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Rootstocks for Kentucky Fruit Trees

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Most fruit trees that can be grown in Kentucky do not come true from seed. For example, a tree grown from a Golden Delicious apple seed will produce an apple tree, but the fruit will have different characteristics than Golden Delicious in color, taste, and shape. This is why fruit trees are reproduced by asexual propagation, such as budding and grafting. The desired cultivar, Golden Delicious in the example above, is budded or grafted onto a rootstock, a close genetic relative suitable for the graft. Rootstocks are selected to impart special traits—including dwarfing, disease resistance, and insect resistance.

This publication describes available and some newer rootstocks that may have limited nursery distribution for apple, cherry, peach, pear, and plum trees with comments as to their suitability for Kentucky growers.

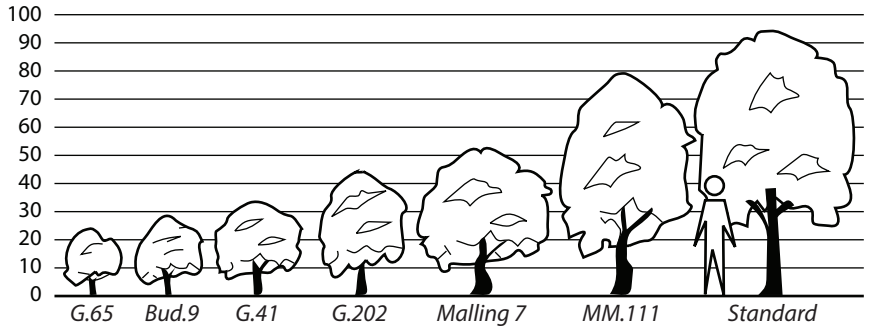
Terminology

The grafted tree consists of the *scion* (e.g., Golden Delicious apple) and the *rootstock* (e.g., B.9). In most nursery catalogs, it would be listed as Golden Delicious/B.9. There are also interstem trees that are found less often. These consist of the scion grafted onto a section of shoot from a dwarf rootstock that provides dwarfing, and this is grafted onto a vigorous rootstock.

Standard trees are full-size trees. They usually have a seedling rootstock and are large. Some standard apple and pear trees may reach heights of 30 feet or more. Rootstocks can be grown from seeds (for example, Halford peach seedlings) or propagated asexually or clonally.

A prefix on apple rootstocks is used to designate the developer of that rootstock. "M" is used to designate rootstocks developed at East Malling Station in Kent, England; "MM" is used for rootstocks developed jointly by John Innes Institute in Merton, England, and the East Malling Station; "B" or "Bud" is used for rootstocks from the Budagovsky breeding program in Russia; "G" is used for rootstocks released and "CG" for rootstocks not yet released from Geneva-Cornell breeding program in New York; "O" is used for rootstocks developed at the Ottawa Research Station in Canada; and "P" is used for rootstocks developed at the Research Institute of Pomology and Floriculture at Skierniewice, Poland.

Figure 1. Comparative dwarfing by rootstocks for apples



Certified disease-free or *virus-free* indicates that the parent rootstock and offspring were subjected to intense inspection and testing and are certified to be disease-free or virus-free. Initial efforts to remove viruses from the M series of rootstocks were not entirely successful, in that only some of the viruses were removed. "A" is used with these rootstocks (e.g., M.7A). EMLA refers to the East Malling and Long Ashton research stations in England that now produces virus-free rootstocks of the East Malling series (EMLA 7 or M.7 EMLA, as opposed to just M.7 or M.7A). Tomato ringspot virus, abbreviated TRSV, is spread by dagger nematodes in the soil and causes apple union necrosis, which can result in a tree breaking off at its graft union. Trees on M.26 and MM.106 are susceptible; M.7 is tolerant. Apple replant disease, characterized by stunted growth, rosette leaves, and reduced fruit production, is caused by a complex of soil organisms that damage the tree's root system. The disease is usually but not always symptomatic of trees planted on sites where an old orchard has been removed to make way for a new one.

Usually, the nursery grows the rootstock for one year before grafting or budding the scion to the rootstock. The trees are then grown for another year. However, June bud peach trees are trees grown from seed and budded in June of the planting year. They are then dug in the fall for sale and planting in the spring. Thus, the scion of a June bud tree is less than 1 year old and is a smaller tree.

Apple Rootstocks

Clonal rootstocks are highly recommended for the commercial apple grower and the backyard hobbyist. These rootstocks control tree size and cause the scion cultivar to begin bearing earlier and produce more heavily than trees on seedling rootstocks (Figure 1). A tree grows throughout its life and even a dwarf tree may get large if it is fertilized heavily, not pruned annually or not cropped consistently. If a dwarf tree is planted with the graft union below the soil line, the scion cultivar will root and the tree will become a full-size standard tree.

