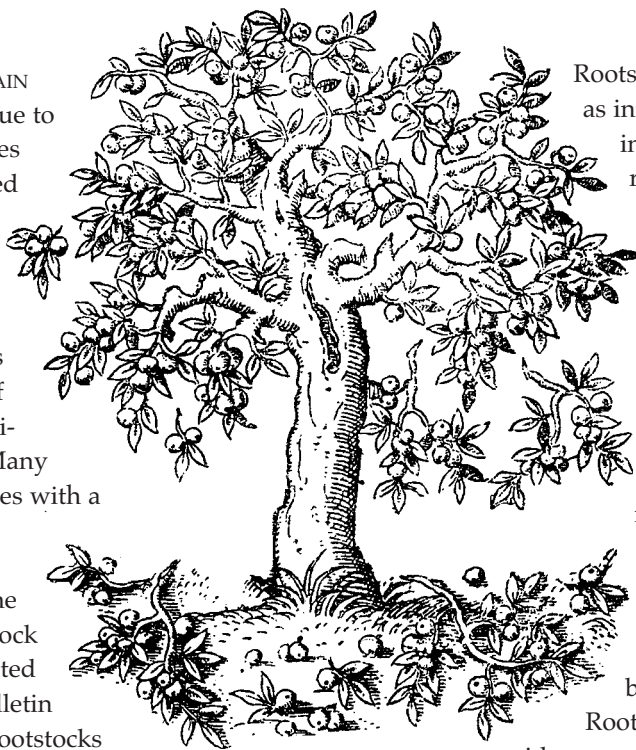


# ROOTSTOCKS FOR FRUIT TREES IN WISCONSIN

**I**N ORDER TO OBTAIN fruit that is true to type, fruit trees are propagated by budding or grafting sections of known cultivars (scions) onto special rootstocks. This creates fruit trees composed of two parts: a scion (cultivar) and a rootstock. Many nurseries now offer trees with a choice of several rootstocks. In this way growers may choose the particular scion/rootstock combination that is suited to their needs. This bulletin describes the various rootstocks available for fruit crops that can be successfully grown in Wisconsin.



Rootstocks may also be used as interstems, a small piece inserted between the rootstock and scion in the propagation process. These trees are known as “three-piece” trees. Interstems reduce the high vigor of otherwise desirable rootstocks.

Some rootstocks are more susceptible to diseases or insects than others. Disease resistance is a major component of rootstock breeding programs.

Rootstocks may also provide some degree of tolerance to soils that are sometimes too wet or too dry.

Rootstocks play an essential role in determining orchard performance. They are responsible for water and mineral uptake and provide anchorage for the tree.

Rootstocks may be winter hardy or cold tender. If the rootstock is killed by cold winter temperatures the scion will leaf out in the spring, but as soon as temperatures warm up, the entire tree will die. Only winter-hardy rootstocks should be planted in Wisconsin.

Rootstocks determine tree size. Small trees are more efficient and may be planted closer together in the orchard. The rootstock has a great effect on how soon a tree begins to produce fruit. Dwarf trees will bear fruit earlier than large trees.

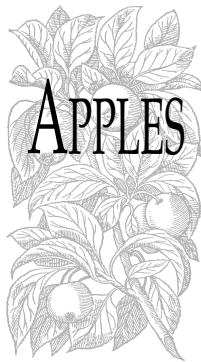
## TYPES OF ROOTSTOCKS

Rootstocks are classified according to tree size and how they are propagated. We commonly refer to rootstocks as dwarfing, semi-dwarfing, or standard, an indication of tree size for cultivars propagated on a particular rootstock. Smaller trees are more efficient, more productive, and more precocious than their larger counterparts.

