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Sweet Cherry Rootstocks for the Pacific Northwest

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Sweet cherry trees on vigorous and semi-vigorous rootstocks.

Credit: Lynn E. Long, © Oregon State University

All commercial sweet cherry trees are either budded or grafted. The part of the tree above the graft/bud union is known as the scion, and the part below the graft/bud union is known as the stock or rootstock. Modern sweet cherry scion breeding programs have focused mainly on achieving improved characteristics such as yield, taste, fruit size, fruit firmness, fruit color, precocity, disease and fruit cracking resistance. In contrast, modern rootstock breeding programs have largely focused on increasing precocity, reducing vigor or, in some cases, adaptation to certain soil and climatic conditions. In recent years, there has been a substantial increase of available rootstocks that provide growers with a complete range of vigor from full vigor, full size to true dwarfing rootstocks that reduce vigor by 50% or more. These dwarfing rootstocks facilitate the harvest of premium quality fruit from high-density, pedestrian orchards. Furthermore, when matched with ultra-high-density training systems, such as slender spindle axis, dwarfing rootstocks may reach full production by fourth leaf. This amount of production may take up to four times longer when fruit is grown on ‘Mazzard’ rootstocks in a traditional training system.

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This publication presents the current level of understanding of the major cherry rootstocks as they pertain to the Pacific Northwest.

Graft compatibility

Since 'Mazzard' rootstocks are *Prunus avium* seedlings, the same species as the scion, they are compatible with all sweet cherry scion cultivars. This is not the case with other commercial sweet cherry rootstocks, which include *Prunus mahaleb*, *Prunus cerasus* or *Prunus canescens* in their parentage. Consequently, some of the rootstocks that arise from these crosses may show signs of incompatibility with some *P. avium* scion material. *Prunus mahaleb* is used extensively around the world and has some significant advantages over 'Mazzard', especially in sandy or alkaline soils. However, some scion cultivars, including 'Chelan', have shown symptoms of incompatibility when combined with 'Mahaleb'. 'Sam' and 'Van' are known to express incompatibility symptoms with 'Weiroot 13' and 'Colt'. With the advent of the 'Gisela' rootstock series, and more recently the Corette series, rootstocks have become complicated hybrids of two or more species. Fortunately, we have grown the most common of the 'Gisela' rootstocks, 'Gisela 5', '6' and '12', long enough to know that these rootstocks are not prone to incompatibility issues. Although we have not seen any problem to date with the Corette rootstock series, they have not been matched with enough cultivars to have the same level of confidence with them. The same lack of data is true of several new rootstocks out of Europe, 'Gisela 13', 'Gisela 17', and the new 'WeiGi' series.

Incompatibility symptoms may show up immediately, or be delayed for several years. From a grower's perspective, it is better that incompatibility symptoms show up early so that plants can be replaced before several years are invested in their growth and major economic losses are incurred. Typical symptoms of incompatibility include poor bud take, gumming at the bud union, necrotic layers or wood discontinuity forming in the grafted region, loss of tree vigor and the eventual collapse of the scion.

Soil and planting

It is important to understand the quality and depth of your soil before selecting a rootstock. Dwarfing and semi-dwarfing rootstocks have more compact root systems than vigorous, full-size rootstocks. It is best to plant dwarfing and semi-dwarfing rootstock on orchard sites with fertile soils and good water-holding capacity. In orchard sites with shallow, nutrient-poor soils that have low water-holding capacity, select semi-dwarfing to vigorous rootstocks that will grow a robust root system capable of coming in contact with more soil moisture and nutrients. Independent of rootstock selection, the impervious layers in the soil must be broken up to ensure drainage and at least 3 feet of active rooting depth is required for adequate growth of cherry rootstocks.

Trees also rely on soil for anchorage. In some instances, semi-dwarfing or dwarfing trees may require additional support. Trees on 'Gisela 6' and sometimes 'Gisela 5' are typically grown without support; however, 'Gisela 6' and sometimes 'Gisela 5' will often tilt away from the prevailing winds. In Wasco County, Oregon, which is prone to much wind, 'Clinton', 'Clare' and 'Cass' (three releases from the Corette series) are also showing varying degrees of tilting and could require support depending on the training system. Taller, more top-heavy training systems, such as the tall spindle axe or Vogel central leader, may need support with these rootstocks.

Cold hardiness and frost

Cold hardiness is a complex physiological process, and findings from cherry rootstock research trials around the world are inconsistent. One of the main confounding issues is that damage to scion budwood in the fall is often due to incomplete acclimation of the scion. The interaction with rootstocks adds a layer of complication to the analysis, as does an interstock such as 'Citation'. However, multiple studies have shown that many scion cultivars grafted onto 'Mahaleb' rootstocks will acclimatize earlier in fall/winter than on other rootstocks, which can be an advantage in years with early hard frosts in fall. The parent material of 'Gisela 5', '6' and '12', *P. cerasus* and *P. canescens*, are both hardier than 'Mazzard' and impart that hardiness to these three 'Gisela' rootstocks. 'Colt' tends to produce a relatively shallow root which, in one case, contributed to high winter mortality in a nonirrigated site in Germany. Other rootstocks in the block survived the winter without damage.

