New Peach (Plum & Apricot) and Apple Rootstocks for the Grower

Western Colorado Horticultural Society
70th Annual Convention
January 16, 2013
Gregory Reighard
Clemson University

United States Rootstocks
(older releases)

Clonal
- Hansen 536 (P. persica x P. dulcis)
- Hansen 2168 (P. persica x P. dulcis)
- Viking (multi-species hybrids)
- Atlas (multi-species hybrids)
- Marianna 2624 (P. cerasifera x P. munsoniana)

Seedling
- Lovell
- Halford
- Bolley
- Teno. Natural
- Nemaguard
- Nemared

United States Rootstocks
(newer releases)

Clonal
- Controller® 5 (P. salicina x P. persica)
- Controller® 9 (P. salicina x P. persica)
- HBOK 27, 32, 10, 50 (Harrow Blood X Okinawa, ~ Controller® 6, 7, 8 & 9.5)
- Cornerstone, Brights Hybrids & Nickels
- (P. dulcis x P. persica)
- Sharpe (P. angustifolia hybrid)
- MP-29 (plum hybrid)

Seedling
- Guardian® (P. persica)
- P. americana

French Rootstocks
(INRA)

(older releases)

Clonal
- Cadaman® (P. persica x P. davidiana)
- Jaspi® (P. salicina x P. spinosa) (plum only)
- Julior (P. insititia x P. domestica) (plum)
- Ishtara (P. cerasifera x P. persica) (plum or apricot*)
- Montclar (P. persica)
- Rubira (P. persica)

French Rootstocks
(INRA)

(newer releases)

Torinel® (P. domestica) (plum)
- Myrotop® (P. cerasifera) (plum or apricot)
- Torilplus® (P. domestica) (plum or apricot)

Spanish Rootstocks
(older releases)

[CSIC & CITA, Zaragoza]
- Adesoto or Empyrean® 101 (P. insititia)
- Adarcias (P. dulcis x P. persica)
- Monegro (P. dulcis x Nemared)
- Felinem (P. dulcis x Nemared)
- Garnem (P. dulcis x Nemared)
Spanish Rootstocks  
(newer releases)

- Agromillora Iberia, Barcelona
- Mirobac cv PAC 941 (\textit{P. cerasifera x P. dulcis})
- Densipac Rootpac® 20 (\textit{P. besseyi x P. cerasifera})
- Nanopac Rootpac® 40 (\textit{P. dulcis x P. persica})
- Purplepac Rootpac® 70 (almond x peach x \textit{P. davidiana})
- Greenpac Rootpac® 90 (almond x peach x \textit{P. davidiana})
- Replantpac Rootpac® R (\textit{P. cerasifera x P. dulcis})

Italian Rootstocks  
(older releases)

- [Pisa]
  - Sirio (\textit{P. persica x P. dulcis})
  - Mr.S. 2/5 (\textit{P. cerasifera})
  - Barrier or Empyrean® 1 (\textit{P. persica x P. davidiana})
  - Polluce (\textit{P. persica x P. dulcis})
  - Castore (\textit{P. persica x P. dulcis})

Italian Rootstocks  
(newer releases)

- [Rome]
  - Penta or Empyrean® 2 (\textit{P. domestica})
  - Tetra or Empyrean® 3 (\textit{P. domestica})
  - Imperial California (\textit{P. domestica})

Russian Rootstocks  
[VRI at Krymsk]

- Krymsk® 1 (\textit{P. tomentosa x P. cerasifera}) (peach*, apricot*, plum)
- Krymsk® 2 (\textit{P. incana x P. tomentosa}) (plum*)
- Krymsk® 86 (\textit{P. cerasifera x P. persica}) (peach, plum*, apricot)
- Krymsk® 9 (\textit{P. cerasifera x P. armeniaca}) (apricot)
- Krymsk® 99 (\textit{P. besseyi x P. salicina}) x \textit{P. cerasifera} (peach*, plum*, apricot)
- Fortuna (\textit{P. cerasifera x P. persica}) (peach*, plum*)