The apple rootstocks within each series description below and at the end in Table 1 are in approximate order of increasing mature tree size relative to the standard-size seedling rootstock. The percent of standard size listed is a rough

Table 1. Characteristics of apple rootstocks

Rootstock	Percent of Standard Size	Support Needed[1]	Burr knots	Root-Suckers	Collar Rot[2,3]	Fire Blight[3]	WAA[3]	Latent Viruses[4]	Yield Efficiency[5]	Apple Replant Disease[3]	Comments
M.27	10-20	Y	few	few	MR	S	S		H		Susceptible to TRSV and winter injury. Best in well-drained soils.
G.65	15-30	Y	few	some	R	R	MS	Y	H	T	Not brittle; training support required; irrigation required; very winter hardy.
Bud.9 Treco	25-35	Y	few	some	VR	T	S	N	VH	VS	Treco is the preferred B.9 clone for KY. Recommended only on well-drained sites. B.9 is very susceptible to apple replant disease.
P.2	25-35	Y	few	few	R	MS	S		H		More dwarfing than M.9; slightly less vigorous than M.26; cold hardy; resistant to crown gall; susceptible to TRSV.
G.41[6]	30-40	Y	rare	few	R	R	R	N	VH	T	Very winter hardy and tolerant to apple replant disease. Brittle graft union.
M.9 T337	30-40	Y	some	few	R	S	VS	N	H	S	Certified virus-free by NAKB; attractive to mice; susceptible to nematodes; occasionally winter injured in KY.
M.9 EMLA	30-40	Y	some	few	R	S	VS	N	H	S	Virus-free version of original M.9; susceptible to nematodes; occasionally winter injured in KY.
M.9 Nic29	30-40	Y	some	some	R	S	VS	N	H	S	The clone that has done best in KY, but is not recommended.
G.11	35-45	Y	rare	few	R	R	MS	N	H	MT	Size between M.9 and M.26, and slightly less vigorous than M.9 T337. Similar productivity to M.9.
G.16	35-45	Y	rare	few	R	R	S	Y	VH	MT	Not as brittle as M.9 with better anchorage; shows some signs of resistance to replant disease. Use only virus-free scion wood. Size and productivity similar to M.9.
G.213	35-45	Y	few	few	R	R	R	N	H	T	New and untested in KY.
G.214[6]	35-45	Y	few	few	R	R	R	N	VH	T	Tolerant to apple replant disease
G.202[6]	40-50	Y	rare	few	R	R	R	N	H	T	Produces a tree about the size of M.26 but not as productive as G.935. Moderate tolerance to apple replant disease.
G.222[7]	40-50	Y	some	some	R	R	R	N	H	S	Similar to M.7 in vigor but more productive.
G.814	40-50	Y	some	some	R	R	S	Y	H	T	Produces a tree between M.9 and M.26 in size and is as yield efficient as M.9.
G.935	40-50	Y	rare	few	R	R	S	Y	VH	T	Produces a tree slightly larger than M.26.
M.26 EMLA	40-50	Y	many	few	VS	VS	VS	N	H	VS	Very winter hardy.
G.30	50-70	Y/N	few	some	R	R	S	N	H	T	Better anchorage than M.7. Very winter hardy. Weak graft unions with weak cultivars during early years.
G.969[7]	60-70	N	few	few	R	R	R	N	H	T	New and untested in KY.
G.210[7]	60-70	Y/N	few	few	R	R	R	N	H	R	Similar to M.7 in size but more productive.
M.7 EMLA	60-70	Y/N	few	many	MR	S	S	N	MH	T	Staking the first 4 to 5 years is suggested. Trees are cold hardy.
G.890[7]	70-80	N	few	few	R	R	R	N	H	T	Can be used to grow weak scion cultivars on a free-standing trees. Untested in KY
MM.106	70-80	N	some	few	VS	MS	R	N	M	S	Very susceptible to TRSV. Susceptible to early winter freezes.
MM.111	80-90	N	many	few	R	T	R	N	L	S	The best semi-dwarf for heavy soils but not suitable for high-density orchards.
Bud.118	90	N	rare	rare	S	MR		N	L	S	Productive and well anchored. Very winter hardy.

1 Y = yes, support is needed; N = no, support is not needed; Y/N = may or may not need support depending upon site, etc.
2 *Phytophthora* spp.; also called Collar rot
3 R = resistant; MR = moderately resistant; T = tolerant; MT = moderately tolerant; S = susceptible; VS = very susceptible
4 Latent virus susceptibility; Y = yes; N = no
5 Yield efficiency is a measure of productivity for a given size tree and is calculated as yield in lbs/square inch of trunk cross-sectional area. VH = very high, H = high, MH = moderately high, M = moderate, L = low
6 Highly recommended rootstocks
7 Very promising for trial and have woolly apple aphid resistance

approximation of the tree size and varies considerably due to orchard soil type and area grown in the U.S. (Northern orchard trees are considerably smaller than the same scion/rootstock in southern U.S. orchards.)

Budagovsky Series

This series is from Dr. Valentin Ivanovich Budagovski's breeding program in Michurinsk State Agrarian University. Michurinsk is in the Tambov Region of Russia.