Rootstocks may be propagated by either asexual or sexual means. Asexually (or vegetatively) propagated rootstocks, known as clonal rootstocks, are produced via cuttings, stooling, or tissue culture. These stocks are genetically uniform. Sexually propagated rootstocks are produced from seed. They are known as seedling or stan-

standard rootstocks and are not genetically uniform. Each propagation method has its advantages, and one type should not be rejected for its propagation method alone. Indeed, most stone-fruit rootstocks come from seed.

Each type of fruit has its own particular rootstocks. Generally, the rootstock must be of the same genus as the scion in order to produce a successful graft.



BEFORE THE EARLY 1950s MOST apple trees sold in North America were propagated on seedling rootstocks. These rootstocks were produced from seeds of apple cultivars expected to be vigorous, winter hardy, or disease resistant or to have other desirable horticultural traits. Trees produced this way were highly variable and the trees were large, slow to bear, and difficult to manage. Since the late 1950s clonal dwarf and semi-dwarf trees have become popular.

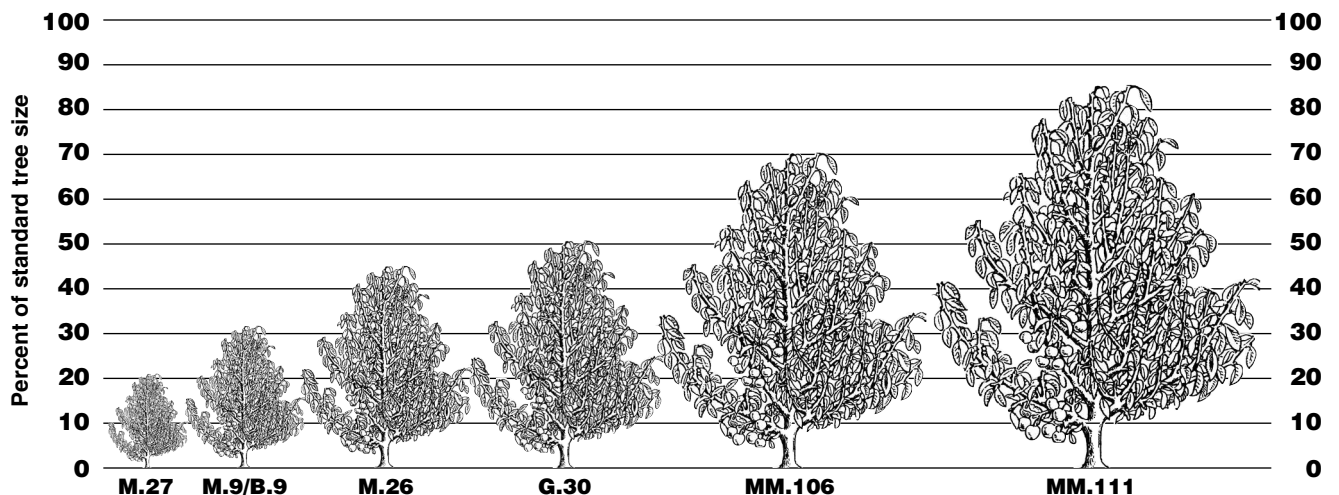
As early as the late 1500s gardeners observed that some apple and pear trees were smaller than others. The roots of these trees were propagated and apple scions grafted onto them. At first this technique was only used in small private gardens, but

in the late 1800s European orchardists recognized the possibilities of smaller trees for commercial orchards.

The initial period of commercial use resulted in substantial confusion as new size-controlling rootstocks were introduced with the same names as older materials and the older stocks acquired many different local names. Beginning in 1912, workers at the East Malling Research Station in England collected and catalogued many of the dwarfing rootstocks throughout Europe and Great Britain. In 1917 the first of these rootstocks were released, designated with the Roman numerals M.I to M.IX (they have since been renamed using arabic numbers). Also in 1917 the Malling Immune series (MI) was introduced, although none of these stocks ever came into wide usage. In 1952 the Malling-Merton (MM) apple rootstock series was released. These rootstocks, designated MM.101 to MM.115, are resistant to woolly apple aphid. Additional work at the East Malling station led to the introduction of the Malling rootstocks through M.27, which is the last to have been released from that program.

