The Strengths and Weaknesses of Geneva Apple Rootstocks

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Strengths: 1) Apple Replant Disease Tolerance

Keys to Successful New Apple Orchards
- Plant high-tree densities (optimum 1,000-1800 trees/acre).
- Produce high early yields (3,000 bu/acre over the first 5 years).
- Grow the trees rapidly to fill the allotted space in the first 3 years.
- Produce high mature yields (>1200 bu/acre) of high quality fruit.

- Poor tree growth due to replant disease in the first 3 years jeopardizes the economic success of the new orchard.
Geneva Replant Disease Evaluation of 38 Genotypes

Kviklys et al
Rootstock Tolerance to Replant Disease in Potted Trees

Kviklys et al
Field Tolerance to Replant Disease at 8 Locations in North America

% Increase in TCA due to Fumigation

- G.16
- G.41
- G.4210
- B.9
- G.30
- M.9T337
- G.210
- G.935
- G.11
- M.9Pajam2
- M.7
- M.26

Robinson et al.
Growth of Gala in a Replant Soil
Washington State

Data from Auvil et al. 2010

% Increase in Growth due to Fumigation

Early Yield Improvement of Gala due to Fumigation in a Replant Soil
Washington State

% Increase in Yield due to Fumigation

WAPATO 2006-2007 Cumulative Yield Per Tree (Kg)

Rootstock

Data from Fazio
## Summary of Replant Resistance Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>G.11</th>
<th>G.41</th>
<th>G.214</th>
<th>G.935</th>
<th>G.210</th>
<th>G.30</th>
<th>M.9</th>
<th>M.26</th>
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Summary

- Several Geneva® rootstocks appear to have tolerance/resistance to apple replant disease.
  - G.11
  - G.41
  - G.214
  - G.935
  - G.202
  - G.210

- The resistance may be due to the initial screening for Phytophthora disease which may also have selected for tolerance to other soil microorganisms.

- Resistant rootstocks show an improvement in yield due to fumigation.

- The variation around the world in soil organisms which cause apple replant disease may result in variable orchard results with the resistant rootstocks.
2. Fire Blight Resistance

- Infection of Rootstocks is a Major Problem in the USA
- Infection of susceptible rootstocks results in the death of the tree
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
Summary of Fire Blight Inoculation Trials

- G.16, G.41, G.214 and G.202 are highly resistant to fire blight but may not be resistant to all strains of fire blight.
- G.11, G.65 and G.935 are resistant to field inoculations of the scion with fire blight.
3. Yield potential of the Geneva Rootstocks

Example
G.814=152t/ha
B.9=77t/ha
Diff.=75t/ha
Value=$56,850/ac

Honeycrisp
Performance of Golden Delicious with Geneva Rootstocks after 10 years (Cahoon Plot)
Performance of Fuji with 53 Rootstocks (Crist Bros. Plot)
4. Cold Hardiness

In the cold snap of 2004 and 2005, G.16, G.30, G.41 and G.935 had the best survival. G.41 and G.935 seem well adapted to the cool climate of the Champlain Valley.
5. Woolly Aphid Resistance

Several Geneva stocks are resistant but some are not

<table>
<thead>
<tr>
<th>Resistant</th>
<th>Susceptible</th>
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<tbody>
<tr>
<td>G.41</td>
<td>G.11</td>
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<tr>
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<td>G.935</td>
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<td>G.202</td>
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<td>G.890</td>
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Weaknesses: 1. Propagation of Geneva® Rootstocks

- Several Geneva Rootstocks root poorly in the stoolbed.
- We have conducted research to improve stoolbed performance
  - Regalis treatment of stoolbed
  - Tissue Culture to induce greater juvenility in stoolbed
  - Tissue Culture plants as rootstocks
Rooting of G.41 Apple Rootstock from tissue culture plants
Propagation by Cuttings is Expanding