Bud.9, B.9 Treco, B.9 Europe: Size 25 to 35% of standard, a highly dwarfing rootstock. Compared to M.9, B.9 is more winter hardy, more dwarfing, and more resistant to fire blight, collar rot, and woolly apple aphids. Like M.9, trees on B.9 require permanent trellis or post support. Burr knots and suckers are rare. The graft union is smoother than that of M.9. B.9 promotes open scion growth and produces crops in two to three years with yield efficiency comparable to M.9. It is has been highly recommended as a dwarf rootstock in Kentucky on well-drained soils but may "runt out" under heat stress conditions. The B.9 Treco clone is the clone that has done best in Kentucky.

B.10 ('Mich96'): A Russian rootstock from a cross of B.9 and semi-dwarf unpatented '13-14'. It produces a tree about 35 to 40% of standard, about M.9 Pajam 2 size. It is resistant to fire blight, tolerant of crown rot, and somewhat tolerant to replant disease. It has better rooting and hardiness than B.9, and improved frost resistance.

Bud.118, B.118: Size 90% of seedling size, similar to EMLA 111. It is very winter hardy, well-anchored, and grows well in most soils. It is free standing, but too vigorous for high-density plantings.

Geneva® Series

This series of rootstocks originated from the breeding program of Dr. James N. Cummins and Dr. Herb Aldwinckle at New York State Agriculture Expt. Station, Cornell University and USDA-ARS, Geneva, New York. All of their stocks are patented. Many of these look very good for Kentucky apple growers because of their fire blight, collar rot, woolly apple aphid, and apple replant disease resistance as well as high yield efficiency and low incidence of burr knots and root suckers. Some of the newer releases may not be available through nurseries yet. A very good chart summarizing these stocks and their characteristics can be found at http://www.ctl.cornell.edu/plants/GENEVA-Apple-Rootstocks-Comparison-Chart.pdf.

G.65: Size 15 to 30% of standard, this rootstock was the first introduction from the breeding program. It originated from a M.27 x Beauty Crab cross made in 1974 and was introduced in 1991. G.65 is precocious, very productive, and produces some root suckers but few burr knots. It is resistant to Phytophthora root rot (also denoted as collar rot or crown rot) and very resistant to fire blight. It is moderately susceptible to woolly apple aphids and is highly sensitive to latent viruses. Trees on G.65 are sturdy and well-anchored, producing trees between those of M.27 and M.9 in size.

G.41: Size 30 to 40% of standard, it is an Ottawa 3 (*Malus domestica*) x Robusta 5 (*M. x robusta*) cross that was selected for its resistance to crown rot, fire blight, and woolly apple aphid. It is a little more dwarfing than M.9 but highly yield efficient, very precocious, very cold hardy, and replant-disease–tolerant. Graft unions are particularly brittle during the first few growing seasons, and trees need to be well supported.

G.16: Size 35 to 45% of standard, it is highly sensitive to common latent viruses, and only virus-free scion wood should be used. It is tolerant to crown rot, has strong resistance to fire blight and scab, and has some tolerance to apple replant disease. G.16 is not brittle and is well anchored. Suckers and burr knots are rare. Some graft union breakage has been observed in one of our plantings.

G.11: Size 35 to 45% of standard, it is less attractive to woolly apple aphid than is M.26 and moderately resistant to both fire blight and collar rot. Precocious with high yield efficiency, it seldom has burr knots or suckers. It is comparable to M.9 in vigor.

G.213: Size 35 to 45% of standard, is highly resistant to fire blight that produces a tree with a size comparable to that of M.9 T337. It is tolerant to replant disease complex and crown and root rots (Phytophthora). It is also resistant to woolly apple aphid and not susceptible to latent viruses. It is as productive and yield efficient as M.9. Cold hardiness is yet to be determined.

G.214: This rootstock produces a tree between M.9 and M.26 in size, 35 to 45% of standard. It was introduced in 2010 from a 1975 cross of Ottawa 3 x Robusta 5, and tested as CG.4214. It has similar vigor and precocity as M.9 Nic 29, and M.26, but is more productive, has good cold hardiness, and is resistant to fire blight, Phytophthora root rot, and woolly apple aphid.

G.814: A new rootstock that is highly resistant to fire blight that produces a tree between M.9 and M.26, about 40 to 50% of standard size. It is tolerant to replant disease complex and crown and root rots (Phytophthora) but is not resistant to woolly apple aphid and is susceptible to latent viruses. It is cold hardy, productive, and as yield efficient as M.9.

G.935: Size 40 to 50% of standard, produces a tree that is between M.26 and M.7 size with excellent production. It is resistant to crown rot and fire blight and is very cold hardy and tolerant to replant disease but is susceptible to woolly apple aphid and latent viruses.

G.202: Size 40 to 50% of standard, selected mostly for its ability to root/propagate. It is resistant to woolly apple aphids as well as crown rot and fire blight, and produces a tree that is between M.26 and G.11 in size but is not as productive as G.11. It may be a good rootstock for weak scions such as Honeycrisp and highly precocious scions with a tendency to produce oversize fruit.