Although scions on productive rootstocks are at least as sensitive to frost as those on standard rootstocks, trees on productive rootstocks will often produce more fruit after a severe frost due to initially higher flower counts. However, in situations where no frost protection is in place or frost protection is overwhelmed by cold temperatures, flowers closest to the ground, where air is coldest, will have higher mortality than those formed at the top of a full-size tree, where the air is warmer. Since most of the flowers are in this colder zone on small trees, a higher percentage of flowers and fruit may be affected on dwarfing and semi-dwarfing rootstocks than on vigorous rootstocks. Given that cherries are such a high value crop, it is advisable to install propane-fueled orchard fans or other mitigation techniques to protect the flowers during spring frosts.

Flowering and fruiting habit

Cherry trees produce only simple buds (such as a solitary bud per node) and each bud will be either vegetative or floral. Vegetative buds on 1-year-old wood may either develop into shoots or remain dormant. In subsequent years, these dormant vegetative buds may become spurs. Spurs are only formed on wood that is 2 years old or older. Spurs can remain productive for up to 10 years if they receive adequate light interception. Floral buds may contain up to seven flowers per bud, and they develop either from an axillary bud on 1-year-old shoots or an axillary bud of a spur. Where axillary buds on 1-year-old wood become floral, flowers will either abort or produce terminal fruit. In either case, this will result in "blind" wood in subsequent years. Where numerous axillary buds on a 1-year-old shoot become floral, this will result in a significant portion of the branch having blind wood that supports neither leaves nor fruit. Some cultivars such as 'Regina', and 'Attika' have a greater propensity than other cultivars for production of blind wood.

Many of the new precocious, vigor-controlling rootstocks change the fruiting habit of the tree, resulting in increased flower density and greater numbers of spurs on the trunk and in the center of the tree. Unfortunately, these precocious rootstocks are also prone to setting more solitary (axillary) flower buds on 1-year-old wood, which results in more blind wood.

Growth habit and tree size

Many of the newly developed rootstocks express some degree of size control. Cherry rootstocks can be grouped into four categories based on tree size. Vigorous rootstocks include 'Mazzard', 'Mahaleb' and 'Colt'. These will produce very tall trees, upwards of 60 feet if left unpruned, but may be confined to a height of 10–20 feet if properly pruned. Semivigorous rootstocks will grow to 80% to 90% of a full-size tree, but are easier to maintain as hard pruning cuts respond in a more controlled manner, without substantial water sucker growth, which is common for trees on more vigorous rootstocks. Semivigorous rootstocks include 'Gisela 6', 'Gisela 12', 'Krymsk 5', and 'Krymsk 6'.

Semidwarfing rootstocks include ‘Gisela 5’ and grow to 50% to 60% of full-size. Fully dwarfing rootstocks include ‘Gisela 3’ and the Corette series. These trees will grow to less than 50% of the size of trees on vigorous rootstocks. The degree to which a tree is dwarfed depends not only on the rootstock but also scion cultivar selection, soils, pruning severity and training system choice. When coupled with ‘Bing’, ‘Gisela 12’ is more dwarfing than ‘Gisela 6’. However, a ‘Regina’/’Gisela 12’ combination produces a tree that is approximately 10% larger than ‘Regina’/’Gisela 6’. Other varieties appear to exhibit similar influences, but observations are inconclusive at this time.

The site or location can also play a role in the relative size of the tree. For example, in the eastern U.S., ‘Gisela 6’ produces a tree that is only 60% the size of a tree on vigorous rootstock, whereas in the Pacific Northwest it produces a larger tree growing to 90% full size. Similarly, ‘Colt’, released in Europe as a semivigorous rootstock, was found to produce a full-sized tree in the Pacific Northwest. However, irrigation influences tree size more than location. Due to higher summer rains, some orchards in the eastern U.S. and northwestern Europe do not have supplemental irrigation. As a result, trees are naturally smaller than irrigated trees. Soil type can also be a factor in size variability between regions. For example, ‘Maxma 14’ grows more vigorously in the fertile loam soils of the Pacific Northwest than in the calcareous soils of southern France.

Knowing that a rootstock may decrease tree size from 50% up to 90% of a standard tree can be helpful. However, it doesn’t tell the whole story. For example, with proper pruning and training system influence, a tree on ‘Gisela 6’ can easily be maintained at a height of only 8 feet. When heavily pruned, many of the productive rootstocks such as the ‘Gisela’ and ‘Krymsk’ series respond with moderate, controlled growth. This moderate response, in conjunction with a naturally wider branch angle for many of these trees, makes trees on many of these productive rootstocks much easier to manage.

Root suckers

Most commercial cherry rootstocks used in the Pacific Northwest express limited to no root suckering. Occasionally, depending on the conditions, ‘Mazzard’ can show low to moderate levels of suckering. Some suckering has also been observed with ‘Krymsk 5’, and ‘Krymsk 6’, as well as ‘Cass’, ‘Clare’, ‘Lake’ and several of the Weiroot clones such as ‘Weiroot 158’. Any root suckering can be difficult to manage, as they interfere with weed sprays, general tree management such as pruning, and harvest. In addition, root suckers can be a reservoir for diseases or insect pests.

