

Characteristics of Apple Rootstocks

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)	100%	Slow bearing, moderate productivity	Well anchored	Considered hardy, may be susc. in late winter	Widely adapted	Resistant, needs further testing	Moderately resistant	Very little suckering; very few burrknots ² .
Antonovka 313 (Ant.313)	100%	Slow bearing, moderate productivity	Well anchored	Considered hardy; susc. 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.	Susceptible	Moderately resistant	Needs further testing.
M.4	80-90%	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 susc. in early winter; hardy in late winter	Best in 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 susc. in late winter.	Best on well drained soils.	Somewhat susceptible ; needs further testing	Tolerant, needs further testing	May be a replacement for MM.106. Almost no suckering; few burrknots ² .
M.7a, EMLA 7	60-70%	Moderately early bearing, moderate productivity.	Free-standing but leans with some cultivars.	Moderate; roots tender, snow cover for best protection	Well adapted on most soils except heavy clay.	Slightly susc. 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	Needs further testing	Needs testing	Resistant	Resistant	Suckering may be a problem. May be released soon.

Rootstock	Size¹	Fruiting	Anchorage	Hardiness	Soil Adaptability	Crown Rot	Fire Blight	Remarks
Supporter 4	55-60%	Very early bearing, good productivity	Better anchored than M.26	Needs testing	Well drained soils	Needs testing	Extremely susceptible	Produces few suckers or burrknots ² . Performs poorly on re-plant sites.
Geneva 30 (G.30)	55-60%	Early bearing, very productive.	Weak graft union with some cultivars, support recommended.	Almost as hardy as M.26.	Well adapted to most soils	Tolerant	Highly resistant	Promising new rootstock. Much less prone to suckering than M.7a; burrknots ² rare. Induces wide crotch angles. Tolerant to re-plant disorder. Susceptible to common latent viruses ⁴ .
Geneva 935 (G.935)	50-60%	Very early bearing, very productive	May need support in early years	Testing required	Well adapted on most soils	Highly resistant	Highly resistant	Promising new rootstock. Produces good fruit size. Induces wide crotch angles. Released in December 2004.
Geneva 202 (G.202)	45-55%	Very early, very productive	Well anchored	Hardier than M.7, needs further testing	Appears well adapted on most soils	Resistant	Highly resistant	Moderate suckering, few burrknots ² . Released in spring 2004.
M.26, EMLA 26	45-55%	Very 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 ring-spot 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 latent viruses ⁴ .
Geneva 16 (G.16)	35-45%	Very early bearing, very productive.	Moderately good, support needed for crop	Needs further testing	Appears well adapted on most soils	Tolerant	Very resistant	Very little suckering; no burrknots ² . Very sensitive to common latent viruses ⁴ , only virus-free scion wood should be used to propagate trees.
M.9 strains	30-45%	Very early bearing, very productive.	Needs support	Slightly harder than M.7a.	Well adapted on most soils	Resistant on most soils	Very susceptible	Suckers heavily; somewhat prone to burrknots ² (variation exists between strains). Promotes good fruit size.
Geneva 41 (G.41)	30-40%	Very early bearing, very productive.	Needs support	Needs further testing	Well adapted on most soils	Highly resistant	Highly resistant	Promising new rootstock. Produces good fruit size. Induces wide crotch angles. Released in December 2004.
Bud. 9 (B.9)	30-40%	Very early bearing, very productive	Needs support	Hardier than M.9, but susc. in late winter	Well drained soils; does to not tolerate wet soils	Very resistant	More tolerant to field infection than M.9	Moderate suckering; very few burrknots ² . Drought susceptible. Susceptible to tomato ringspot virus ³ . ISU observations suggest it is very susceptible to voles.