G.222: A semi-dwarfing rootstock that produces a tree 45 to 55% of standard size with similar vigor to M.7 but more precocious and productive. This rootstock was introduced in 2011. It has good cold hardiness, and resistance to fire blight, Phytophthora root rot and woolly apple aphid. Young grafted trees need support. It is not very tolerant to replant disease.

G.30: Size 50 to 70% of standard, it is more precocious and more productive than

M.7, with yield efficiencies three to five times better than M.7, and is less prone to suckers and burr knots. It is resistant to crown rot and fire blight but tends to have thorns that must be cut off before planting. G.30 forms weak graft unions with brittle cultivars during the early years and is not recommended for use with Gala, Golden Delicious, Honeycrisp, Jonagold, or Braeburn. Tree support is highly recommended.

G.969: A semi dwarfing rootstock that produces a tree 60 to 70% of standard with similar vigor to M.7. It originated from a 1976 cross of Ottawa 3 x Robusta 5, was tested as CG.6969, and introduced in 2010. The grafted tree is free standing, precocious, and productive, and has good cold hardiness and resistance to fire blight, Phytophthora root rot, and woolly apple aphid.

G.210: A semi-dwarfing rootstock that produces trees 60% to 70% of standard, about M.7 and G.30 in size. It was introduced in 2010 from a 1975 cross of Ottawa 3 x Robusta 5, and tested as CG.6210. It is resistant to crown rot, fire blight, woolly apple aphid, and replant disease. The grafted tree is semi-freestanding and intended for use with processing orchards or weak scion cultivars. It has higher precociousness for scions than M.7, cumulative yield efficiency similar to M.9, good cold hardiness, and resistance to fire blight and woolly apple aphid. It is tolerant to the replant disease complex.

G.890: A semi-dwarfing apple rootstock that produces a tree 70 to 80% of standard size with vigor similar to that of MM.106. It originated from a 1976 cross of Ottawa 3 x Robusta 5, was tested as CG.5890, and introduced in 2010. The grafted tree is free-standing and intended for processing orchards or weak scion cultivars. It is more precocious than M7 and M106. G.890 is tolerant to replant disease, and resistant to fire blight, crown rot, and woolly apple aphid. It is a winter hardy rootstock with low suckering and cumulative yield efficiency similar to M.9.

Malling Series

Malling 27 (M.27): Released in 1991, trees on this rootstock are 15% of standard and rarely produce suckers. Must be supported and is not recommended for commercial production in Kentucky because the tree is too small. Cultivars on this stock are early bearing and productive but have reduced fruit size. It is resistant to collar rot if planted in well-drained soils, but it is susceptible to fire blight and tomato ringspot virus. The rootstock is slow to harden off in the fall and is more susceptible to winter injury.

Malling 9 T337 (M.9 T337, M.9 NAKBT337): Size 30 to 40% of standard. It is a certified selection of M.9 tested for viruses by the General Netherlands Inspection Service for Woody Nursery Stock (NAKB), usually referred to in nursery catalogs as M.9 T337. It fruits early and is productive for its size. Trees on M.9 NAKBT337 are slightly less dwarfing than the classic M.9 but should still be supported by a wire trellis or posts. The rootstock is susceptible to nematodes, woolly apple aphid, and fire blight but is resistant to Phytophthora root rot. It requires irrigation on sandy soils and responds well to mulching on most soils but is unusually attractive to mice. It is suitable for high-density plantings. This is the preferred M.9 clone in Kentucky but is as susceptible to winter injury as the classic M.9 in extreme cold winters.

Malling 9 (M.9 EMLA): Size 30 to 40% of standard. Similar to the classic M.9 that was received from East Malling in 1931. It is a replacement clone that has undergone heat treatment to eliminate common latent virus. The rootstock is susceptible to nematodes, woolly apple aphid, and fire blight but is resistant to Phytophthora root rot (crown or collar rot). Winter injury is an occasional problem in Kentucky.

Malling 9 Nic29 (M.9 Nic29, aka M.9 Pajam 2): Size 30 to 40% of standard. A mutation of M.9 discovered and developed by Rene Nicolai at his nursery in Belgium. M.9 Nic29 is recommended for use with cultivars that are less vigorous such as Empire or Honeycrisp. M.9 Nic29 has slightly more vigor than other clones of Malling 9 yet is similar in other horticultural characteristics.

Malling 26 (M.26 EMLA): Size 40 to 50% of standard. Provides somewhat better anchorage than the M.9 clones, but staking or other support is recommended for all but the most compact cultivars. Empire and similar cultivars fruit too early on M.26, and chemical fruit thinning should be used to prevent loss of leaders. Most cultivars have been quite productive on M.26, but those especially susceptible to fire blight (such as Gala and Jonathan) should be avoided. Susceptible to fire blight, woolly apple aphid, and crown rot, M.26 is the most tolerant of low winter temperatures of all the English rootstocks but requires a well-drained but not droughty soil. Under Kentucky conditions, problems with fire blight and collar rot have severely limited sites and cultivars with which it can be used.