Yield and fruit quality

Compared to trees on full-size rootstocks, those on size-controlling rootstocks are more precocious and often more productive. When matched with the most precocious training systems, such as super slender axe and upright fruiting offshoots some rootstocks, namely the Corette series — ‘Cass’, ‘Clare’, ‘Clinton’, ‘Crawford’ and ‘Lake’ — can produce a small amount of fruit in the second leaf. These true dwarfing rootstocks, when planted in high density of up to 3,000 trees or more per acre, can produce 3–4 tons per acre or more by the third leaf. With high-density plantings, high per-tree yields are not necessary in order to obtain high per-acre yields. While the Corette series and ‘Gisela 5’, ‘Gisela 6’ and ‘Gisela 12’ are all very precocious, there are semivigorous rootstocks that are less precocious. ‘Maxma 14’ and ‘Krymsk 5’, although more precocious than vigorous rootstocks, are less precocious than the Corette series and ‘Gisela’ rootstocks. Less precocious rootstocks should produce small yields by the third or fourth leaf, about one year later than those that are highly precocious and one year earlier than most vigorous rootstocks.

Yield efficiency, which considers both yield and tree size, is greater with dwarfing rootstocks than trees on vigorous rootstocks. Higher per-tree yields or even greater yield efficiency can be beneficial if the leaf-to-fruit ratio remains

balanced. When the leaf-to-fruit ratio is balanced, all rootstocks will produce fruit of similar quality. However, dwarfing rootstocks, when pruned inadequately, have a greater tendency to overset, resulting in smaller fruit of poorer quality. Thus, it is imperative that trees are pruned properly each year, which is the first and most important step in growing a balanced tree. See *Four Simple Steps to Pruning Cherry Trees on Gisela and Other Productive Rootstocks*, (https://catalog.extension.oregonstate.edu/pnw592)PNW 592, for more information on how to properly prune trees on dwarfing rootstocks.

Bacterial canker

Bacterial canker, caused by *Pseudomonas syringae*, is a pathogen of sweet cherries found in all cherry production areas around the world. Infection rates of 50% to 80% have been reported in some of the wetter regions of the Pacific Northwest such as the Willamette and Hood River valleys in Oregon. Even in the drier regions of central Washington and Oregon, infection and mortality rates can approach 10% or more in some years.

The *P. avium* rootstock clone, F.12/1, has shown tolerance to this pathogen. Therefore, it is used in the Willamette Valley as a high budded stock in order to slow down or stop a branch infection before it infects the trunk and threatens the entire tree. In this situation, the stock is grown out to the point of branching and scion wood is budded onto the branches of the rootstock.

Little research has been done looking at the relative susceptibility of sweet cherry rootstocks to bacterial canker. However, researchers in 2010 found that ‘Colt’ shows greater tolerance to the disease than ‘Mazzard’, while ‘Krymsk 5’ shows greater to similar tolerance to the disease when compared to ‘Mazzard’. Additionally, trees grown on ‘Gisela 6’ were less tolerant than ‘Mazzard’. Cherry growers in Chile have observed that both ‘Colt’ and ‘Maxma 14’ provide some protection for their trees against bacterial canker infection, and that ‘CAB-6P’ (a sour cherry rootstock clone) is more susceptible to bacterial canker than ‘Mazzard’.

Virus and phytoplasma susceptibility

Prune dwarf virus and Prunus necrotic ringspot virus are commonly found in mature orchards throughout the Pacific Northwest. These are pollen-borne viruses that spread easily within an orchard. Most strains of these two viruses show few if any symptoms when trees on 'Mazzard', 'Mahaleb' or 'Colt' rootstocks are infected. However, even these rootstocks can show some symptoms and produce lower yields when infected. In addition, some rootstocks, such as 'Gisela 7' and 'Weiroot 158' show varying degrees of sensitivity to one or both of these viruses when inoculated in controlled trials. In the same trial, 'Gisela 5', 'Gisela 6' and 'Gisela 12' exhibited varying levels of tolerance to these two viruses, with only a slight reduction in vigor when infected.

In contrast, both 'Krymsk 5' and 'Krymsk 6' are hypersensitive to these viruses. When scion wood infected with the Prune dwarf or Prunus necrotic ringspot virus is budded onto 'Krymsk 5' or 'Krymsk 6' rootstocks, significant gumming and necrosis occur at and below the scion/rootstock graft union. The tree collapses shortly thereafter. When planning a 'Krymsk 5' or 'Krymsk 6' orchard, budwood free of these viruses must be used. However, depending on the virus strain, there is some evidence that mature trees could die more slowly. How mature trees on 'Krymsk 5' and 'Krymsk 6' rootstocks respond to these virus infections needs to be further researched. Yet, both 'Krymsk' rootstocks have been in commercial production for nearly 20 years in Oregon with no reports of major mortality or decline. However, it would be wise not to plant trees on hypersensitive rootstocks in an interplant situation among mature trees or close to blocks of older trees that may be infected with one or both of these viruses.

