

Characteristics of Apple Rootstocks

Prepared by Dr. Paul Domoto, Dept. of Horticulture

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Rootstock	Size ¹	Fruiting	Anchorage	Hardiness	Soil Adaptability	Crown Rot	Fire Blight	Remarks
Seedling	100%	Slow bearing, yield variable but generally low.	Well anchored	Considered hardy, but variable	Widely adapted	Variable	Tolerant	65-85% size control with spur-type Red Delicious strains; some size control with other spur-type strains. Suckering may be a problem; very few burrknots ² .
Novole	100%	Slow bearing, low productivity	Well anchored	Needs testing	Adapted to most soils	Resistant	Resistant	Tolerant to meadow voles, may be of value in low input production systems.
Polish 18 (P.18)	90 - 100%	Slow bearing, moderately productive	Well anchored	Considered very hardy; may be susceptible in late winter	Widely adapted	Resistant, need further testing	Moderately susceptible	Very little suckering; very few burrknots ² . Has a horizontal rooting habit; may be suitable on wet soils as an understock for interstem trees.
Antonovka 313 (Ant.313)	90 - 100%	Slow bearing, moderately productive	Well anchored	Considered hardy; susceptible in late winter	Widely adapted	Resistant	Moderately susceptible	Some suckering; few burrknots ² .
Bud.118 (B.118)	85 - 95%	Somewhat early bearing, moderately productive	Well anchored	Reported very hardy, needs further testing	Well drained soils	Resistant	Moderately resistant	Needs further testing.
M.4	81 - 90%	Moderately early bearing, good productivity	Well anchored, but subject to leaning	Moderate	Widely adapted	Resistant	Tolerant	Most productive vigorous rootstock in regional testing. Moderate to heavy suckering; few burrknots ² .
MM.111	80 - 90%	Somewhat early bearing, moderately productive	Well anchored	Moderate	Adapted to most soils; drought tolerant, but does not tolerate wet feet	Tolerant on well-drained soils	Tolerant	Tree form is more up=right. Little suckering; prone to burrknots ² . Semi-dwarf with spur-type Delicious strains. Moderately susceptible to tomato ringspot virus ³ .
MM.106	70 - 80%	Moderately early bearing, very good productivity for tree size	Good on most soils	Very susceptible in early winter; hardy in late winter	Best on loam and sandy loam soils. Avoid poorly drained soils	Very susceptible	Moderately susceptible	Very little suckering; prone to burrknots ² . Very susceptible to tomato ringspot virus ³ .
Bud.490 (B.490)	70 - 80%	Moderately early bearing, very good productivity for tree size	Well anchored	Considered hardy, but appears susceptible in late winter	Best on well drained soils	Moderately resistant	Moderately susceptible	May be a replacement of MM.106. Almost no suckering; somewhat prone to burrknots ² .
EMLA 7 M.7a	60 - 70%	Moderately early bearing, moderately productive	Free-standing, but leans with some cultivars.	Moderate; roots are tender, snow cover for best protection	Well adapted on most soils except heavy clays	Slightly susceptible on poorly drained soils	Tolerant	Suckers heavily; somewhat prone to burrknots ² . fruit size often small. Most widely adapted clonally propagated rootstock.
CG.6210	60 - 65%	Early bearing, very productive	Well anchored	Appears hardy, evaluated in two Iowa trials with no symptoms of winter injury	Needs further testing	Resistant	Resistant	Suckering may be a problem. Being considered for release
Supporter 4	55 - 60%	Very early bearing, good productivity	Better anchored than M.26	Needs testing	Well drained soils, needs further testing	Modertely resistant	Extremely susceptible	Produces few suckers or burrknots ² . Performs poorly on re-plant sights.
Geneva 30 (G.30)	55 - 60%	Early bearing, very productive	Weak graft union with some cultivars, support is recommended	Almost as hardy as M.26	Well adapted to most soils	Tolerant	Highly resistant	More productive and much less prone to suckering than M.7a; burrknots ² are rare. Induces wide crotch angles. Tolerant to re-plant disorder. Susceptible to common latent viruses ⁴ . Difficulty to propagate has held back its availability.
Geneva 935 (G.935)	50 - 60%	Very early bearing, very productive	May need support in early years	Appears to be very hardy	Well adapted to most soils	Highly resistant	Highly resistant	Promising new rootstock. Produces good fruit size. Induces wide crotch angles. Produces very few suckers or any burrknots ² . Good replacement for M.26; been more productive than M.26 in the Iowa planting of the 2003 NC-140 rootstock trial, and has not exhibited symptoms of winter injury.
Geneva 202 (G.202)	45 - 55%	Very early, very productive	Well anchored	Hardier than M.7, need further testing	Appears well adapted to most soils.	Resistant	Highly resistant	Moderate suckering, few burrknots ² . Good resistance to wooly apple aphid. Presently, only available in New Zealand.
M.26 EMLA 26	45 - 55%	Early bearing, good productivity	May need support in early years	Hardest M. or MM. series rootstock; somewhat slow to harden-off	Well drained soils	Moderately susceptible on poorly drained soils	Extremely susceptible	Very little suckering; very prone to burrknots ² . Susceptible to tomato ringspot virus ³ . Compatibility problems have been identified with some cultivars.
Geneva 11 (G.11)	40 - 50%	Very early bearing, very productive	Needs support in early years	Needs further testing	Well adapted on most soils	Resistant	Moderately resistant	Promising new rootstock. Little suckering; very few burrknots ² . Promotes good fruit size
Ottawa 3 (O.3)	40 - 50%	Early bearing, very productive	Good, but does best with support	Very hardy	Well adapted on most soils	Resistant on most soils	Susceptible	Roots poorly; may be a factor in orchard establishment. Moderate suckering; very few burrknots ² . Moderately susceptible to tomato ringspot virus ³ and common