Rootstock Characteristics

1. Nematode resistance
2. Replant disease
3. Soil fungal pathogens
4. Calcareous soils
5. Waterlogging
6. Vigor control

Root-knot Nematodes (\textit{Meloidogyne spp.})
Root-knot Nematodes

- **Immune or Tolerant** to *M. incognita* and *M. javanica*

  Guardian®, Nemaguard, Florguard, HBOK®s (Harrow Blood x Okinawa),
  Adesoto 101 (*P. insititia*),
  Penta (*P. domestica*),
  Krymsk# 1 (*P. tomentosa x P. cerasifera*),
  Sharpe (*P. angustifolia hybrid*) & MP-29 (peach x plum),
  Barrier 1 or Empyrean® 1 (*P. persica x P. davidiana*),
  Cadarn® (*P. persica x P. davidiana*),
  Pumiselect® (*P. pumila*),
  Felinem, Garnem, and Monegro (*P. dulcis x P. persica cv. Nemared*),
  Replantpac (*P. dulcis x P. cerasifera*), Densipac (*P. besseyi x P. cerasifera*).

Rootstocks & Ring Nematodes

- Guardian® and Viking have good tolerance
- HBOK 50 (Controller 9.5), tolerance in early trials
- Sharpe & MP-29 are likely tolerant
- *P. pumila* (Pumiselect®) and *P. besseyi* are poor ring nematode hosts

Rootstocks & Lesion Nematodes

- Guardian® has some tolerance
- Viking & Atlas have some tolerance
- Krymsk® 1 is greenhouse tolerant
- Krymsk® 86 is considered more tolerant
- Krymsk® 99 has reported tolerance
- Brights Hybrid #5 & Cornerstone is less susceptible
- Replantpac has some greenhouse tolerance
- Densipac has reported resistance
- Torinel has the highest tolerance but incompatibility issues

Rootstocks & Dagger Nematodes

- Vector for tomato ringspot virus (TomRSV)
- *P. persica* rootstocks are susceptible
- *P. cerasifera* less sensitive to TomRSV
- Mr.S. 2/5, Adara, Replantpac, Krymsk® 1 & 2 may have genetic potential for field tolerance but have not been specifically inoculated with TomRSV

Rootstock Characteristics

1. Nematode resistance
2. **Replant disease**
3. Soil fungal pathogens
4. Calcareous soils
5. Waterlogging
6. Vigor control
**Rootstock Characteristics**

1. Nematode resistance
2. Replant disease
3. **Soil fungal pathogens**
4. Calcareous soils
5. Waterlogging
6. Vigor control

**Rootstocks Highly Susceptible to Bacterial Canker &/or Replant Diseases**

- Jaspire®
- Julior®
- Ishara®
- Adenoto 101
- Monegro
- Garmen
- Barrier 1 (Empyrean® 1)
- Krymsk® 86
- Controller 5
- *P. americana*

**Rootstocks Influencing Tolerance to Bacterial Canker**

- Guardian® - excellent
- Viking - excellent
- MP-29 - excellent
- Sharpe – moderate
- Penta – fair

**Non-nematode replant soils**

- Guardian®
- Replantpac, Nanopac & Densipac
- Cadaman®
- Barrier 1 (Empyrean® 1)
- Krymsk® 86 & Krymsk® 99
- Tetra

**Armillaria or Oak Root Rot**
**Armillaria Root Rot Resistance**

- Sharpe and MP-29 (USDA-Byron GA) have shown good resistance/tolerance in limited trials in Georgia, US
  - Both are plum hybrids with plum or peach
- SAM 1 and SAM 2 (Progressive Genetics Group, CA) both are almond (?) hybrids
- Densipac Rootpac® 20 (Agromillora Iberia, Spain)

**Phytophthora spp. resistance?**

- Penta and Tetra Rootstocks
- Cornerstone
- Cadaman ?

**Crown Gall – Agrobacterium tumefaciens**

- Cornerstone ?
- Rigatano (P. mume)

**Cotton root rot – Phymatotrichum omnivorum**

- Nothing yet!

---

**Rootstock Characteristics**

1. Nematode resistance
2. Replant disease
3. Soil fungal pathogens
4. **Calcaceous soils**
5. Waterlogging
6. Vigor control

**Iron Chlorosis Tolerance**

- Cadaman Barrier 1
- Adesoto 101
- GF 677
- Felinem
- Garnem
- Monegro
- Penta
- Viking
- Krymsk®86
- Replantpac
- Nanopac
- Densipac
- Mirobac

**Waterlogged Soils**

(root asphyxia)
**Waterlogging tolerance**

- Viking & Krymsk® 86 more tolerant than peach
- Cadaman also better than peach
- Plums and plum hybrids generally are tolerant such as Penta, Tetra, Mr.S 2/5, Adesoto 101, Krymsk® 1
- Krymsk® 99 is tolerant
- Mirobac, Densipac & Replantpac are tolerant

**Rootstock Characteristics**

1. Nematode resistance
2. Replant disease
3. Soil fungal pathogens
4. Calcareous soils
5. Waterlogging
6. **Vigor control**

---

Peach seedling roots = Too much vigor!

