Biopesticides: Pest management in greenhouse vegetable production.
• Netherlands Greenhouse Industry
Greenhouse Europe
Almeria, Spain
45. Biological Control of Pepper Weevil: *B.t. galleriae*

66. Insecticides Biologicals compatible with *Bacillus subtilis*

71. Aphid, WF: Quassia Extract (Bitterwood)

66. TSSM: Met 78:

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**Biological Projects to Focus on:**
<table>
<thead>
<tr>
<th>Type of Production</th>
<th>KG/M2</th>
<th>Lbs/Yard2</th>
<th>Increase per Acre against Field Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Large Scale GH (&gt;10 Acre)</td>
<td>60-65</td>
<td>110-120</td>
<td>20x</td>
</tr>
<tr>
<td>New Semi-closed GH (&gt;10 Acre)</td>
<td>80-114+</td>
<td>147-210</td>
<td>30x</td>
</tr>
<tr>
<td>Field Production</td>
<td>3.0.-3.6 (USDA Average)</td>
<td>5.5-6.6</td>
<td>1</td>
</tr>
<tr>
<td>Small Scale GH &lt; 10 Acres</td>
<td>30-35</td>
<td>55-110</td>
<td>10X</td>
</tr>
</tbody>
</table>
• 1989: Canadian Greenhouses, but new to US.
• Greenhouse Tomato Less than 0.5% of US Retail sales in 1989
  • Today: Retail Groceries: ~60%
  • Big Box: ~72%

North American Large Scale History 1989 - 1996
• Tomato: 94%
• Cucumber: 4%
• Pepper: 1%
• Eggplant: 1%
Less than 1° C difference  90-100 meters long
Internal walkway shots
What motivated Village Farms and other NA Greenhouses, to consider biopesticides for use in disease and pest management
• Beneficials
• Biologicals and Biorationals
Beneficials – primary cast of characters

- *Bombus sp.*
  - Bumble bee
- *Encarsia formosa*
  - Parasitoid wasp
  - Whitefly (all sp.)
- *Eretmocerus sp.*
  - parasitoid wasps
  - Whitefly (all sp.)
- *Amblyseius swirskii*
  - Predatory mite
  - Thrips, Whitefly
  - Not tomato

Koppert and BioBest Supply industry.

$400,000/year or up to $10,000 per acre
Std. Growth Curve

- Lag Phase
- Transitional Phase
- Exponential Phase
- Plateau Phase

Population Size vs. Time
• Mono-crop
• 121 Mile Rule for Foliar application
  • Chemigation > Fogging > Dusting > Foliar
• Tomato: 1-3 PHI
• Cucumber: 0-1 PHI
  • Under lights mini-cukes 4X/day
• Pepper: 3-5 PHI
• Application type:
  • Fog (cold and Hot), dusting,
  • Chemigation, and ULV and electrostatic

Challenges - Flexability
What we would like to see in the future and the future of Integrated Crop Management and use of biopesticides in commercial vegetable production.
• 45. Biological Control of Pepper Weevil: *B.t. galleriae*

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• 71. Aphid, WF: Quassia Extract (Bitterwood)

• 66. TSSM: Met 78:
Questions?
- Bacillus thuringiensis (Bt)
  - Bt (kurstaki) – LEPS (WORMS)
  - Bt (galleriae) - Coleoptera (Beetle and weevils)
- Pending
  - Bt (israelensis) - Fungus gnats, shore fly
- Cease
  - Bacillus subtilis
  - Botrytis and PM
- MilStop (kurstaki)
  - Botrytis and PM
- RootShield
  - Root disease
- Suffoil-X
  - Insects and PM
- IGR’s
- Regalia
  - Regulatory
  - PM, Alternaria, DM, GSB, Phytophtora
- Affirm WDG replacement for Veranda by NuFarm
- Polyoxin D zinc salt
- Disease Control
- Actinovate (Streptomyces lydicus)
- Bacterial phage
  - Cmm, Spot, Speck
- BotaniGard
- Brauveria bassiana
  - Many insects (soft bodied)
- M-Pede
  - Potassium salt of fatty acid
  - Insects and PM
- Met 52
  - Metarhizium anisopliae (Tomato and Peppers)
- Grandevo PTO
- Chromobacterium subtsugae
  - Insect and mites
- NemaShield®
  - Steinernema feltiae
  - Fungus Gnat and Western Flower Thrips