X-disease, caused by the phytoplasma *Candidatus Phytoplasma pruni*, is a reemerging problem for sweet cherry growers in the Pacific Northwest. The most obvious symptom of X-disease are little cherries, which are poorly flavored, small, pale red to greenish-white, and pointed or flat sided at harvest. These cherries do not ripen and are often interspersed among normal-looking fruit. Most rootstocks, including 'Mazzard' and the 'Gisela' series, are considered susceptible to X-disease. Currently, 'Mahaleb' is the only known sweet cherry rootstock that exhibits a hypersensitive response to the X-disease phytoplasma. In this case, hypersensitivity has some benefits. Dead trees can quickly alert an orchardist to an X-disease infection and sick trees can be removed before the phytoplasma can be transmitted to healthy trees. However, as mentioned previously, interplanting hypersensitive rootstocks among an older mature block or next to an old block is ill-advised.

General tips for choosing the right rootstock

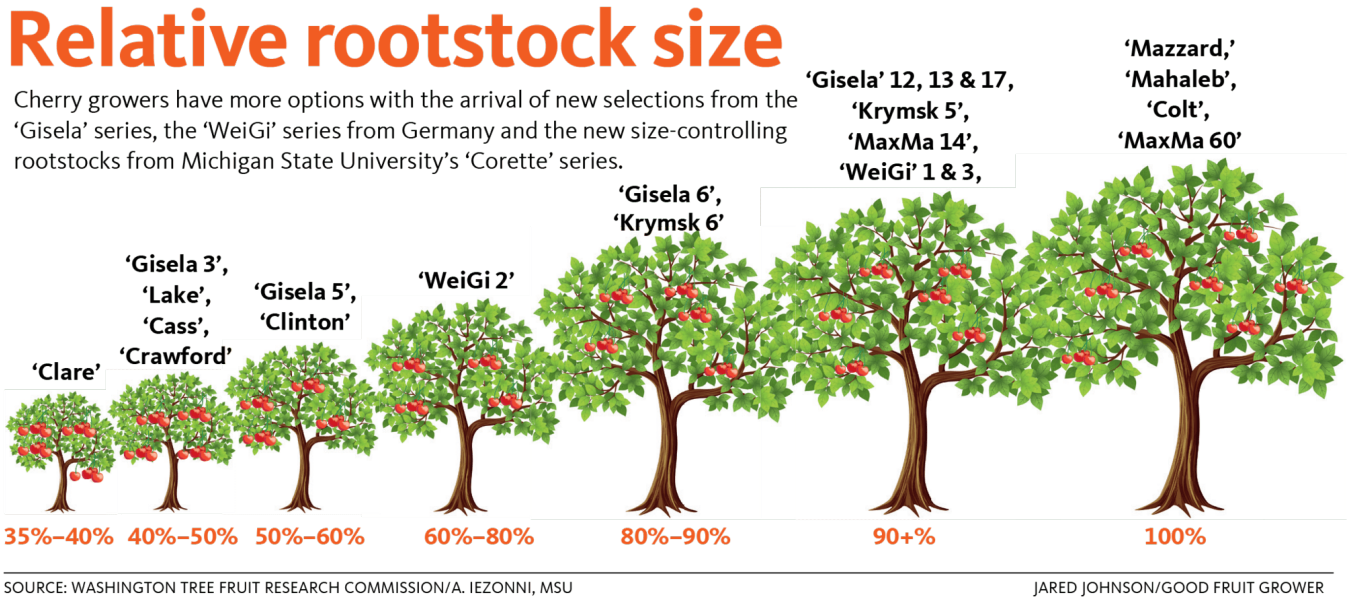
Several factors must be considered when selecting rootstocks for a new orchard. Soil fertility, scion cultivar choice and desired training system are some of the more important considerations. In most cases, you will want to avoid the most dwarfing rootstocks such as the Corette series or 'Gisela 5' where soils are shallow or low in fertility. Other productive rootstocks such as 'Gisela 12' or 'Krymsk 5' may perform more satisfactorily on those sites, but higher planting densities should be considered where soils are poorest. In addition, it is best to avoid planting 'Mahaleb' rootstocks in heavy soils. 'Mahaleb' will do poorly under these conditions, and will potentially die out, whereas 'Krymsk 5' and 'Krymsk 6', although not adapted to wet soils, will survive in heavier soil conditions better than 'Mahaleb' or even 'Mazzard'.

Vigorous rootstocks are best suited to standard density orchards of 120 to 160 trees per acre at 15-feet-by-20-feet spacing. However, when trained as a Spanish Bush or Kym Green Bush, all three of these rootstocks may be grown at densities of between 300 and 340 trees per acre at 13-feet-by-16-feet spacing. Commercial plantings in the Pacific Northwest, Australia and Spain have successfully used these training systems at these higher densities. Due to the

increased vigor of these rootstocks, a spindle or central leader system is usually not recommended since these trees tend to grow very tall. Furthermore, scion cultivars of low productivity, such as ‘Regina’ and ‘Early Robin’ have not produced satisfactory yields on these rootstocks.

Soil depth for the semi-dwarfing and dwarfing rootstocks should be at least 3 feet. On shallower soils, it is necessary to increase tree density per acre. Not all rootstocks are suitable for all training systems. The central axe system should be avoided when using vigorous rootstocks. , while the slender spindle axis system should be matched only with dwarfing rootstocks. Likewise, rootstocks for Kym Green Bush should be limited to semivigorous or vigorous rootstocks.