Rootstock	Size ¹	Fruiting	Anchorage	Hardiness	Soil Adaptability	Crown Rot	Fire Blight	Remarks
Polish 2 (P.2)	30-40%	Very early bearing, very productive	Needs support	Very hardy mid-winter, but susc. in late winter.	Best on well drained soils.	Resistant, needs further testing.	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 susc. in late winter	Best on well drained soils; drought susceptible	Resistant on most soils	Susceptible	Suitable for vigorous cultivars on fertile sites. Very prone to abnormal swelling at ground line (root mass proliferation) that stunts the trees & reduces fruit size. Moderate suckering; prone to burrknots ² . Moderately susceptible to tomato ringspot virus ³ .
Bud. 146 (B.146)	20-30%	Very early bearing, very productive.	Roots are brittle, needs support	Reported very hardy in mid-winter. Needs further testing.	Well drained soils. Needs further testing.	Needs further testing	Susceptible	Several strains have been identified w/ 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 in mid-winter. Needs further testing.	Well drained soils.	Susceptible	Susceptible	Suitable for vigorous cultivars on fertile sites. Produces few suckers and 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 sites. Prone to suckering; produces few burrknots ² .
Geneva 65 (G.65)	10-20%	Very early bearing, very productive. Fruit size reduced.	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 for very vigorous cultivars on fertile sites. Some suckering; nearly no burrknots ² . Susceptible to tomato ring spot ³ , and common latent viruses ⁴ . Difficult to propagate in stool bed.
M.27, EMLA 27	10-20%	Very early bearing, very productive. Fruit size reduced.	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 for very vigorous cultivars on fertile sites. Almost no suckering, or burrknots ² . Susceptible to tomato ringspot virus ³ .
Polish 22 (P.22)	10-20%	Very early bearing, productive.	Needs support	Very hardy mid-winter; appears susc. in late winter.	Well adapted on most soils	Resistant	Moderately susceptible	Too dwarfing for most high density orchards; has potential for very vigorous cultivars on fertile sites. Very little suckering or burrknots ² .

- ¹ Size control as a percentage of the size of a cultivar on a seedling rootstock. Remember that the vigor of the scion cultivar also influences the ultimate size of the tree on any rootstock.
- ² Burrknots are above ground root primordia that form under shaded conditions (either from a trunk wrap or excessive suckering). They are very sensitive to winter injury, and a potential point of entry for fire blight bacteria.
- ³ Tomato ringspot virus is a nematode-transmitted virus that can induce Apple Union Necrosis and Decline disease 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.

Characteristics of Apple Interstem Combinations

Interstem / Rootstock	Size ¹	Fruiting	Anchorage	Hardiness	Soil Adaptability	Crown Rot	Fire Blight	Remarks
M.27, M.9 / MM.106	45-60% ⁵	Early bearing, productive	Good in most soils; may need support on light soils or when the interstem-rootstock graft union is above ground.	Slightly harder with interstem-rootstock graft union below ground	Well drained soils; better adapted with interstem-rootstock graft union below ground	More tolerant with interstem-rootstock graft union below ground	Susceptible as M.27 or M.9	Suckering is a problem; can be reduced by planting interstem-rootstock graft union below ground. Additional cost.
M.27, M.9 / MM.111	45-60% ⁵	Early bearing, productive	Good in 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 interstem-rootstock graft union below ground. Additional cost.

- ¹ Size control as a percentage of the size of a cultivar on a seedling rootstock. Remember that the vigor of the scion cultivar also influences the ultimate size of the tree on any rootstock.
- ² Burrknobs are above ground root primordia that form under shaded conditions (either from a trunk wrap or excessive suckering). They are very sensitive to winter injury, and a potential point of entry for fire blight bacteria.
- ³ Tomato ringspot virus is a nematode-transmitted virus that can induce Apple Union Necrosis and Decline disease 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 the ground, tree size is between M.9 and M.26; with the interstem-rootstock graft union below the ground, tree size is between M.26 and M.7a and depends upon how much of the interstem is exposed.

Sources of information:

Robinson, T., L. Anderson, A. Azarenko, B. Barritt, G. Brown, J. Cline, R. Crassweller, P. Domoto, C. Embree, A. Fennell, D. Ferree, E. Garcia, A. Gaus, G. Greene, C. Hampson, P. Hirst, E. Hoover, S. Johnson, M. Kushad, R. Marini, R. Moran, C. Mullins, M. Parker, R. Perry, J.P. Prive, G. Reighard, C. Rom, T. Roper, J Schupp and M. Warmund. 2002. Performance of Cornell-Geneva rootstocks in North America NC-140 rootstock trials. Compact Fruit Tree 35(4):99-102.

Web Sites:

Apple Rootstock Fact Sheets: <http://www.nysaes.cornell.edu/hort/breeders/appleroots/Factsheets/FSAccess.htm>
 NC-140 Regional Rootstock Research Project: <http://www.nc140.org/>