Virus-infected rootstocks can transmit viruses to the scion. All of the early size-controlling rootstocks were virus infected. The East Malling and Long Ashton Stations cooperated to remove viruses from the rootstocks. These were subse-

**Figure 1. Relative size of apple trees propagated on clonal apple rootstocks.**



quently introduced in the late 1950s and early 1960s. They were identified as M.7a, M.9a, etc., which are partially virus free, and EMLA 7, EMLA 9, and EMLA 27, etc., which are free of all known viruses. Eliminating viruses from these stocks increased their vigor by 10–15%.

Apple rootstocks can be divided into four size categories: dwarfing, semi-dwarfing, semi-vigorous, and vigorous. While these size classes are not absolute, they will give some indication of final tree size (figure 1). The scion also has a great effect on final tree size. Vigorous cultivars will produce larger trees than cultivars with a strong spur-type growth habit.

The following sections provide summary information on rootstock characteristics that should apply to most areas in Wisconsin. Apple rootstocks are listed in order of increasing size.

### **Dwarf**

**M.27**—This is the most recent and the smallest of the Malling clones. M.27 is very dwarfing, often producing a bush rather than a tree. Trees on M.27 are only 15–20% of seedling size. It typically is not used in commercial orchards in Wisconsin because it is too low in vigor. Its use may increase in the future as low-vigor, high-density planting systems are developed. Trees on M.27 must be staked at planting, as they are poorly anchored.

**M.9**—This is one of the original East Malling introductions. It is the most dwarfing rootstock in use in Wisconsin today and the most common dwarfing rootstock in use worldwide. M.9 produces a tree about 25 to 35% of seedling size. It is precocious, sometimes bearing fruit the year after planting. However, these fruit should be removed to avoid runting out the tree (stopping vegetative growth). *M.9 is recommended for high-density plantings because it is both productive and precocious.*

Roots of M.9 are brittle and break easily, so these trees should be staked or supported on a trellis immediately at planting. M.9 will produce suckers but not in large numbers. It is susceptible to fire blight.

Many clones of M.9 have been identified that vary in size. The most common clone used in North America is NAKBT 337. Other common clones include RN29, Pajam 1 and 2, and Flueren 56. Nurseries typically don't indicate what clone they are using, but the information can usually be obtained by asking.

**Budagovsky 9**—This rootstock is frequently called Bud.9 or simply B.9. It originated in central Russia and is very cold hardy. B.9 is similar to M.9 in dwarfing characteristics, susceptibility to fire blight, and brittleness of roots (both rootstocks require staking). Tests in Wisconsin suggest that it is slightly larger and slightly less productive than M.9. The biggest advantage of B.9 is its superior cold hardiness. *B.9 is recommended for orchards in areas with more severe climates where root hardiness is essential.*

**Ottawa.3**—Sometimes designated O.3, this rootstock is also hardy and equally productive to B.9. Its roots are not as brittle. The major drawback is that it is difficult to propagate in stool beds. As a result, it is difficult to find trees grafted onto O.3.

### **Semi-dwarf**

**M.26**—Mature trees on M.26 are 40–50% of seedling size. After its introduction in 1959, M.26 became very popular because of its size and productivity. M.26 produces a freestanding tree, is well anchored, and has enough vigor that it usually does not runt out. However, it may benefit from some type of support. It is the most cold hardy of all Malling introductions now used commercially. It does not sucker readily. M.26 will not tolerate wet soils and is susceptible to crown rot and highly susceptible to fire blight. A virus-indexed EMLA 26 was introduced in 1969. *M.26 is recommended for medium-density orchards under either standard or moderate spur-type cultivars in Wisconsin.*