It's also important to match the rootstock to an appropriate cultivar. Since vigorous rootstocks are less productive than those in the other categories, they should be reserved for only the most productive cultivars. ‘Chelan’, ‘Lapins’ and ‘Sweetheart’ are examples of productive cultivars. Cultivars of low productivity, such as ‘Benton’, ‘Early Robin’, ‘Regina’ and ‘Tieton’, are best matched with dwarfing rootstocks in order to boost their productivity. Most other cultivars have a wider range of acceptable rootstock matches.



Credit: Good Fruit Grower/Washington Tree Fruit Research Commission/MSU

Rootstocks

Numerous rootstocks are available for orchardists in the Pacific Northwest. The remainder of this publication will provide descriptions of individual rootstocks.

‘Colt’

P. avium x P. pseudocerasus

‘Colt’ was released by the research station in East Malling, England, in the 1970s as a semivigorous rootstock. However, in the irrigated orchards of the Pacific Northwest it produces a vigorous tree that is similar in size to ‘Mazzard’ with similarly low precocity. In addition, ‘Colt’ is sensitive to droughty soils and to cold winter temperatures.

'Colt' has been widely planted in California due to its resistance to cherry stem pitting, a debilitating virus disease readily found in that state. It has also shown resistance to *Phytophthora* root rot, bacterial canker and gopher damage, but is susceptible to crown gall. In the Pacific Northwest, 'Colt' performs well in replant situations where cherries follow cherries on nonfumigated sites.

Corette series

P. cerasus hybrids

Five new hybrid dwarfing clonal rootstocks have recently been released by Michigan State University. 'Cass' and 'Clare' are complex hybrids with *P. avium*, *P. cerasus* and *P. fruticosa* parentage; 'Clinton' and 'Crawford' have *P. canescens* and *P. cerasus* parentage; and 'Lake' has P. *avium* and *P. fruticosa* parentage. In evaluations conducted in Oregon and Washington, tree vigor on all these rootstocks was equal to or less than 'Gisela 5', with the most dwarfing, more in line with 'Gisela 3' size.

These five rootstocks have been evaluated in four university trials in Washington and Oregon and several grower-led trials. In the earliest Washington trial, precocity and productivity (number of flowering spurs) was very high, with 'Lake', 'Cass' and 'Clinton' exceeding that for 'Gisela 5'. Due to this prolific flowering, fruit grown on these rootstocks may need to be thinned to achieve acceptable fruit size and quality. However, this may enable growers to more consistently produce optimal yields. This Washington trial found 'Lake', 'Cass' and 'Clare' advanced ripening by four days compared to 'Gisela 5'.

F.12/1

P. avium

F.12/1 is a vegetatively propagated clone of 'Mazzard' used in many locations around the world instead of the seedling-propagated 'Mazzard'. Western Oregon growers prefer F.12/1 to 'Mazzard' due to its resistance to bacterial canker. The F.12/1 rootstock forms the trunk from the branch union down and the scion is budded onto each lateral branch. The bacterial-resistant rootstock slows the progression of canker infection that develops on the branches and hinders the infection from proceeding to the trunk.

Many nurseries, however, prefer not to grow this selection due to sensitivity to crown gall caused by Agrobacterium tumefaciens. F.12/1 is more vigorous than 'Mazzard' seedling in many locations where it is grown.

'Gisela 5'

P. cerasus x P. canescens

Although a popular rootstock in northern Europe and the northeast United States, 'Gisela 5' has failed to gain widespread acceptance in the Pacific Northwest. Cooler summer temperatures in northern Europe and the Northeast allow for less tree stress and better growth than in the Pacific Northwest. However, with a moderate to low productive cultivar and necessary attention given to management, including irrigation, fertilization and pruning, it is possible to successfully grow 'Gisela 5' in higher density orchards of 500–800 or more trees per acre in the Pacific Northwest. A few orchards in the state of Washington have been successful with the rootstock in high-density blocks in good soil.

'Gisela 5' tends to advance both flowering and fruit ripening by two to four days, a potential advantage for early ripening cultivars where an early harvest window provides higher returns. However, this may be disadvantageous in a frost-susceptible site or when the harvest of a late-ripening cherry is advanced.

‘Gisela 5’ produces trees that are open and spreading with wide branch angles, but branching may be sparse. Anchorage is usually adequate, but some growers have taken the precaution to support the tree. Some suckering may occur depending on growing conditions, but this is usually not a problem. Trees on ‘Gisela 5’ rootstock have shown good winter hardiness and scion compatibility has not been an issue.

‘Gisela 5’ does not perform well in heavy soils and needs good drainage. Trees show sensitivity to replant stress so should only be planted on virgin sites or where the soil has been properly treated with fumigants prior to planting.

‘Gisela 6’

P. cerasus x P. canescens

‘Gisela 6’ was the first precocious rootstock to gain acceptance by Pacific Northwest growers. Through the early 2000s it was the most popular precocious rootstock, and in some areas the most popular rootstock planted in the Pacific Northwest. However, in recent years it has declined somewhat in popularity due to its sensitivity to heat. As temperatures approach 100F, the leaves lose turgor and show symptoms of wilting. Fruit quality is also compromised at these temperatures. Some growers have attempted to reduce this response with woodchip and other mulches under the tree to keep the roots moist and cool. While ‘Gisela 6’ has lost popularity, ‘Gisela 12’ and ‘Krymsk 6’ have gained in popularity and are now the preferred precocious rootstock for the semivigorous size category.

