

## Characteristics of Apple Rootstocks

| Rootstock               | Size <sup>1</sup> | 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 <sup>2</sup> .                     |
| 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 <sup>2</sup> .                                                                                                                                    |
| 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 <sup>2</sup> .                                                                                                                                                |
| 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 <sup>2</sup> .                                                                           |
| 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 <sup>2</sup> . Semi-dwarf with spur-type Delicious strains. Moderately susceptible to tomato ringspot virus <sup>3</sup> . |
| 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 <sup>2</sup> . Very susceptible to tomato ringspot virus <sup>3</sup> .                                                                           |
| 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 <sup>2</sup> .                                                                                                          |
| 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 <sup>2</sup> . 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          | Size <sup>1</sup> | 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 <sup>2</sup> . 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 <sup>2</sup> rare. Induces wide crotch angles. Tolerant to re-plant disorder. Susceptible to common latent viruses <sup>4</sup> .        |
| 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 <sup>2</sup> . 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 <sup>2</sup> . Susceptible to tomato ring-spot virus <sup>3</sup> . 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 <sup>2</sup> . 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 <sup>2</sup> . Moderately susceptible to tomato ringspot virus <sup>3</sup> and common latent viruses <sup>4</sup> . |
| 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 <sup>2</sup> . Very sensitive to common latent viruses <sup>4</sup> , 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 <sup>2</sup> (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 <sup>2</sup> . Drought susceptible. Susceptible to tomato ringspot virus <sup>3</sup> . ISU observations suggest it is very susceptible to voles.                            |

| Rootstock        | Size <sup>1</sup> | 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 <sup>2</sup> . Susceptible to tomato ringspot virus <sup>3</sup> .                                                                                                                                                                                     |
| 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 <sup>2</sup> . Moderately susceptible to tomato ringspot virus <sup>3</sup> . |
| 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 <sup>2</sup> . 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 <sup>2</sup> . 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 <sup>2</sup> .                                                                                                                                                                                 |
| 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 <sup>2</sup> . Susceptible to tomato ring spot <sup>3</sup> , and common latent viruses <sup>4</sup> . 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 <sup>2</sup> . Susceptible to tomato ringspot virus <sup>3</sup> .                                                                               |
| 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 <sup>2</sup> .                                                                                                                                  |

<sup>1</sup> 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.

<sup>2</sup> 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.

<sup>3</sup> 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.

<sup>4</sup> Virus problems can be greatly reduced by selecting virus-free cultivars.

## Characteristics of Apple Interstem Combinations

| Interstem / Rootstock | Size <sup>1</sup>   | Fruiting                  | Anchorage                                                                                                        | Hardiness                                                          | Soil Adaptability                                                                    | Crown Rot                                                       | Fire Blight                | Remarks                                                                                                           |
|-----------------------|---------------------|---------------------------|------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|--------------------------------------------------------------------------------------|-----------------------------------------------------------------|----------------------------|-------------------------------------------------------------------------------------------------------------------|
| M.27, M.9 / MM.106    | 45-60% <sup>5</sup> | Early bearing, productive | Good in most soils; may need support on light soils or when the interstem-rootstock graft union is above ground. | Slightly hardier 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% <sup>5</sup> | 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. |

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<sup>2</sup> 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.

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<sup>4</sup> Virus problems can be greatly reduced by selecting virus-free cultivars.

<sup>5</sup> 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/FSAAccess.htm>

NC-140 Regional Rootstock Research Project: <http://www.nc140.org/>