Malling 7 (M.7, M.7A, and M.7 EMLA): Size 60 to 70% of standard, it performs best on deep, well-drained soil and is somewhat drought tolerant. While most trees on M.7 are self-supporting, staking for the first four to five years is suggested. M.7 should be used as a rootstock for Delicious and Idared on only the most favorable sites as it produces larger than desired trees. M.7 is prone to burr knots and suckers badly but is resistant to fire blight and crown rot. The virus-free clone of M.7 is M.7 EMLA; it has exceptional winter hardiness.

Malling-Merton 106 (MM.106): Size 70 to 80% of standard, it is consistently a highly productive rootstock. Much better anchored and substantially more productive than trees on M.7, it hardens off late in the fall and can be damaged by early freezes. Early bearing with few suckers, its susceptibility to collar rot and early winter injury restricts its usefulness in Kentucky. It is resistant to woolly apple aphid. It should not be planted on sites with poorly drained soil. Trees of Red Delicious and some other cultivars on MM.106 are susceptible to union necrosis and decline caused by tomato ringspot virus.

Malling-Merton 111 (MM.111, EMLA 111): Produces trees 80 to 90% of standard that are moderately slow to bear with medium productivity. More drought tolerant and better anchored than most other rootstocks, it is resistant to woolly apple aphid and has been an outstanding rootstock for Idared, spur-type Red Deli-

cious, spur-type McIntosh, Jonathan, and Rome Beauty. Best adapted clonal stock for survival in Kentucky, particularly on heavy soil. However, it is too large for most plantings.

Interstem B.9 or M.9/MM.111: Made by interposing a 6- to 10-inch stem piece of either B.9 or M.9 between the MM.111 rootstock and the scion cultivar. Dwarfing effect of the interstem is less than if either B.9 or M.9 is used directly as a rootstock and results in a tree that is moderately dwarf to large semi-dwarf in size. Mature stature intermediate in size to trees on G.11 to M.7 rootstocks (30-70% of standard) are possible, depending on the length of the stem piece, orchard growing conditions, and scion cultivar. Staking can usually be avoided, but the tree should be planted with the soil level halfway up on the interstem. It is more tolerant of drought than either B.9 or M.9 alone and is collar rot resistant.

Canadian Rootstocks

Ottawa 3 (0.3): Size 40 to 50% of standard, it is very productive and early bearing, susceptible to fire blight, woolly apple aphids, and tomato ringspot virus but is resistant to collar rot. It is sensitive to extremely acidic soils but is free of suckers and burr knots. Support has not been required in Kentucky. This rootstock has fallen out of favor and is no longer widely planted.

P Series

A breeding program at the Research Institute of Pomology and Floriculture at Skierniewice, Poland, began in 1954 to develop rootstocks hardier than those in the Malling series. These stocks are known as the P series (percent of standard size is in parentheses): P1 (70), P2 (30), P14 (65), P16 (35), P18 (100), P22 (30), P59 (28), P60 (55), P61 (29), P62 (32), P63 (22), P64 (18), P65 (28), P66 (42), P67 (52), and P68 (48). P.67 and P.68 have been reported to have low susceptibility to fire blight and P.66 medium susceptibility. Although all of these rootstocks are listed in the Polish National List of Fruit Plant Varieties, their availability in the USA is limited to negligible. A few of the more common ones are listed below.

P.22: Size is 15 to 25% of standard. Trees on P.22 are less vigorous than trees on M.9. It is resistant to collar rot and highly resistant to apple scab, powdery mildew, and crown gall. It is susceptible to woolly aphid and fire blight, but burr knots and suckers are rare. Exceptionally winter hardy but is considered to produce too small of a tree and is not recommended for Kentucky.

P.2: Size 25 to 35% of standard, its cropping efficiency is similar to M.9, and it is resistant to collar rot and crown gall. It is slightly susceptible to fire blight and woolly apple aphid. Trees require a permanent trellis or post support.

P.1: A dwarfing rootstock with vigor similar to M.7. It is considered resistant to collar rot, but susceptible to woolly apple aphid and fire blight.

P.18: A well-anchored, hardy, widely-adapted rootstock that produces a tree the same size as a standard seedling. It is very resistant to crown rot and moderately resistant to fire blight. It has very little suckering and very few burr knots.

Pear Rootstocks

Pear rootstocks that control size in European pears generally do not dwarf Asian pears. A good source of pear rootstock information can be found at: http://treefruit.wsu.edu/web-article/pear-rootstocks/.

Pyrodwarf: A new rootstock which produces trees that are 50% of standard without reducing fruit size. It is a cross of Old Home x Bonnie Luise. Pyrodwarf is precocious, has moderate resistance to fire blight, and does not root sucker. It has not been evaluated in Kentucky, but its moderate resistance to fire blight makes it of questionable value.

Quince A: Size is 45 to 55% of standard. A semi-dwarfing pear rootstock selected at the East Malling Station, England. Quince A is more vigorous but not as precocious as Quince C. Quince A is resistant to crown gall, mildew, nematodes, and pear decline but is very susceptible to fire blight and produces too many root suckers. Provence Quince, from France, produces a tree 65% of standard. None of these are recommended for Kentucky.