**G.30**—This is a new introduction from Cornell University. G.30 is usually somewhat larger than M.26, but is far more productive. G.30 is a free-standing tree and will not require any sort of support, although a single stake may be beneficial during training. This rootstock is also resistant to fire blight. It has been hardy in the coldest test sites. Gala/G.30 has a weak graft union and is not a good combination. *G.30 is recommended for medium-density orchards under standard or moderate spur type cultivars in Wisconsin, especially those that are fire blight susceptible.*

**M.7**—Trees on M.7 are 55–65% of seedling size. M.7 was one of the original Malling rootstocks. It originated in France and was known as Doucin. It has been one of the most widely used rootstocks in the U.S. apple industry since clonal rootstocks became popular. It is widely adapted to many soil types and climates and is very disease tolerant. M.7 trees are freestanding and should not need support. However, M.7 is slow to bear and suckers readily. The full array of M.7 trees are available as M.7 (has viruses), M7a (some harmful viruses removed), and EMLA 7 (all known viruses removed). *M.7 is recommended for medium-density orchards under less-vigorous standard or spur-type cultivars in Wisconsin.*

### **Semi-vigorous**

Two semi-vigorous rootstocks—MM.106 and MM.111—are available for Wisconsin but are not recommended except for poor sites with infertile, rocky soils. They may also have value if replanting trees onto orchard land that has not been allowed to lie fallow or been fumigated following tree removal. These rootstocks are too vegetatively vigorous and are not precocious. Although nurseries still propagate trees on these rootstocks they are far less popular now than they were a decade ago.

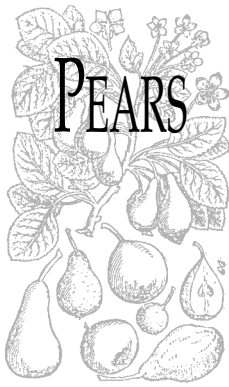
### **Vigorous**

**Seedling or standard**—Trees on apple seedlings were the basis for Wisconsin's apple industry until the late 1950s. Less than 2% of the apple trees planted in commercial orchards in the past 5 years in Wisconsin have been on seedling roots. Seedling rootstocks produce large, vigorous trees that are freestanding, are well rooted, and have delayed fruiting. However, considerable variability is apparent among all of these traits in seedling trees. *Because of their low to moderate productivity and lateness in bearing (poor precocity), seedling trees are NOT recommended for planting in Wisconsin.*

### **New rootstocks**

Several apple rootstock breeding programs are active around the world. Several rootstocks are currently under trial in various states under the auspices of the NC-140 regional project. Wisconsin participates in this project. The purpose of this project is to evaluate new and promising rootstocks before they are available in the commercial industry. Thus far the NC-140 project has identified some problems with new rootstocks. These data allow nurseries and growers to decide whether these rootstocks have commercial value in North America.

The breeding program at Cornell University is perhaps the most active. Several new rootstocks in both the dwarf and semi-dwarf size categories will be released over the next several years. Not all will be commercial successes, but they will broaden the choices growers have when planning new plantings. There have been some problems with misnamed or mislabeled plant material coming out of this project, but these problems have largely been resolved.



FEWER ROOTSTOCK CHOICES are available for pears than for apples. Most apple cultivars and rootstocks are of the same genus and species (*Malus x domestica*), while pear rootstocks are from several genera.

Desirable pear rootstocks should be resistant to fire blight, be cold tolerant, control tree size, and be compatible with a wide range of cultivars. So far no pear rootstock has been found with all these characteristics. In the past most pear rootstocks were Bartlett seedlings (*Pyrus communis*). Seeds were typically obtained from cannery waste. Seedlings of other *Pyrus* species have also been used.

Characteristics of individual pear rootstocks follow, listed from most commonly used to least commonly used. Not all rootstocks listed are suited to Wisconsin conditions.