Typical Rooting of G.41
Weaknesses: 2) Graft Union Strength

- Some Geneva Rootstocks have a more brittle graft union with certain varieties.
  - Honeycrisp
  - Envy
  - Crimson Crisp
Graft union breaks of M.9Nic29 and G.41 with Scilate (Envy) as the scion variety
Graft Union strength of Honeycrisp on G.41 and M.9Nic29 in the Nursery

- **HC/G.41 Avg. force per graft CSA to break graft**
  - HC/G.41 Avg. force per graft CSA to break graft
  - June
  - August
  - October

- **HC/Nic.29 Avg. force per graft CSA to break graft**
  - HC/Nic.29 Avg. force per graft CSA to break graft
  - June
  - August
  - October

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- Bud up
- Bud down
- WT stacked
- WT sideways
- Saddle stacked
- Saddle sideways

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N/cm²

- 0.00
- 20.00
- 40.00
- 60.00
- 80.00
- 100.00
- 120.00

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HC/G.41 Avg. force per graft CSA to break graft

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HC/Nic.29 Avg. force per graft CSA to break graft

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Average force per graft CSA to break graft
Graft Union strength of 39 rootstocks with Gala as the scion in the Nursery.
Graft Union strength of G.30 with 20 scion varieties in the Nursery

- Northern Spy
- Fuji Red Sport
- Golden Delicious
- Granny Smith
- Nova Easy Grow
- Idared
- White Angel
- Gala
- Haralson
- Washington Red
- Anna
- Jonathan
- Rome Beauty
- Cox’s Orange Pippen
- Yellow Transparent
- Spokane Beauty
- Novosibirski Sweet
- Wijck McIntosh
- James Grieve

Cultivars Grafted on G30

Bending Stress (N cm$^2$)

Legend:
a, ab, abc, a-d, a-d, a-d, a-e, a-e, b-e, c-f, c-f, c-f, c-f, d-f, d-f, efg, efg, fg, g, g

Note: The diagram shows the bending stress of Graft Union strength for G.30 with 20 scion varieties, indicating which cultivars have significantly different strengths.
Graft Union strength of G.30 over 10 years

- Honeycrisp/G30 one-year-old
- Gala/G30 four-years-old
- Gala/G30 ten-years-old

The regression equation is:

\[ y = 59.732 \ln(x) - 33.263 \]

with an R^2 value of 0.9827.
Released Geneva® Apple Rootstocks Arranged by Tree Size

- M.27 Size
  - G.65
  - M.9 T337
  - G.11
  - M.9 PAJ 2
  - G.41
  - G.16

- M.26 Size
  - G.935
  - G.214
  - G.222
  - G.213
  - G.202
  - G.814

- M.7-MM106 Size
  - G.30
  - G.969
  - G.210
  - G.890

- Seedling Size
  - G.41
  - G.935
  - G.890
Commercialization of Geneva® Rootstocks in North America

• Licensed Nurseries:
  Willow Drive Nursery (Washington)
  Willamette Nursery (Oregon)
  North American Plants (Oregon)
  Treco (Oregon)
  Kit Johnston (Oregon)
  Todd Cameron (Washington)
  Copenhaven (Oregon)
  Mori Nursery (Canada)
  KCK Farms (Oregon)
  Van Well Nursery (Oregon)
  Helios Nursery (Washington)
  Pyteligence (Washington)
  ProTree (California)
  Crown Nursery (Washington)
  Consortio Sacramento (Mexico)

• Rootstocks
  G.11    G.41
  G.214   G.935   G.222
  G.202   G.969
  G.30    G.210   G.890
Geneva Rootstock Liner Production in the USA
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
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.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.202 New Zealand
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.969

- Vigor between M.26 y M.7
- Very efficient and productive
- Very cold tolerant
- Resistant to fire blight
- Resistant to Phytopthora
- Resistant to Woolly Apple Aphid
- Good Anchorage
- Excellent rootstock for weak scions like Honeycrisp
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
With Several New Rootstock Options of Varying Vigor Levels the Challenge Becomes Selecting the Rootstock that Gives the Best Combination of Growth and Yield for the Variety We are Planting

G.11 for strong varieties
G.41 for weak varieties or replant
G.935 or G.202 for very weak varieties