OHxF 333: Size is 50 to 70% standard. It is a semi-dwarfing pear rootstock from Oregon. In limited tests at Geneva, Bartlett trees on OHxF 333 rootstock were about half standard size, while Bosc trees on OHxF 333 rootstock were about two-thirds standard size. It is resistant to fire blight, collar rot, woolly pear aphid, and pear decline. Trees are productive, precocious, and well-anchored. Some report that fruit size is reduced. It does not dwarf Asian pear. We think OHxF 333 is worthy of commercial planting.

OHxF 87: Size is 60 to 70% of standard, it is a semi-vigorous pear rootstock, resistant to fire blight, crown rot, woolly pear aphids, and pear decline. OHxF 87 is a precocious and well-anchored pear rootstock. This rootstock is highly recommended for commercial planting in Kentucky.

OHxF 97: Is a vigorous, disease-resistant rootstock sibling of OHxF 333. Bartlett and Bosc cultivars grafted on OHxF 97 have produced standard-size (100%) trees that are more productive and precocious than trees on seedling rootstock. OHxF 97 works well for Asian pears.

Old Home: Hardy, fire-blight-resistant cultivar primarily used as a rootstock; produces standard-size trees.

Pyrus betulifolia (seedling): Produces standard-size trees. It is recommended for Asian pears as it increases fruit size.

Cherry Rootstocks

Mazzard: Standard rootstock for cherry; the preferred rootstock for both tart and sweet cherries in Kentucky. Produces a full-sized tree.

Gisela®3, Gisela®5, Gisela®6 and Gisela®12: These are the result of a breeding program in Giessen, Germany, and stand for GIessen's SELection for *Prunus avium*. They produce trees about 35%, 45 to 50%, 60 to 65%, and 55 to 60% of the size of trees on Mazzard rootstock in the Eastern U.S., respectively. Trees need to be supported and intensively managed through appropriate irrigation, pruning, and fertilization so as to prevent overcropping. All do well in heavy soils. Gi. 3 and Gi.5 have been shown to reduce sweet cherry fruit size and sugar content

when overcropped. Gi. 6 is less tolerant of bacterial canker.

Colt: Released in 1977 from East Malling Research Station, it produces trees about the size of Mazzard. It is very vigorous, has good anchorage, does well in heavy clay soils, but is not cold hardy.

Krymsk®5, Krymsk®6 and Krymsk®7: The Krymsk series originates from the breeding program in Vavilov Research Institute in Russia. They produce trees about 50 to 60%, 70 to 80%, and 90% the size of those grown on Mazzard in the Eastern U.S., respectively. Trees are tolerant of water stress and are adaptable to a range of soil conditions. Krymsk®5 and 6 are precocious and compatible with all cherries but are sensitive to Prunus ringspot and Prunus dwarf virus.

Clinton, Lake, Cass, Crawford, and Clare: Developed by Dr. Amy Iezzoni's cherry rootstock breeding program at Michigan State, and still being evaluated. Clinton produces trees about 50-60% the size of Mazzard. Lake, Cass, and Crawford produce trees about 40-50% of the size of Mazzard. Clare produces trees about 35-40% of the size of Mazzard.

Peach Rootstocks

Guardian: A registered nematode-resistant rootstock that is a southeastern standard. It has slightly less resistance to root-knot nematode (*Meloidogyne* spp.) than Nemaguard, but greater resistance to ring nematode and is thus less susceptible to bacterial canker and peach tree short life. This rootstock has performed very well in Kentucky trials and is highly recommended.

Halford: Peach seedling rootstock that performs similarly to Lovell in Kentucky but is difficult to find.

Lovell: Peach seedling rootstock that has been outstanding in most NC-140 trials, survives very well in Kentucky, and is highly recommended. It is susceptible to root-knot and root-lesion (*Pratylenchus vulnus*) nematode and to oak-root fungus, and somewhat susceptible to bacterial canker. It is becoming difficult to find.

Mariana 2624: Will produce a semi-dwarf tree 10 to 15 feet tall. It does well on wet soils and tolerates a variety of soils. It is compatible as a rootstock for plums and peaches.

Monegro: A clonal almond X peach hybrid rootstock for almond. Origin: Unidad de Fruticultura, SIA–DGA, Zaragoza, Spain. A cross of Garfi almond x Nemared peach, selected in 1987, and tested as GN-9. Introduced in 1999. It is readily propagated via softwood and hardwood cuttings; the unbudded tree has red leaves. It is adapted to calcareous soils; resistant to lime-induced chlorosis, superior to peach seedling rootstocks; performs well under drought conditions; has significantly higher vigor than trees budded on peach seedling rootstocks, comparable to GF677. Fruit production is similar to GF677, and is resistant to a broad range of root-knot nematodes including *M. arenaria, M. incognita, M. javanica, and M. hispanica.*

MP-29: Semi-dwarf plum-peach hybrid rootstock with moderate vigor that produces a tree about 70% the size of trees on Guardian but with better yield efficiency. It is resistant to peach tree short life and *Armilaria* root rot and several species of root-knot nematodes including *M. incognita* and *M. floridensis.*

Nemaguard: A Chinese rootstock that induces late blooming but is very susceptible to wet-feet. It is a nematode-resistant rootstock that is not winter hardy in Kentucky.