Geneva 16 (G.16)	35 - 45%	Very early bearing, very productive	Moderately good, support needed for crops	Has exhibited winter injury symptoms in an Iowa planting, needs further testing	Appears well adapted on most soils	Tolerant	Very resistant	Very little suckering; very few burrknots ² . Very sensitive to common latent viruses ⁴ , only virus-free scion wood should be used to propagate trees. Tends to produce small-sized fruit.
M.9 strains	30 - 45%	Very early bearing, very productive	Needs support	Slightly hardier than M.7a	Well adapted on most soils	Resistant on most soils	Very susceptible	In the 1994 NC-140 rootstock trial with Gala as the cultivar, the size range of M.9 strains ranked Pajam2 = RN(Nic)29 (similar to M.26) > EMLA > T337 > Fluren 56. Suckers heavily; somewhat prone to burrknots ² (variation exists between strains). Promotes good fruit size.
Geneva 41 (G.41)	30 - 45%	Very early bearing, very productive	Needs support	Appears to be very hardy	Well adapted on most soils	Highly resistant	Highly resistant	Promising new rootstock. Produces good fruit size. Induces wide crotch angles. Possible replacement for M.9; been more productive than M.9 Pajam 2 and T337 in the Iowa planting of the 2003 NC-140 rootstock trial, and has not exhibited symptoms of winter injury.
Bud. 9 (B.9)	30 - 40%	Very early bearing, very productive	Needs support	Hardier than M.9, but susceptible in late winter	Well drained soils; does not tolerate wet soils	Very resistant	More tolerant to field infection than M.9	Moderate suckering, very few burrknots ² . Drought susceptible. Suceptible to tomato ringspot virus ³ . Iowa observations suggest it is very susceptible to voles.
Polish 2 (P.2)	30 - 40%	Very early bearing, very productive	Needs support	Very hardy mid-winter, but susceptible in late winter	Best on well drained soils	Resistant	Susceptible	Very little suckering; few burrknots ² . Susceptible to tomato ringspot virus ³ .
Mark	20 - 30%	Very early bearing, very productive	Roots are brittle, needs support	Hardy early, but susceptible in late winter	Best on well drained soils; drought susceptible	Resistant on most soils	Susceptible	Suitable for vigorous cultivars on fertile soils. Very prone to abnormal swelling at the ground line (root mass proliferation) that stunts the tree & reduced fruit size. Moderate suckering; prone to burrknots ² . Moderately susceptible to tomato
Bud. 146 (B.146)	20 - 30%	Very early bearing, very productive	Roots are brittle, needs support	Reported very hardy mid-winter; needs further testing	Well drained soils; needs further testing	Needs further testing	Susceptible	Several strains have been identified with variability existing between strains. Suitable for vigorous cultivars on fertile sites. Moderately prone to suckering and burrknots ² . Consider for planting on a limited trial basis.
Bud.491 (B.491)	20 - 30%	Very early bearing, very productive	Needs support	Reported very hardy mid-winter; needs further testing	Well drained soils	Susceptible	Susceptible	Suitable for vigorous cultivars on fertile soils. Produces few suckers or burrknots ² . Consider for planting on a limited trial basis.
Polish 16 (P.16)	20 - 30%	Very early bearing, very productive	Needs support	Appears very hardy; needs further testing	Well adapted on most soils	Resistant	Susceptible	Suitable for vigorous cultivars on fertile soils. Prone to suckering; produces few burrknots ² . Consider for planting on a limited trial basis.
Geneva 65 (G.65)	10 - 20%	Very early bearing, very productive	Well anchored, support needed for crop	Appears hardy, needs further testing	Well adapted on most soils	Highly resistant	Very resistant	Too dwarfing for most high density orchards; has potential of very vigorous cultivars on fertile sites. Some suckering; nearly no burrknots ² . Susceptible to tomato ringspot ³ & common latent viruses ⁴ . Tends to produce small-sized fruit.
M.27 EMLA 27	10 - 20%	Very early bearing, very productive	Needs support	Moderately hardy, slow to harden-off	Well adapted on most soils	Resistant on most soils	Susceptible	Too dwarfing for most high density orchards; has potential of very vigorous cultivars on fertile sites. Almost no suckering or burrknots ² . Susceptible to tomato
Polish 22 (P.22)	10 - 20%	Very early bearing, very productive	Needs support	Very hardy mid-winter; appears susceptible in late winter	Well adapted on most soils	Resistant	Moderately susceptible	Too dwarfing for most high density orchards; has potential of very vigorous cultivars on fertile sites. Very little suckering or burrknots ² .
Interstem / Rootstock Combinations⁵								
M.27, M.9 / MM.106	45 - 60%	Early bearing, productive	Good on most soils; may need support on light soils or when the interstem-rootstock graft union is above ground	Slightly hardier with the interstem-rootstock graft union below ground	Well drained soils; better adapted with the interstem-rootstock graft union below ground	More tolerant with the interstem-rootstock graft union below ground	Susceptible as M.27 or M.9	Suckering is a problem; can be reduced by planting with the interstem-rootstock graft union below ground.
M.27, M.9 / MM.111	45 - 60%	Early bearing, productive	Good on most soils; may need support on light soils or when the interstem-rootstock graft union is above ground	Moderate	Widely adapted to most soils	Tolerant on most soils	Susceptible as M.27 or M.9	Suckering is a problem; can be reduced by planting with the interstem-rootstock graft union below ground.

