin
- EPA will likely allow field use

**Insect Control**

**Major Insects**
- Aphids
- White Flies
- Spider Mites
- Armyworms
- Cabbage Loopers
- Tomato Fruitworm
- Fungus Gnats
- Leaf Miners
- Pinworms
- Slugs

**Methods of Insect Control**

**Biological Control**
- Predators
  - Lady Beetle
  - Ground Beetle
  - Lacewing
  - Damsel Bug

- Parasites
  - Braconid Wasp
  - Encarsia formosa
  - Predatory mites (thrips)

- Diseases
  - Protazoa
  - Bacteria (most effective)
  - Fungi
  - Virus

**Mechanical Control**
- Solarization
- Reflective (Colored) Mulch
- Physical Barriers
- Hand Picking - Hornworms
- Sweeping
Aphids

Chemical Control
- Thiodan /Phaser
  50WP @ 1 lb/100 gal
  3EC @ 1 qt/100 gal
- Malthion
  57EC @ 1 qt/100 gal
  25WP @ 4 lb/100 gal
- Insecticidal Soap
- Admire 2F
  1.4 fl oz / 1,000 plants

White Flies

Control
- Knack or Distance
  6 to 8 fl oz/100 gal (treat 20,000 ft²)
- Insecticidal Soap
- Azatin EC
  10 – 16 fl oz/100 gal
- Admire (sup.)
  1.4 fl oz 1,000 plants

Spider Mites

Control
- Malathion
  57EC @ 1 qt/100 gal
  25WP @ 4 lb/100 gal
- Insecticidal Soap
- Fulex Nicotine
- Admire (sup.)

Armyworms

Control
- Bt's
- Thiodan /Phaser
  50WP @ 1 lb/100 gal
  3EC @ 1 qt/100 gal
- Malthion
  57EC @ 1 qt/100 gal
  25WP @ 4 lb/100 gal
- Azatin EC
  10 – 16 fl oz/100 gal
- Avaunt (?)
- Confirm (?)
## Cabbage Loopers

**Control**
- *Bt's*
- Azatin EC 10 – 16 fl oz/100 gal
- Malthion 57EC @ 1 qt/100 gal 25WP @ 4 lb/100 gal

## Fungus Gnats

**Control**
- Gnatrol 4 to 8 tsp/gal (biological)
- Malthion 57EC @ 1 qt/100 gal 25WP @ 4 lb/100 gal
- Azatin EC 10 – 16 fl oz/100 gal
- Capture (?)

## Tomato Fruitworm

**Control**
- *Bt's*
- Avaunt (?)
- Capture (?)
- Confirm (?)

## Leaf Miners

**Control**
- Malthion 57EC @ 1 qt/100 gal 25WP @ 4 lb/100 gal
- Azatin EC 10 – 16 fl oz/100 gal
Pinworms
Control
- *Bt*'s
- Malthion
  57EC @ 1 qt/100 gal
  25WP @ 4 lb/100 gal
- Azatin EC
  10 – 16 fl oz/100 gal
- Thiodan /Phaser
  50WP @ 1 lb/100 gal
  3EC @ 1 qt/100 gal

New Insecticide – IR-4
DPX-E2Y45
- Common Name
gynaxypyr (sp?)
- Proposed Trade Names
  Altacor 35WG
  Coragen 1.67SC
New Chemistry
- Lepidopteron Insecticide
- Crops (DuPont)
  Fruiting Vegetables
  Cucurbit Vegetables
  Leafy Greens
- IR-4
  GH Tomatoes

Slugs
Control
- Snail and Slug Killer Pellets
  (metaldehyde)

Harvesting
Pick ripe fruit
- Better flavor
- More Lycopene
- Better customer satisfaction
Harvest at least twice a week
Marketing

Marketing Options
- Wholesale
  Spring Crop
  Fall Crop
- Retail
  Spring Crop
  Fall Crop
- Greenhouse and Field (?)
  Long Season (April 1 to December 31)

Production Systems

Greenhouse Cucumber Production

Production Systems
- Soil Culture
  Most room for error
- Bag Culture
  Moderate room for error
- Nutrient Film Technique (NFT)
  No room for error

Cropping Systems – Approach 1

Fall Crop
- Start Seed
  August 1st
- Transplant
  August 18th
- First Harvest
  Late – September
- End Crop
  Mid – late December

Spring Crop
- Start Seed
  Early January – Early February
- Transplant
  Mid – January – Mid – February
- First Harvest
  Early March – Early – April
- End Crop
  July 1st
Cropping Systems – Approach 2

10 Month Crop
- Start Seed August 1st
- Transplant August 18th
- First Harvest Late – September
- End Crop July 1st

Concerns
- Vine Health
- Fertility
- Diseases
- Insects
- Heat Bills
- Light Intensity

Varieties

Beit-Alpha Types
- ‘Mansur’
- ‘Nova’
- ‘Saber’

Long (English) Types
- ‘Discover’
- ‘Roxynante’

“Pickles”
- ‘Excelesior’

Growing Media / Containers

Media
- Perlite
- Ground Pine Bark
- Misc. Materials
  - Coconut Hull
  - Cotton Gin Trash

Containers
- Upright Bags
- Flat Bags
- Buckets
- Pots

American Slicers

‘Alcazar’
‘Tamazula’
For trial:
- ‘P08040’
- ‘P08044’
Cucumber Plant Spacing

Between Row
- Double row configuration on 5 ft. centers
- Approximately 1 - 2 ft. between each double row

In-row
- Fall Crop
  - 24 in.
- Spring Crop
  - 18 in.
- 5 to 7 ft² / plant
- Depends on the container used?

