Fire Blight-Resistant Apple Rootstocks

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Fire Blight Infection of Rootstocks is a Major Problem in the USA

- Infection of susceptible rootstocks results in the death of the tree
Fire Blight Limits Planting of New Varieties

The high susceptibility of new varieties such as Pink Lady and Jazz make it difficult to plant new orchards on M.9 rootstock.

With a fire blight-resistant rootstock, when the tree is infected the tree survives and the infected branches can be quickly re-grown.
The Geneva Apple Rootstock Breeding and Development Program

Cornell University Program 1968-2008
Dr. James Cummins and Herb Aldwinckle

Joint Program with USDA and Cornell University (1998-present)
Dr. Gennaro Fazio, Herb Aldwinckle and Terence Robinson

**Goal:** Produce a series of rootstocks which are resistant to important rootstock diseases and insects that are dwarfing, productive and efficient.

- Resistance to fire blight
- Resistance to *Phytophthora* root rot
- Resistance to woolly apple aphid
- Cold tolerant
- Resistant to apple replant disease.
Geneva® Apple Rootstock Breeding Team:

James Cummins    Terence Robinson    Herb Aldwinckle
Crosses are made with bees

Seed is harvested (5,000 per year)

Seedlings are inoculated with Phytophthora and Fire blight (95% are killed)

Rootstocks are budded and tested in the field

Breeding New Apple Rootstocks
Rootstock Evaluations at Geneva:

• In the greenhouse
  – Fire blight
  – Phytophthora
  – Wooly apple aphid

• In the nursery
  – Spines
  – Rooting

• In the orchard
  – Survival
  – Tree size
  – Yield efficiency
  – Fruit size
  – Suckering
  – Tolerance to fire blight
  – Tolerance to replant disease
  – Graft union strength
DNA Fingerprinting: The Geneva® rootstocks are a distinct genetic group from most commercial rootstocks.
Map for Marker Assisted Breeding

- Dwarfting
- Root Morphology
- Apple Scab
- Powdery Mildew
- Wooly Apple Aphid

More Dwarfing? Precocity?? Replant Resistance??
Released Geneva® Apple Rootstocks Arranged by Tree Size

Seedling Size

M.7-MM106 Size

M.26 Size

M.9 T337
M.9 PAJ 2

M.27 Size

G.65
G.11
G.41
G.16
G.935
G.202
G.30
G.214
G.213
G.222
G.969
G.210
G.890

New Releases
The Geneva® rootstocks are much more resistant to fire blight than most other rootstocks.
Rootstock Blight Development after Inoculation of Gala Trees on Various Rootstocks
Tolerance of Geneva Rootstocks to Fire Blight Inoculation and Natural Infection
(Norelli, et al. 2002)

<table>
<thead>
<tr>
<th>Rootstock</th>
<th>% Tree Death due to Fire Blight</th>
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<tbody>
<tr>
<td></td>
<td>Inoculation</td>
</tr>
<tr>
<td>M.26EMLA</td>
<td>100</td>
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<tr>
<td>M.9</td>
<td>91</td>
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<tr>
<td>M.7</td>
<td>--</td>
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<tr>
<td>MM.111EMLA</td>
<td>8</td>
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<tr>
<td>G.11</td>
<td>25</td>
</tr>
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<td>G.16</td>
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</tr>
<tr>
<td>G.30</td>
<td>0</td>
</tr>
<tr>
<td>G.41</td>
<td>0</td>
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# Sensitivity of Various CG Rootstocks to Different Strains of Fire Blight

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<tr>
<th>Rootstock</th>
<th>Ea273</th>
<th>EA2002</th>
<th>E4001a</th>
<th>E2017p</th>
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<tr>
<td>G.11</td>
<td>2</td>
<td>13</td>
<td>11</td>
<td>0</td>
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<tr>
<td>G.16</td>
<td>0</td>
<td>33</td>
<td>26</td>
<td>7</td>
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<td>G.30</td>
<td>1</td>
<td>45</td>
<td>39</td>
<td>5</td>
</tr>
<tr>
<td>G.41</td>
<td>0</td>
<td>17</td>
<td>5</td>
<td>--</td>
</tr>
<tr>
<td>G.935</td>
<td>6</td>
<td>56</td>
<td>30</td>
<td>6</td>
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<td>G.202</td>
<td>31</td>
<td>44</td>
<td>21</td>
<td>19</td>
</tr>
<tr>
<td>M.7EMLA</td>
<td>12</td>
<td>42</td>
<td>45</td>
<td>11</td>
</tr>
<tr>
<td>M.9EMLA</td>
<td>91</td>
<td>96</td>
<td>87</td>
<td>--</td>
</tr>
<tr>
<td>M.26EMLA</td>
<td>83</td>
<td>74</td>
<td>--</td>
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</tbody>
</table>
Summary of Fire Blight Inoculation Trials