***Pyrus communis* seedling**—Domestic pear seedlings are still the most acceptable rootstocks for pear cultivars in terms of vigor, hardiness, and compatibility. These trees are adapted to a wide range of soil types and climatic conditions. Trees on pear seedlings are well anchored and strong. However, all pear trees on seedling roots are susceptible to fire blight. *Pear trees on domestic seedling roots are recommended for Wisconsin.*

***Pyrus calleryana* seedling**—Seedlings of *Pyrus calleryana* are adapted to many soil conditions and produce semi-vigorous growth. *Pyrus calleryana* is very resistant to fire blight, but it is not sufficiently winter hardy for Wisconsin. *Pyrus calleryana* seedlings are not recommended for Wisconsin.

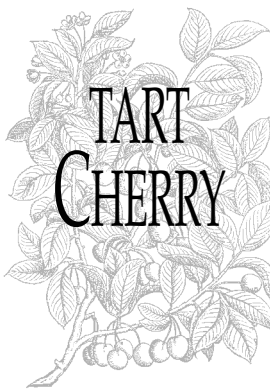
***Pyrus betulaefolia* seedling**—Seedlings of *Pyrus betulaefolia* are also adapted to many soils and conditions. The trees are vigorous, larger than Bartlett seedling, and moderately tolerant of fire blight. *Pyrus betulaefolia* is winter hardy but has not been widely tested under Wisconsin conditions. *Pear trees on **Pyrus betulaefolia** are recommended for trial in Wisconsin.*

**Old Home x Farmingdale clones**—These clones show a wide range of diversity in tree size and vigor. They all have at least two characteristics in common that make them acceptable for Wisconsin: they are winter hardy and resistant to fire blight. *There has not been wide experience with these clones in Wisconsin, so they should be planted for trial only.*

**Clones of Old Home x Farmingdale**

Rootstock	Description
OHxF 51	Dwarfing
OHxF 97	Vigorous
OHxF 333	Semi-dwarfing

**Quince seedlings or clones**—Seedlings of quince (*Cydonia oblonga*) have been used for many years to give some size control for pears. Quince is not compatible with all pear cultivars. Trees on quince are somewhat smaller than on domestic pear and are precocious and efficient. All quince rootstocks are winter tender and highly susceptible to fire blight. *Quince should not be used as a pear rootstock in Wisconsin.*



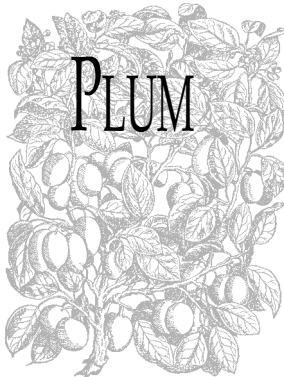
ROOTSTOCK SELECTIONS for tart cherry are limited. Commercial cherry plantings in Wisconsin are primarily 'Montmorency' on Mahaleb (*Prunus mahaleb*) seedling rootstocks. Mahaleb is slightly smaller than Mazzard (*Prunus avium*) and is more

winter hardy. Several new clonal cherry rootstocks are now available, but for tart cherries these have few advantages over Mahaleb. Following is a brief description of tart cherry rootstocks.

**Mahaleb**—*Prunus mahaleb* is native to Asia minor and southeast Europe. Mahaleb is preferred for dry sites and cold areas. It is a vigorous stock producing full-sized trees. *Mahaleb is the rootstock of choice for tart cherries in Wisconsin.*

**Mazzard**—*Prunus avium*, or bird cherry, is also native to Europe and Asia minor. This is the same species as sweet cherry. Mazzard is not as cold hardy as Mahaleb, but it will tolerate poorly drained soils better than Mahaleb. *Mazzard may be an acceptable rootstock in warmer sites with less-well-drained soils in Wisconsin.*

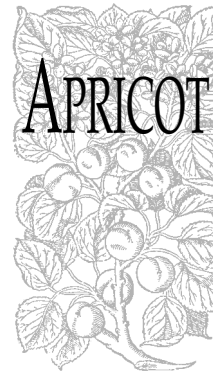
**Gisela series**—These stocks were developed in Germany and have recently been introduced into commercial trade. Their chief advantage is size control; their greatest drawback is their need for support. These stocks are primarily used to reduce the size of sweet cherry trees. Since tart cherries are mechanically harvested these stocks are of little advantage (see table below).