**Compatible Dwarfing Rootstocks Needed**

- HBOK 50 (= Controller 9.5) (95%)
- Controller 9 (90%)
- Penta and Imperial California (90%)
- HBOK 10 (= Controller 8) (80%)
- HBOK 32 (= Controller 7) and MP-29 (75%)
- HBOK 27 (= Controller 6) (70%)
- Controller 5 interstem (70%)
- Pumiselect® (70%)
- Nanopac (70%)
Dwarfing Rootstocks
(<70% of Lovell Peach)

- Krymsk® 99 (65%)
- Krymsk®1 (60%)
- Controller 5 (60%)
- Sharpe (60%)
- Wavit (60%)
- Rigatano (60%)
- Densipac Rootpac® 20 (60%)
**Apricot and Plum Rootstocks**

- **Krymsk® 3 (P. tomentosa x P. cerasifera)**, 70% of Citation vigor, preliminary observations show it is one of the best size controlling rootstocks for apricot in California. Compatibility may be an issue for some cultivars. Compatible with plum.
- **Citation (OP Red Blast plum, P. salicina)**, standard size trees (similar to peach seedling rootstocks), may increase fruit size and does advance maturity, has serious incompatibility issues with apricots such as Bulida, Canino, Royal, etc. and does not tolerate wet soils.
- **Very productive rootstock for Japanese plums**
- **Krymsk® 9 cv 'Myroco' (P. cerasifera x P. armeniaca)**, 60% of Citation vigor, advances bloom and maturity by 3-5 days, may be too dwarfing
- **Krymsk® 99 (formerly Evrica) (P. besseyi x P. salicina) x P. cerasifera)**. This stock is semi-dwarfing in the range of Krymsk®1 and tolerant of wet soils, easy to propagate from cuttings, and has shown long term compatibility with many apricot cultivars. It has recently been released to the U.S. and is at NRSP5.
- **Wavit® (P. domestica 'Wangenheim' seedling)**, 60% of Myrobalan vigor, improves fruit size and advances maturity, compatible with many apricots and all plums.

**Future of Stone Fruit Rootstock Development?**

1. Primarily private breeders and commercial nurseries with a few public breeders so most new rootstocks will be proprietary and protected by patents and licenses
2. Asexual propagation techniques continue to improve for more efficient and economical production of complex hybrid rootstocks for stone fruit growers
3. Biotechnology such as using marker assisted selection for desired traits in fruit trees has now become feasible and economically viable with the genome sequencing of peach

**New Apple Rootstocks from Vineland and Geneva**
Rootstock: The Key Determinant of Productivity

The North American Rootstock Situation

• M.9, M.26, B.9 are the primary rootstocks used.
• M.7 and M.111 are used in small quantities.
• Fire blight is a limiting factor for North American apple growers with M.9 and M.26.

Fire blight infection of rootstocks is a major problem in the USA

• Infection of susceptible rootstocks results in the death of the tree
• Infection of resistant rootstocks does not result in the death of the tree. The tree survives and the infected branches can be quickly re-grown.

Geneva® Series Apple Rootstocks

• Breeding program initiated by Jim Cummins and Herb Aldwinckle in 1970.
• Primary goals have been to develop fire blight and Phytophthora resistant rootstocks, tolerance to apple replant disease resistance and increased cold hardiness.
• 11 Rootstocks have been released to date.

GENERAL CHARACTERISTICS of GENEVA® ROOTSTOCKS

• Disease Resistance
  – Fire Blight
  – Crown and Root Rot (Phytophthora)
  – Wooly Apple Aphid
  – Replant Disease Complex
• Precocity – at least as good as M.9
• Productivity/Yield Efficiency – as good or better than M.9
• Low suckering and burr knots
• Cold hardiness

The Geneva® rootstocks are much more resistant to fire blight than most and other rootstocks
Characteristics of G.11

- Tree size similar to M.9 T337.
- Productivity is similar to M.9.
- Large fruit size
- Resistant to Fire Blight but not immune.
- Resistant to Crown Rot
- Not tolerant to replant
- Susceptible to Wooly Apple Aphid
- Commercial sales in the US are picking up volume (~150,000)
- Good rooting in stoolbed (close to M.9)

Characteristics of G.41

- M9 vigor
- Highly yield efficient
- Highly productive (most U.S. trials yields 100-125% of M.9)
- Very precocious
- Very cold hardy
- Does well in warmer climates (Mexico)
- Immune to Fire Blight and Crown Rot and Wooly Apple Aphid
- Replant tolerant
- Some issues with propagation being resolved
- In the USA new stoolbeds were planted in 2009 and 2010 (100,000 plants).