Plant Population

30’ x 96’ GH
- Use 30’ x 85’
- 5 double rows (10 rows)
- 57 plants/row @ 18”
- 43 plants/row @ 24”
- 430 – 570 plants
- 4.5 – 6 ft²/plant

Planting Configuration

```
  x x x x x x x x x x x x x x
  x x x x x x x x x x x x x x
  x x x x x x x x x x x x x x
  x x x x x x x x x x x x x x
  x x x x x x x x x x x x x x
```

Training / Pruning

Modified Umbrella
- Prune to a single stem
- Remove all suckers up the plant to the wire
- Allow two suckers to develop at the wire
- Break out top
- Let suckers grow back toward ground
  - Terminate at about 2/3 the distance to the ground
  - Allow new suckers to develop

Fruit Pruning
- Remove the bottom 6 to 10 fruit from each main vine
  - Increases vigor of the plants
  - Increases the size and quality of fruit
Profitable Greenhouse Production of Local Produce
Allen Straw, Virginia Cooperative Extension

Support

- Greenhouse itself
- Separate frame
- Provide overhead support - wire
- Nylon twine
  - Clipped to base of the plant
  - Tied to a wire or cable

Nutrient Solution – First Fruit to Termination (J.B. Jones, 1983)

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<tr>
<td>Mo</td>
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Nutrient Solution – Seeding to First Fruit (J.B. Jones, 1983)

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<td>Zn</td>
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Elemental Concentrations of Whole Leaves (J.B. Jones, 1983)

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<th>Element</th>
<th>Value</th>
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<tbody>
<tr>
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</tr>
<tr>
<td>P</td>
<td>0.4 – 0.8 %</td>
</tr>
<tr>
<td>K</td>
<td>4.0 – 6.0 %</td>
</tr>
<tr>
<td>Ca</td>
<td>1.0 – 2.0 %</td>
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<tr>
<td>Mg</td>
<td>0.5 – 1.0 %</td>
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<tr>
<td>Fe</td>
<td>60 – 250 ppm</td>
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<tr>
<td>Zn</td>
<td>25 – 75 ppm</td>
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<tr>
<td>Mn</td>
<td>50 – 200 ppm</td>
</tr>
<tr>
<td>Cu</td>
<td>5 – 10 ppm</td>
</tr>
<tr>
<td>B</td>
<td>40 – 60 ppm</td>
</tr>
<tr>
<td>Mo</td>
<td>? ppm</td>
</tr>
</tbody>
</table>
Elemental Concentrations of Whole Leaves (Gerber, 1985)

- N: 2.5 – 5.0 %
- P: 0.5 – 1.0 %
- K: 3.0 – 6.0 %
- Ca: 2.0 – 8.0 %
- Mg: 0.4 – 0.8 %
- S: 0.4 – 0.8 %
- Fe: 90 – 150 ppm
- Zn: 50 – 150 ppm
- Mn: 50 – 300 ppm
- Cu: 4 – 10 ppm
- B: 40 – 100 ppm
- Mo: ? ppm

Temperature Control

- Germination: 80 – 85°F
- Seedling Development:
  - Nighttime: 65°F
  - Daytime: 75 - 80°F
- Optimum Production: 75 - 80°F
- Bag / NFT Culture:
  - Minimum night temperature: 60 – 65°F
  - Minimum day temperature: 70 - 75°F
  - Maximum temperature: 85 - 95°F

Watering Schedule

- Depending on size, temperature, humidity, etc.
- Plants will use from:
  - 1 quart / day
  - 4 quarts / day
  - 3 quarts / day is often enough
- Rule of Thumb: 10 – 20% of bags draining after watering
- Automated to apply small amounts of water many times / day.
  - Time: 30 seconds every hour
  - Light accumulation: 30 seconds every 0.8 mhos of light

Humidity Control

- As low as possible
- Optimum: 60 – 70%
- Realistic: 80 – 90%
- Humidity control fan:
  - Switch
  - Timer
  - Humidistat
Pollination
Parthenocarpic Greenhouse Cucumbers
- Should not be pollinated
- Pollination will cause the development of seed, causing the fruit to become bitter

Pest Control
Weed Control
- Bag / NFT Culture
  Should be no weeds
Disease Control
- Biological
  Resistant Varieties
- Cultural
  Humidity Control
  Temperature Control
  Fertilization
  Pruning
- Sanitation
- Chemical
  Fungicides
  Bactericides