EUROPEAN AND American plums may be grown successfully in Wisconsin. Japanese plums are not sufficiently cold hardy. Rootstocks must provide cold hardiness and productivity as well as be compatible with all cultivars. Most plums have been grafted onto plum seedlings.

**Myrobolan seedling**—Most European plum cultivars can be grown successfully on Myrobolan seedling rootstocks (*Prunus cerasifera*). It is the most widely used plum rootstock in North America because it is easily propagated and provides good anchorage. Plum trees are not

usually large, so size control is not as important as with other tree fruits. Myrobolan seedling is winter hardy, and it will tolerate a wide range of soils except extremely heavy soils. Its greatest drawback is its variability. *Myrobolan is recommended for plums in Wisconsin.*



APRICOT SEEDLINGS ARE USED almost exclusively as rootstocks for apricot scions. Sometimes peach seedlings are used, but incompatibility problems can occur, and peach seedlings are not winter hardy. *Apricots grafted on peach seedlings are not recommended in Wisconsin.* Most apricot trees in Wisconsin are on

Manchurian or other apricot seedlings. *Apricot seedlings are recommended for use as apricot rootstocks in Wisconsin.*

## SELECTING A ROOTSTOCK

Rootstocks are an important component determining orchard production. You should match the rootstock to your specific orchard characteristics. While choices are limited for pear and stonefruit growers in Wisconsin, all orchardists should consider the following factors when selecting a rootstock.

### Gisela tart cherry rootstock clones

Rootstock	Size (% of Mazzard)	Description
Gisela 1 (GI 172-9)	25	Productive and precocious, but sensitive to viruses. Not currently recommended.
Gisela 5 (GI 148-2)	45	Productive and precocious. Produces wide crotch angles and is cold hardy. Tolerates heavy soils and viruses.
Gisela 7 (GI 148-8)	50	Heavy bearing, well anchored, but support is suggested. Sensitive to <i>Prunus necrotic ringspot virus</i> .
Gisela 6 (GI 148-1)	60	Semi-dwarfing, well anchored and adapted to a wide variety of soils, including heavy soils. Resistant to common cherry viruses.

## *Orchard design*

Tree spacing and tree density should be the first considerations when selecting a rootstock. If you are planting a high-density apple orchard (>500 trees per acre), then you must use a full dwarfing rootstock. Medium-density orchards (100–500 trees per acre) may use either semi-dwarf or semi-vigorous rootstocks, depending on density. Low-density orchards (<100 trees per acre) may use semi-vigorous or seedling rootstocks. Trees that are planted too close together and are too vigorous will shade each other, reducing fruit yield, size, and quality.

## *Scion*

Strongly spur-type apple cultivars must have a more vigorous rootstock than standard cultivars. Spur-type cultivars planted on dwarfing rootstocks produce little vegetative growth and little fruiting wood (runt out), thus producing few, small fruit of poor quality. On the other hand, a very dwarfing rootstock will control the growth of a very vigorous cultivar.

The scion must be compatible with the rootstock, especially for stone fruits. Reputable nurseries should be able to indicate incompatibility problems before the trees are propagated.

## *Cold hardiness*

Both the scion and the rootstock must be able to survive harsh Wisconsin winters. This is a major limiting factor on the types of tree-fruit crops that can be grown in the state. The relative cold hardiness of the major apple and pear rootstocks is indicated in the previous descriptions. Stone-fruit rootstocks are generally less hardy than apple and pear rootstocks; only the hardiest stone-fruit rootstocks should be used. Peach seedlings are sometimes used as rootstocks for apricot and plum, but are not recommended for Wisconsin.