Even though it is a relatively vigorous rootstock, it is easy to manage. Recommended planting densities are 300–500 trees per acre. Although it exhibits medium-high vigor, it is also very precocious, producing harvestable crops by the third leaf with full production possible by the fifth leaf. Due to these high production levels, trees on ‘Gisela 6’ need to be properly pruned from an early age in order to maintain fruit size and quality. Premium fruit quality is possible with cultivars of moderate to low productivity such as ‘Bing’, ‘Skeena’ and ‘Regina’, but more difficult with very productive cultivars, such as ‘Chelan’ or ‘Sweetheart’. Matching highly productive cultivars to ‘Gisela 6’ is not recommended. As with all size-controlling rootstocks, it is imperative to maintain adequate levels of vigor in order to produce high-quality fruit. The production of new shoots is much easier to achieve with ‘Gisela 6’ compared to ‘Gisela 5’ and is one of the reasons for the popularity of this rootstock.

‘Gisela 6’ tends to advance flowering and fruit-ripening only slightly compared to ‘Mazzard’. Trees are open and spreading with good branching. Anchorage can be a problem, especially on windy sites, although most growers in the Pacific Northwest do not provide support.

‘Gisela 6’ is well-suited for a wide range of soil types from light to heavy. However, good drainage is essential. Trees grown on this rootstock have not been prone to suckering, and scion compatibility has been good.

‘Gisela 12’

P. cerasus x P. canescens

Tree vigor and size on ‘Gisela 12’ is variable depending upon cultivar combination. Several years of testing in The Dalles, Oregon, and Prosser, Washington, indicated that when combined with ‘Bing’, ‘Gisela 12’ produced a tree intermediate in size to ‘Gisela 5’ and ‘Gisela 6’. However, grower experience with ‘Regina’ indicates that ‘Gisela 12’ produces a tree approximately 10% larger than ‘Gisela 6’. Most growers expect ‘Gisela 12’ trees to be slightly more vigorous than trees on ‘Gisela 6’. For this reason, some growers prefer ‘Gisela 12’ as they find it easier to maintain vigor and, ultimately, fruit size.

‘Gisela 12’ is both precocious and productive, producing early heavy crops, with full production possible by the fifth leaf. Good fruit size and quality are possible with proper pruning.

‘Gisela 12’ is adapted to a wide range of soils. It resists suckering and is well anchored. The tree structure is open and spreading and new branches form readily. Scion incompatibility has not been a problem.

‘Gisela 13’

P. cerasus x P. canescens

‘Gisela 13’ is a recently commercialized clonal rootstock just introduced in the U.S. and thus in need of widespread site evaluation. Sweet cherry trees on ‘Gisela 13’ are semivigorous, precocious and productive, and develop horizontal branch angles. They have good anchorage and no suckering. To date, there have been no reports of incompatibility problems. ‘Gisela 13’ is reported to perform well in less-fertile soils and better than ‘Gisela 6’ in hot climates.

‘Gisela 17’

P. canescens x P. avium

‘Gisela 17’ is a recently commercialized semivigorous to vigorous clonal rootstock just introduced in the U.S. and thus in need of widespread site evaluation. However, it was tested from 1998–2007 in the NC140 coordinated regional rootstock trials across North America. Initial interest was limited due to the focus on identifying dwarfing rootstocks, but sweet cherry trees on ‘Gisela 17’ were found to be vigorous, precocious and productive. In Prosser, Washington, trees on ‘Gisela 17’ were slightly more vigorous than on ‘Gisela 6’, but of similar vigor to ‘Gisela 6’ at Summerland, British Columbia.

‘Krymsk 5’

P. fruticosa x P. lannesiana

The ‘Krymsk’ series originated in the Black Sea region of Russia. Grower experience in the Pacific Northwest suggests that ‘Krymsk 5’ is comparable in size to ‘Gisela 12’ with somewhat less precocity and yield. On a trial conducted in Oregon, ‘Krymsk 5 had similar production to ‘Maxma 14’ when combined with ‘Sweetheart’, a highly productive cultivar, but had significantly higher yields when grafted to the less productive ‘Regina’ cultivar. This is a rootstock that can provide precocity to some of the more productive varieties such as ‘Chelan’, ‘Lapins’ and ‘Sweetheart’ while maintaining fruit size and quality. In a commercial planting in Oregon, ‘Lapins’ on ‘Krymsk 5’ has produced high-quality fruit for nearly 20 years.

‘Krymsk 5’ is adapted to a wide range of soil types, with reports that it will grow better in heavier soils than ‘Mazzard’. Accounts out of Russia indicate that the rootstock is well-adapted to cold climates. In addition, trees on this rootstock have performed well in hot climates as leaves remain turgid in extreme heat and don’t show the characteristic cupping of ‘Gisela 6’ trees in hot conditions. Trees are well anchored and do not need support. Low to moderate levels of root suckers can be found growing from the crown, but usually not in the tree row. The tree has wide branch angles, and is well suited for many training systems, including steep leader, upright fruiting offshoots, Kym green bush, tall spindle axe and Vogel central leader.