Rutgers Red Leaf: Originated at Rutgers University, New Brunswick, New Jersey, and introduced by M.A. Blake in 1947. Parentage is unknown. The small white-fleshed freestone fruit is of no value, but the tree is used as a source of hardy seedling rootstock that is readily identified by its red leaves in the nursery.

Sharpe: Clonal plum hybrid rootstock for peach. Origin is USDA-ARS, Byron, Georgia, and University of Florida, by R. Sharpe (UFL), T. Beckman (USDA-ARS), J. Chaparro (UFL), and W. Sherman (UFL). A cross of *P. angustifolia* x unknown species, discovered in Florida and tested as FLA1-1. Introduced in 2007. It is readily propagated by softwood and hardwood cuttings and has a chilling requirement of 500 h. Budded trees display moderate vigor, 60% less than trees budded on seedling rootstock; more resistant to armillaria root rot (*Armillaria tabescens*) than Guardian; resistant to peach tree short life similar to Guardian; resistant to root-knot nematodes (*M. incognita* and *M. floridensis*), similar to Nemaguard and Flordaguard, respectively; suggested for armillaria root rot infested sites.

St. Julian GF 655-2: A clonal rootstock for peaches and plums that produces moderately vigorous, productive trees that do well on heavy, wet soils. Resistance to Phytophthora and bacterial canker is fair.

Tennessee Natural: Not recommended in Kentucky.

Bailey: Survived better than Lovell and Halford in Illinois trials and yielded similarly to these rootstocks. It is recommended for Kentucky.

Stocks from Zaiger Genetics Breeding Program

Atlas™: This Zaiger Genetics patented peach-almond-plum-apricot hybrid rootstock has about 120 percent of the vigor of Lovell and has nematode resistance similar to Nemaguard. It is well-anchored and productive with good fruit size. It may be intolerant of wet soil conditions and delay fruit maturity in some varieties. It performed very well in Kentucky trials and is highly recommended.

Viking™: This Zaiger Genetics–patented peach-almond-plum-apricot hybrid rootstock has about 110 percent of the vigor of Lovell. It is well-anchored and has nematode resistance similar to Nemaguard. Scions are precocious and productive with good fruit size. Trees show tolerance of wet soil conditions.

Citation: This patented dwarfing rootstock for peaches and plums is a complex peach x plum hybrid bred by Floyd Zaiger of California. Peach trees on Citation are about half of standard size; Redhaven/Citation have not performed well in two trials in Kentucky and are not recommended for Kentucky.

Agromillora Catalana Breeding Program

A number of peach rootstocks have originated from the Agromillora Catalana breeding program in Barcelona, Spain. Only Replantpac has been tested in Kentucky.

Densipac (Rootpac 20): Clonal plum hybrid rootstock for peach and nectarine, *P. besseyi* x *P. cerasifera* (both unpatented, unnamed clones); selected in 1998 by J. Pinochet, tested as PAC 9801-02, introduced in 2011. It is propagated easily via tissue culture; the unbudded tree has a semi-erect, compact form, a medium chilling requirement (600–800 h), and is reproductively sterile. It is low vigor similar to GF655-2, advances fruit maturity and increases fruit size compared to peach rootstocks, has little or no rootstock suckering, is tolerant of calcareous and wet soils, has moderate resistance to root-knot nematode, resistance to lesion nematode populations and to *Rosellinia necatrix* root fungus, and has good compatibility with peach and nectarine varieties.

Greenpac: A clonal, complex hybrid rootstock for peach, from Agromillora Catalana, Barcelona, Spain, by J. Pinochet. A cross of Felinem (almond x peach) x Cadaman (peach x davidiana), tested as PAC 9904-01 and introduced in 2009. It is propagated via hardwood cuttings with difficulty but propagates easily via in vitro methods. The unbudded tree is vigorous with green leaves, appears to be sterile, and has a chilling requirement of 400–600 h. It has good compatibility with a wide range of peach and nectarine cultivars; grafted trees are vigorous, comparable to those on GF677, and fruit production is superior to that of GF677. It is adapted to calcareous soils, resistant to lime-induced chlorosis, resistant to *M. incognita* root-knot nematode, and moderately resistant to *M. javanica*. It is not tolerant to waterlogging, and is susceptible to crown gall (*Agrobacterium tumefaciens*) and likely susceptible to lesion nematodes.

Replantpac™: A rootstock originating from Agromillora Catalana breeding program. It is a plum x almond rootstock that produces a tree with about 110% of the vigor as Lovell, similar to Mariana 2624. It was the most vigorous rootstock in 2009 NC-140 peach rootstock trial at Princeton, Kentucky, though somewhat less productive than Lovell. It is very resistant to root-knot nematodes and slightly susceptible to lesion nematodes, and its survival rate in replanted soils has been high.