Insect Control
Major Insects
- Aphids
- White Flies
- Spider Mites
- Armyworms
- Cabbage Loopers
- Tomato Fruitworm
- Fungus Gnats
- Leaf Miners
- Pinworms
- Slugs

Mechanical Control
- Solarization
  During the summer months
- Reflective (Colored) Mulch
  Yellow repels aphids
  Silver repels thrips
- Physical Barriers
  Aluminum foil, small cans
- Hand Picking - Hornworms
- Sweeping
### Methods of Insect Control

#### Biological Control
- **Predators**
  - Lady Beetle
  - Small, soft bodied insects
- Ground Beetle
  - Small, soft bodied insects, eggs, worms
- Lacewing
  - Small, soft bodied insects, eggs, worms
- Damsel Bug
  - Small, soft bodied insects, eggs, worms

#### Chemical Control
- Thiodan /Phaser
  - 50WP @ 1 lb/100 gal
  - 3EC @ 1 qt/100 gal
- Malthion
  - 57EC @ 1 qt/100 gal
  - 25WP @ 4 lb/100 gal
- Insecticidal Soap
- Admire
  - 1.4 fl oz / 1,000 plants

### White Flies

#### Control
- **Knack or Distance**
  - 6 to 8 fl oz/100 gal (treat 20,000 ft²)
- Insecticidal Soap
- Azatin EC
  - 10 – 16 fl oz/100 gal
- Admire (sup.)
  - 1.4 fl oz 1,000 plants

### Aphids

#### Chemical Control
- Thiodan /Phaser
  - 50WP @ 1 lb/100 gal
  - 3EC @ 1 qt/100 gal
- Malthion
  - 57EC @ 1 qt/100 gal
  - 25WP @ 4 lb/100 gal
- Insecticidal Soap
- Admire
  - 1.4 fl oz / 1,000 plants

### Spider Mites

#### Control
- Malathion
  - 57EC @ 1 qt/100 gal
  - 25WP @ 4 lb/100 gal
- Insecticidal Soap
- Fulex Nicotine Generator
**Armyworms**

Control
- *Bt's*
- Thiodan /Phaser
  - 50WP @ 1 lb/100 gal
  - 3EC @ 1 qt/100 gal
- Malathion
  - 57EC @ 1 qt/100 gal
  - 25WP @ 4 lb/100 gal
- Azatin EC
  - 10 – 16 fl oz/100 gal
- Avaunt (?)
- Confirm (?)

**Fungus Gnats**

Control
- Gnatrol
  - 4 to 8 tsp/gal
  (biological)
- Malthion
  - 57EC @ 1 qt/100 gal
  - 25WP @ 4 lb/100 gal
- Azatin EC
  - 10 – 16 fl oz/100 gal
- Capture (?)

**Cabbage Loopers**

Control
- *Bt's*
- Azatin EC
  - 10 – 16 fl oz/100 gal
- Malthion
  - 57EC @ 1 qt/100 gal
  - 25WP @ 4 lb/100 gal

**Slugs**

Control
- Snail and Slug Killer Pellets
  (metaldehyde)
**Harvesting**

Pick fully developed cucumbers
- Longer shelf life
- Better customer satisfaction

**Harvest:**
- Cool
  - Every day
- Hot
  - Twice a day

**Greenhouse Lettuce Production**

**Short Season Crop**
- Spring and Fall
  - 28 to 32 days
- Winter
  - 45 to 60 days
- Varieties
  - ‘Flandria’
  - ‘Rex’

**Germinating Lettuce**

**Seeding**
- Oasis Cubes
  - Place seed in holes
    - Primed / Pelleted
    - Raw
  - Sunlight
  - Place sheet of oasis cubes in a shallow tray
  - Add water to pan and let water wick
- Germinate if 5 to 10 days

**Young Seedlings**
Young Seedlings (cont.)

Seedlings are grown at a closer spacing from 1 to 4 weeks
- Dependant on temperature and light intensity
- Fertilizer / per 40 gallons of mix
  - 1 oz of 3-15-28
  - 1 oz of calcium nitrate

Growing Plants

Are moved to the “gutters”
- 6 to 8 inch spacing
- 2 to 4 weeks
- Increase fertilizer / 40 gallons of solution
  - 2, 3, 4 oz of 3-15-28
  - 2, 3, 4 oz of calcium nitrate

Larger Plants

“Water System”
Mature Plants

Ready for Harvest
- As much size and weight as possible
- Before bolting
- Before bitter

Resources and Sources

Further Resources
- G.H. Tomato
  Rick Snyder
  Mississippi State
  msucares.com/crop/s/comhort/greenhouse.html
- Hydroponic Lettuce
  Cornell
  www.cornellca.com/Lettuce_Handbook/introduction.htm

Common Sources
- Local Greenhouse Suppliers
- Hydro-Gardens
  www.hydrogardens.com
  (719) 495-2266
- Crop King
  www.cropking.com
  (330) 302-4203

Marketing

Do not plant a seed until you know where the fruit is going to be sold!
- Retail
  - On-Farm
  - Farmer’s Market
- Wholesale

Thank You!

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Phone: 276.944.2202
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Questions?