‘Krymsk 6’

P. cerasus x (P. cerasus x P. maackii)

‘Krymsk 6’ has become a popular rootstock in Oregon and is gaining acceptance in Washington state. Tree size is similar to ‘Gisela 6’ and productivity is usually intermediate between ‘Gisela 6’ and ‘Krymsk 5’. That said, a study in Oregon with ‘Regina’ showed precocity and per-tree productivity similar to ‘Gisela 6’ but less than ‘Gisela 12’. Like ‘Krymsk 5,’ commercial production of ‘Krymsk 6’ has been ongoing in Oregon since the early 2000s with excellent results with both ‘Skeena’ and ‘Lapins’.

Like ‘Krymsk 5’, ‘Krymsk 6’ rootstocks seem to be adapted to both cold and hot climates as well as heavier soils. Trees are well anchored, but there is low to moderate root suckering. Tree form is good, with wide crotch angles. Like ‘Krymsk 5’, ‘Krymsk 6’ is hypersensitive to Prune dwarf virus and Prunus necrotic ringspot virus.

‘Mahaleb’

P. mahaleb

‘Mahaleb’ is slightly more precocious and slightly less vigorous than ‘Mazzard’ and it is one of the most drought-tolerant cherry rootstocks, having deep-set roots. ‘Mahaleb’ is, however, extremely sensitive to water-logged soils as well as soils that may be anaerobic for a short time during the winter months. ‘Mahaleb’ is best suited to deep, well-drained loams and sands as well as the calcareous soils typical of Spain and southern Italy. There, and in similar locales around the world, ‘Mahaleb’ is the preferred rootstock. In the Pacific Northwest, ‘Mahaleb’ rootstocks are generally used only in light, sandy-loam soils and quickly die out in ravines and other low-lying areas where water collects.

Incompatibility of some sweet cherry cultivars can be a problem with ‘Mahaleb’ as this condition has been detected up to six years after planting. ‘Chelan’ and ‘Tieton’ have expressed incompatibility symptoms when grown on ‘Mahaleb’, and these combinations are not recommended. In addition, ‘Mahaleb’ is attractive to gophers. Consequently, control measures for these pests must be pursued with diligence.

‘Maxma 14’

P. mahaleb x P. avium

‘Maxma 14’ originated in Oregon from an open-pollinated ‘Mahaleb’ tree. However, it has been most widely accepted in France due to its precocity, semidwarfing nature and resistance to iron-induced chlorosis caused by calcareous soils. It is also popular in central Asia for the same reason. Growers in Chile like the rootstock due to its tolerance to bacterial canker. Since neither calcareous soils nor high-bacterial canker pressure are common in most of the Pacific Northwest, ‘Maxma 14’ has had limited acceptance there.

‘Maxma 14’ is best matched with highly productive cultivars like ‘Chelan’ or ‘Lapins’, where an increase in precocity is desired, but oversetting might be a problem with more productive rootstocks. ‘Maxma 14’ is tolerant to heat, but intolerant of water-logged soils. It shows good scion compatibility and a broad adaptation to soil types and environmental conditions. Suckering has not been a problem.

‘Mazzard’

Prunus avium

Growers in the Pacific Northwest have a long tradition of planting trees on ‘Mazzard’ rootstock. It is well adapted to the region’s soils, winter hardy and because it is the same species as sweet cherry cultivars, there have been no cases of incompatibility. In addition, due to high vigor and moderate productivity, premium fruit quality can be obtained with only moderate inputs in pruning and management.

Unfortunately, it lacks precocity, often not coming into production until the fifth or sixth leaf or full production until the 12th leaf. Vigorous growth makes it difficult to control in high-density plantings and the large tree size reduces picker efficiency and increases the hazards associated with harvest.

‘Mazzard’ does well in a wide range of soils from sandy loam to clay loam, however, as with other cherry rootstocks it does not perform well in poorly drained or wet soils. Root suckers are usually not a problem except in limited situations.

‘WeiGi 1’

P. cerasus x O.P.

‘WeiGi 1’ is a recently commercialized semivigorous clonal rootstock just introduced in the U.S. and thus in need of widespread site evaluation. ‘WeiGi 1’ is comparable to ‘Gisela 6’ in vigor, precocity and productivity, with no suckering. It is reportedly adaptable to hot, dry conditions.

‘WeiGi 2’

P. cerasus x (P. avium x P. canescens)

‘WeiGi 2’ is a recently commercialized semidwarfing clonal rootstock just introduced in the U.S. and thus in need of widespread site evaluation. ‘WeiGi 2’ is slightly more vigorous than ‘Gisela 5’ in precocity and productivity, and is reportedly adaptable to hot, dry conditions. In tests conducted in Provence, France, ‘WeiGi 2’ produced a tree about the same size as ‘Gisela 5’.

‘WeiGi 3’

P. cerasus x (P. avium x P. canescens)

‘WeiGi 3’ is a recently commercialized semivigorous clonal rootstock just introduced in the U.S. and thus in need of widespread site evaluation. ‘WeiGi 3’ is comparable to ‘Gisela 6’ and ‘Gisela 12’ in vigor, precocity and productivity, with no suckering, and is reportedly adaptable to hot, dry conditions.