- **G.16, G.41, G.214 and G.202** are highly resistant to field inoculations of the scion with a high dose of fire blight but may not be resistant to all strains of fire blight.
- **G.11, G.65 and G.935** are moderately resistant to field inoculations of the scion with fire blight.
Performance of McIntosh with Geneva and Supporter Rootstocks after 10 years
(B&D Plot)
Performance of Golden Delicious with Geneva Rootstocks after 8 years (Cahoon Plot)
Performance of Gala with Geneva, Supporter, JM and PiAu Rootstocks after 7 years (Han 15 Plot)
Performance of Fuji with 53 Rootstocks after 4 years
(Crist Bros. Plot)
Propagation of Geneva® Rootstocks

• Several Geneva Rootstocks root poorly in the stoolbed.
• We are conducting research to improve stoolbed performance
  - Regalis treatment of stoolbed
  - Tissue Culture to induce greater juvenility in stoolbed
  - Tissue Culture plants as rootstocks
Micropropagation of Geneva® Rootstocks

Shelves full of G.41 plantlets at North American Plants

Rooted G.41 plants at NA-Plants

ProTree Nursery Micropropagation Lab - Rooted acclimated plants G.935
Rooting of G.41 Apple Rootstock from tissue culture plants
Propagation by Cuttings is Expanding

Typical Rooting of G.41
Additional Rootstock Studies

- Uptake of mineral nutrients
- Drought tolerance
- Root architecture
- QTL mapping of root characteristics
Geneva® Rootstock Commercialization in North America

- Propagation licenses held by:
  - Treco
  - Willow Drive Nursery
  - Willamette Nursery
  - Copenhaven
  - Mori Nursery (Canada)
  - Consortio Sacramento (Mexico)
  - Others in the future

- Rootstocks being commercialized
  - G.11
  - G.41
  - G.214
  - G.935
  - G.202
  - G.30
  - G.969
G.11

- Tree size similar to M.9 T337.
- Very high yield efficiency
- Large fruit size
- Tolerant to Replant Disease
- Resistant to Fire Blight but not immune.
- Resistant to Crown Rot
- Susceptible to Wooly Apple Aphid
- Good rooting in stoolbed

Courtesy of Stefano Musacchi
G.41

- M.9 vigor
- Very high yield efficient
- Highly productive
- Very precocious
- Resistant to replant disease
- Very cold hardy
- Does well in warmer climates (Mexico)
- Highly Resistant to Fire Blight and Crown Rot and Wooly Apple Aphid
- Requires tissue culture mother plants for stoolbed
G.214

- Vigor similar to M.9 Pajam2
- Highly yield efficient
- Highly productive
- Good precocity
- Tolerant to replant disease
- Resistant to Fire Blight, Crown Rot and Wooly Apple Aphid
- Very good stool bed propagation
- No commercial production of liners.
G.935

- Vigor intermediate between M.9 Pajam 2 and M.26
- Very high yield efficiency
- Very cold hardy
- Resistant to Replant Disease
- Resistant to Fire Blight and Crown Rot
- Susceptible to Wooly Apple Aphid
G.202

- Size similar to M.26
- Precocious, productive
- Resistant to woolly apple aphid, fire blight, and crown rot
- Tolerant to apple replant disease
- Good choice for weak growing cultivars like Honeycrisp
- Moderate rooting in stoolbed
G.210

- Vigor between M.7 and MM.106
- Precocious, productive
- Yield efficiency similar or better than M.9
- Resistant to apple replant disease.
- Resistance to woolly apple aphid, fire blight, and crown rot.
- Good rooting in stoolbed few spines.
- Mostly for Organic Production
Geneva Rootstock Liner Production in the USA

Liners Production (number)

- G.11
- G.41
- G.935
- G.16
- G.30
- G.202
- Total CG
Geneva® Rootstock Commercialization in Europe

• Propagation licenses held by:
  Janssen (Netherlands)
  DL (France)
  Castang (France)
  CIV (Italy)
  Others in the future

• Rootstocks being commercialized
  G.11
  G.41
  G.214
  G.935 (Weak varieties)
  G.202 (Weak varieties or Organic)
  G.210 (Organic)

• About 20,000 liners of G.11 and G.41 in 2012
Released Geneva® Apple Rootstocks Arranged by Tree Size

M.27 Size

M.9 T337

M.9 PAJ 2

M.26 Size

M.7-MM106 Size

Seedling Size

G.65

G.11

G.41

G.16

G.935

G.202

G.30

G.214

G.969

G.210

G.890

G.222

G.213

New Releases

Geneva® Apple Rootstocks Arranged by Tree Size
Questions?