## *Availability*

In the past, many orchardists selected rootstocks based on nursery availability. The resulting mistakes in orchard design decreased production and income potential. In most instances it is desirable to wait for the trees you want or to have trees custom budded rather than accept whatever is available. You will need to allow 2 to 3 years for delivery of custom budded trees.

## *PROPER CARE*

For rootstocks to produce the desired result, they must be handled properly in the nursery and the orchard. The scion must be budded onto the rootstock at the proper height. For apples and pears on dwarfing rootstocks, low budding is preferred to avoid burr knot problems. Trees on dwarfing rootstocks must be planted with the graft union 2–3 inches above ground, because the dwarfing effect of the rootstock will be lost if the scion is allowed to root. Trees on seedling rootstocks should be planted with the graft union about 1–2 inches below ground to strengthen the graft union.

Although good anchorage is desirable for rootstocks, it is not always achieved, particularly in the most dwarfing rootstocks. Apple trees on dwarfing rootstocks (M.27, M.9, Mark, and M.26) and cherry trees on Gisela rootstocks should be staked or otherwise supported at planting. Trees on other rootstocks also benefit from staking.

## *CONCLUSION*

Because rootstocks play a large role in tree physiology, selecting the right rootstock is critical. Apple and pear growers have more rootstocks from which to choose, but selecting the right rootstock is also important for stone-fruit growers. Proper orchard management is required regardless of the rootstock selected. Good management can never fully compensate for poor rootstocks, nor will good rootstocks perform to their potential with poor management.

## GLOSSARY

**budding**—a method of grafting in which a single bud is inserted into a rootstock or interstem. The bud retains the characteristics of the original plant.

**burr knot**—roots that form in the bark of the above-ground portion of a rootstock shank. These roots eventually break through the bark and die, leaving a mass of dead tissue that may eventually girdle and kill the tree.

**clone**—plant materials that have specific characteristics which are maintained by asexual (vegetative) propagation. Clones are produced by cuttings, grafting, stooling, or tissue culture.

**cultivar**—a contraction of cultivated variety. This term replaces the term variety. Cultivar is used instead of variety to avoid confusion with botanical varieties.

**dwarfing rootstock**—a rootstock producing a mature tree roughly 25–40% the size of the same cultivar grafted to a seedling rootstock. Typically propagated by vegetative means.

**grafting**—a method of propagating in which a small scion is placed in close cambial contact with another stem so that the two grow together, forming a new plant.

**interstem**—a piece of stem that is inserted between the rootstock and scion, making a three-piece tree. Dwarfing interstems can control tree size similarly to dwarfing rootstocks.

**precocious**—bearing fruit at a young age, quick to bear fruit.

**rootstock**—the trunk or root material onto which buds or scions are inserted in grafting or budding.

**runt out**—a low-vigor condition characterized by cessation of vegetative growth and by small fruit size.

**scion**—a piece or cutting of a twig, shoot, or small limb of the cultivar which is inserted into the rootstock to form a union or graft. Also, the above-ground portion of grafted trees.

**seedling rootstock**—a rootstock produced from seed via sexual propagation.

**seedling tree**—a tree on which the scion is propagated onto a seedling rootstock. The rootstock is produced by sexual propagation. See standard tree.

**semi-dwarfing rootstock**—a rootstock producing a mature tree roughly 40–70% the size of the same cultivar grafted to a seedling rootstock. Typically propagated by vegetative means.

**spur type**—apple trees that bear fruit on short shoots called spurs. Trees are slightly smaller than standard cultivars.

**standard tree**—a tree growing on a seedling rootstock.

**stool**—shoots that originate below ground and become rooted. A method of vegetative propagation.

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**Author:** T.R. Roper is professor of horticulture, College of Agricultural and Life Sciences, University of Wisconsin-Madison and University of Wisconsin-Extension, Cooperative Extension. Produced by Cooperative Extension Publications, University of Wisconsin-Extension.

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