Table 1. Planting parameters for various commercially available cherry rootstocks

	Best for super high density (more than 1,000 trees/acre)	Best for moderately high to high density (100–1,000 trees/acre)	Best for low density (less than 100 trees/acre)	Best for shallow or poor soils	Best with low productive varieties	Best with highly productive varieties
Cass'*	Yes	Yes	No	At higher densities	Yes	No
Clare'*	Yes	Yes	No	At higher densities	Yes	No
Clinton'*	Yes	Yes	No	No	Yes	No
Colt'	No	No	Yes	Yes	No	Yes
Crawford'*	Yes	Yes	No	At higher densities	Yes	No
Gisela 5'	Yes	Yes	No	No	Yes	No
Gisela 6'	No	Yes	No	At higher densities	Yes	With proper management
Gisela 12'	No	Yes	No	At higher densities	Yes	With proper management
Gisela 13'	No	Yes	Yes	Yes	Yes	With proper management
Gisela 17'	No	Yes	Yes	Yes	Yes	With proper management
Krymsk 5'	No	Yes	No	At higher densities	Yes	With proper management
Krymsk 6'	On poor soils	Yes	No	At higher densities	Yes	With proper management
Lake'*	Yes	Yes	No	At higher densities	Yes	No
Mahaleb'	No	No	Yes	Avoid heavy soils	No	Yes
Maxma 14'	No	Yes	No	Avoid heavy soils	Yes	With proper management
Mazzard'	No	No	Yes	Yes	No	Yes

	Best for super high density (more than1,000 trees/acre)	Best for moderately high to high density (100–1,000 trees/acre)	Best for low density (less than 100 trees/acre)	Best for shallow or poor soils	Best with low productive varieties	Best with highly productive varieties
WeiGi 1'	No	Yes	Yes	Yes	Yes	With proper management
WeiGi 2'	Yes	Yes	No	At higher densities	Yes	With proper management
WeiGi 3'	No	Yes	Yes	Yes	Yes	With proper management
Cass'*	Yes	Yes	No	At higher densities	Yes	No
Clare'*	Yes	Yes	No	At higher densities	Yes	No
Clinton'*	Yes	Yes	No	No	Yes	No
Colt'	No	No	Yes	Yes	No	Yes
Crawford'*	Yes	Yes	No	At higher densities	Yes	No
Gisela 5'	Yes	Yes	No	No	Yes	No
Gisela 6'	No	Yes	No	At higher densities	Yes	With proper management
Gisela 12'	No	Yes	No	At higher densities	Yes	With proper management
Gisela 13'	No	Yes	Yes	Yes	Yes	With proper management
Gisela 17'	No	Yes	Yes	Yes	Yes	With proper management
Krymsk 5'	No	Yes	No	At higher densities	Yes	With proper management
Krymsk 6'	On poor soils	Yes	No	At higher densities	Yes	With proper management
Lake'*	Yes	Yes	No	At higher densities	Yes	No

	Best for super high density (more than1,000 trees/acre)	Best for moderately high to high density (100–1,000 trees/acre)	Best for low density (less than 100 trees/acre)	Best for shallow or poor soils	Best with low productive varieties	Best with highly productive varieties
Mahaleb'	No	No	Yes	Avoid heavy soils	No	Yes
Maxma 14'	No	Yes	No	Avoid heavy soils	Yes	With proper management
Mazzard'	No	No	Yes	Yes	No	Yes
WeiGi 1'	No	Yes	Yes	Yes	Yes	With proper management
WeiGi 2'	Yes	Yes	No	At higher densities	Yes	With proper management
WeiGi 3'	No	Yes	Yes	Yes	Yes	With proper management

*Corette series

Table 2. Attributes of various commercially available cherry rootstocks

	Tree size (% full size)	Precocious	Advance bloom/harvest	Compatibility	Root suckers	Anchorage
'Cass'*	40–50	Yes	4 days	?	Low	Good
'Clare'*	40–50	Yes	4 days	?	Moderate	Good
'Clinton'*	40–50	Yes	0–1 day	?	No	Fair
'Colt'	100	No	No	Good	No	Good
'Crawford'*	40–50	Yes	0–1 day	?	No	Good
'Gisela 5'	50–60	Yes	2–4 days	Good	No	Fair–good
'Gisela 6'	80–85	Yes	0–1 day	Good	No	Fair
'Gisela 12'	85–90	Yes	No	Good	No	Fair–good
'Gisela 13'	85–90	Yes	No	Good	No	Good
'Gisela 17'	85–90	Yes	No	Good	No	Good
'Krymsk 5'	85–90	Moderate	No	Good	Moderate	Good
'Krymsk 6'	75–85	Moderate	No	Good	Moderate	Good

	Tree size (% full size)	Precocious	Advance bloom/harvest	Compatibility	Rootsuckers	Anchorage
'Lake'*	50	Yes	No	?	Moderate	Good
'Mahaleb'	90–95	Slight	No	Fair–good	No	Good
'Maxma 14'	85–90	Moderate	No	Good	No	Good
'Mazzard'	100	No	No	Good	Low	Good
'WeiGi 1'	80–85	Yes	No	Good	No	Good
'WeiGi 2'	60–80	Yes	No	Good	No	Good
'WeiGi 3'	85–90	Yes	No	Good	No	Good

*Corette series

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