Footnotes:

- ¹ Size control as a percentage of the size of a cultivar on a seedling rootstock. Remember that the vigor of the scion, site conditions and management practices also influence the ultimate size of the tree on any rootstock.
- ² Burrknots are above root primordia that form under shaded conditions (either from a trunk wrap or excessive shading). They are very sensitive to winter injury, and potential point of entry for fire blight bacteria and bores.
- ³ Tomato ringspot virus is a nematode-transmitted virus that can induce Apple Union Necrosis and Decline when a sensitive cultivar is propagated on a sensitive rootstock. It has not yet been found in Iowa, but as a precaution, purchase virus-free trees. If the disease is ever found in your orchard, avoid combinations of a sensitive cultivar propagated on a sensitive rootstock. Cultivars sensitive to tomato ringspot virus include: Red Delicious, McIntosh, Paulared, Spartan, Tydeman's Red and Stayman.
- ⁴ Virus problems can be greatly reduced by selecting virus-free cultivars.
- ⁵ Used as interstems, M.27 and M.9 produce similar sized trees. With the present propagation practice of using 6- to 8-inch interstem sections, relative tree size is more dependent upon planting depth: With the interstem-rootstock graft union above ground, tree size is between M.9 and M.26; with the interstem-rootstock graft union below ground, tree size is between M.26 and M.7a and depends on how much of the interstem is exposed.

Resources:

The National Apple Rootstock Breeding Program
TRECO Oregon Rootstock and Tree Co., Inc.
eXtension Apple Rootstocks and Cultivars
NC-140 Regional Rootstock Research Project

<http://www.ars.usda.gov/Main/docs.htm?docid=15654>
<http://www.treco.nu/Rootstock.htm>
<http://extension.org/apples/>
<http://www.nc140.org>