Characteristics of G.935

- Vigor intermediate between M.9 Pajam 2 and M.26
- Very cold hardy
- Good graft union and propagation characteristics
- Resistant to Fire Blight and Crown Rot
- Tolerant to Replant Disease Complex
- Susceptible to Wooly Apple Aphid
- Best semi-dwarf rootstock in NY trials

Characteristics of G.202

- It is similar in size to M.26
- Precocious, productive
- It is resistant to woolly apple aphid, fire blight, and crown rot
- In New Zealand it has been a top performer
- Good choice for weak growing cultivars like Honeycrisp
- Tolerance to apple replant disease
- Moderate rooting in stoolbed.
- Geneva® 202 was released in New Zealand in 2002. And in the USA in 2004.

Characteristics of G.214

- Vigor similar to M.9 Pajam2
- Highly yield efficient
- Highly productive (most U.S. trials yields 100-125% of M.9 check)
- Good precocity
- Resistant to Fire Blight, Crown Rot and Wooly Apple Aphid
- Replant tolerant
- Very good stool bed propagation

Characteristics of G.969, G.210 and G.890

- Vigor between M.7 and MM.106
- Replacements for G.30
- Free standing
- Precocious, productive
- Yield efficiency similar or better than M.9
- Resistance to woolly apple aphid, fire blight, and crown rot.
- Tolerance to apple replant disease.
- Good rooting in stoolbed few spines.
- Mostly for processing industry
Performance of Golden Delicious with Geneva Rootstocks after 8 years (Cahoon Plot)

 Released Geneva® Apple Rootstocks
Arranged by Tree Size

Geneva® Rootstock Commercialization in North America
-Propagation licenses held by:
  - Treco
  - Willow Drive Nursery
  - Willamette Nursery
  - Copenhaven (Oregon)
  - Mori Nursery (Canada)
  - Consorcio Sacramento (Mexico)
  - Others in the future

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

Geneva Rootstock Liner Production

Micropropagation of Geneva® rootstocks

Micropropagation of Geneva® rootstocks
### Summary of Geneva Rootstocks
- G.41, G.11 and G.935 are outstanding rootstocks in NY and in other areas.
- G.214 looks promising but has had little testing.
- G.969 and G.890 are promising stocks for processing orchards.
- We have made significant progress in developing stoolbeds of G.11 and G.41 and to a lesser extent G.935 and G.202.
- We have had a setback in the development of stoolbeds of G.214 and its propagation is starting over (18 month delay).
- There will be 500,000 Geneva liners planted in the US nurseries this coming spring and 1 million in 2013.

### Description
- Developed by Dr. Alec Hutchinson
- ‘Kerr’ applecrab x ‘M.9’ rootstock
- Seven rootstocks in the series (‘V.1’, ‘V.2’-‘V.7’)
- Tested in 1980 (Washington, Ohio)
- Tested in 1994-2003 (NC-140)
- Tested in Simcoe 1997, 2002
- Tested in Manitoba and Edmonton (1997-?)

### Presentation Overview
(John Cline, Ph.D. Univ. Guelph)

**Vineland Series Apple Rootstocks**
- Description
- Attributes
- Availability

### Tree size and cumulative yield of 10-yr-old Gala on 20 rootstocks

### Mean tree size and cumulative yield for 10-Yr-old trees on various Vineland rootstocks
Vineland Rootstock Availability

- Commercial development by the University of Guelph and the Ontario Ministry of Agriculture.
- ‘V.1’, ‘V.2’ and ‘V.3’ have been licensed
- More information is required to determine the suitability of commercializing ‘V.5’, ‘V.6’, and ‘V.7’.
- ‘V.2’ has been commercially released but has been difficult to propagate in the nursery, therefore it may have limited availability.
- ‘V.4’ will not be commercialized.