Krymsk Rootstocks

These rootstocks originate from the breeding program in Vavilov Research Institute in Russia.

Krymsk 1: This dwarfing rootstock produces a tree about 50% the size of that of Lovell. Krymsk 1 had the highest mortality (75%) of any of the rootstocks tested in the 2009 peach rootstock trial at Princeton, Kentucky, and is not recommended.

Krymsk 2: A patented (USPP 15,957) interspecific cross of *P. incana* x *P. tomentosa* that was released in 2005. Trees on this stock are about 60% of the size of standard peach seedlings. This rootstock is untested in Kentucky.

Krymsk®86: Is a peach/plum hybrid that produces a tree similar in size to Lovell. Its yield and yield efficiency were significantly lower than that of Lovell in the 2009 NC-140 peach rootstock trial at Princeton, Kentucky. It is susceptible to nematodes, but more tolerant to oak root fungus than Mariana 2624 and has less sensitivity to Phytophthora and less susceptibility to *Verticillium* than Lovell.

Controller™ Series

The Controller™ rootstocks are from the breeding programs at the University of California, Davis, and the USDA-ARS at Fresno, California. Several of these rootstocks are typically listed as numbered HBOK selections, being crosses of Harrow Blood x Okinawa. Harrow Blood originated in Harrow, Ontario, Canada, through the efforts of G.M. Weaver. Introduced in 1967, it was recommended as a dwarfing rootstock for peach in root knot nematode infested areas but did not perform well in Kentucky. Okinawa originated in Gainesville, Florida, by R.H. Sharpe, who imported the seed from Okinawa. The tree was introduced in 1957 with resistance to root knot nematodes.

Controller 5™: Introduced in 2004, from a cross between an unnamed plum selection from the USDA-ARS Fresno breeding program ('K47-31') x 'Flavorcrest' peach. It produces a tree about 60% of the size of Lovell, or 50 to 60% of that of Nemaguard. Yield efficiency was about 10 to 15% of that of Lovell in the 2009 NC-140 peach rootstock trial at Princeton, Kentucky. This rootstock survived well and root suckering was negligible.

HBOK 10 (Controller 8™): Introduced in 2010. It has low to moderate vigor, about 60% the size of trees on Nemaguard or 90% of Lovell; yield efficiency and tree survival were comparable to trees on Lovell in the 2009 NC-140 peach rootstock trial in Princeton, Kentucky; root suckering was negligible and anchorage was good. This rootstock is (heterozygous) resistant to root-knot nematode (*M. incognita*) and has lower reproduction of lesion nematode compared to Nemaguard.

HBOK 27 (Controller 6™): Introduced in 2012. Produces a tree with low to moderate vigor, about 50% the size of trees on Nemaguard; yield efficiency is comparable to trees on Nemaguard; very few root suckers with moderate resistance to root-knot nematode (*M. incognita*).

HBOK 32 (Controller 7™): Introduced in 2010. It has low to moderate vigor, about 60% the size of trees on Nemaguard, or about 80% of Lovell. It had a yield efficiency comparable to trees on Lovell in the 2009 NC-140 peach rootstock trial at Princeton, Kentucky, with little or no root suckers. It is (homozygous) resistant to root-knot nematode (*M. incognita*) with reproduction of lesion nematode comparable to Nemaguard.

HBOK 50 (Controller 9.5™): Introduced in 2010 from a peach F2 hybrid. Size and yield efficiency is comparable to trees on Nemaguard. It has few, if any, root suckers, (heterozygous) resistance to root-knot nematode (*M. incognita*), and lower reproduction of lesion nematode compared to Nemaguard.

Plum Rootstocks

Many of the rootstocks that can be used with peaches can also be used with plums. Some specific rootstocks recommended for growing plums in Kentucky are listed below.

St. Julian GF 655-2: A clonal rootstock for peaches and plums that produces moderately vigorous, productive trees that do well on heavy, wet soils and have fair resistance to Phytophthora and bacterial canker.

Myrobolan (Myro): A standard-size rootstock that produces a well-anchored tree, grows well on a wide range of soil types, and is highly compatible with many cultivars. Suckers at the trunk base are common.

Marianna GF 8-1: A vigorous French rootstock, somewhat more tolerant of poorly drained soils than Myrobolan. Winter hardiness is questionable. It is tolerant of calcareous soils but is sensitive to common nematodes. It is only suggested for limited trial.

Kentucky Rootstock Research

The University of Kentucky has an ongoing program for evaluating fruit tree rootstocks. UK is a member of NC-140, a cooperative rootstock research group whose membership includes most fruit-producing areas in the United States, in addition to Mexico, Australia, and three provinces in Canada. Because rootstock evaluation is a long-term project, this group plans and executes cooperative research projects. Sharing of information and the cooperative effort reduces the time needed to evaluate rootstock characteristics. Kentucky rootstock evaluation plantings are located at the UK Research and Education Center in Princeton. Results of these trials are published annually in the Fruit and Vegetable Research Report which may be found at http://www2.ca.uky.edu/agcomm/pubs/PR/PR757/PR757.pdf.

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