

## **Rootstock Options for California Almond Orchards**

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Nemaguard has been the workhorse rootstock of the California almond industry for many decades. It is well adapted to the well-drained, non-calcareous loam and sandy loam soils common throughout the San Joaquin Valley. Nemaguard is vigorous, immune to rootknot nematode, compatible with all almond varieties, doesn't sucker much, has decent anchorage and is easy to grow at the nursery. However, there are many situations in which nemaguard struggles.

Nemaguard, as with most peach rootstocks, is prone to lime induced chlorosis (yellowing / iron deficiency) in high pH soils. It is also susceptible to salt toxicity (sodium, chloride & boron), "wet feet", *Phytophthora* root rot, oak root fungus, crown gall and "heart rot". Despite the name "nemaguard", this rootstock is susceptible to ring and root lesion nematodes. The susceptibility to ring nematode leads to the danger of bacterial canker in orchards replanted into sandy soil.

Since 1998, UC Cooperative Extension farm advisors in Kern, Stanislaus, San Joaquin, Colusa and Butte Counties have researched several alternative rootstocks for California almond growers. These include most of the common, commercially available rootstocks in California along with many newly available rootstocks from other countries. While there is no such thing as the perfect rootstock, there are better choices than nemaguard where many chemical or physical soil problems exist. Below are some suggestions for specific challenging situations.

**Heavy soil / poor drainage.** Nemaguard is not adapted to poorly drained soils and can become yellow, stunted or even die from lack of oxygen. Lovell, another peach seedling rootstock, is not much better. As a group, plum rootstocks are pretty tolerant to heavy soil. Marianna 2624 has traditionally been the rootstock of last resort when nemaguard and Lovell have failed due to overly wet soil conditions. However, Marianna 2624 has a whole bucket of problems. It is considered incompatible with Nonpareil which requires Nonpareil trees to be budded on an interstem at the nursery. Marianna is also marginally compatible with Butte and other varieties and is susceptible to union mild etch. Marianna 2624 also produces a very small tree that suckers profusely and is highly susceptible to bacterial canker.

Another Marianna rootstock called M-40 (not a sibling to M 2624) performs similarly to M 26-24 in heavy soil but is slightly more vigorous and doesn't sucker as much. Tolerance to oak root fungus has not been proven for M-40.

A new alternative for heavy soils may have come to us from Russia. Krymsk 86 is a peach x plum cross. USDA plant pathologist, Dr. Greg Browne, has shown that it is resistant to *Phytophthora megasperma*. Several almond varieties, including Nonpareil, have performed well on Krymsk 86 in University of California rootstock trials in Stanislaus and Colusa Counties. Vigor of Krymsk 86 is a little less than nemaguard but more than Marianna 2624.

Suckering is not a problem. This new rootstock appears to be very promising but it will take many years before we know for sure that it will not have unforeseen problems.

**High lime / high pH / alkaline soils.** There are probably no rootstocks better than the peach x almond hybrids for alkaline soil conditions. This group includes Hansen, Nickels, Bright's, Cornerstone, & Titan hybrid. Although there are subtle differences, these rootstocks are all pretty similar. As a group, these rootstocks are very vigorous, have good anchorage, are relatively "drought tolerant", and are highly resistant to rootknot nematode. Nickels tends to be the most vigorous of these peach x almond hybrids.

On the downside, this group does not tolerate wet soil conditions and is highly susceptible to many root diseases, including Phytophthora, crown gall, and oak root fungus. They are also very susceptible to ring nematode and thus bacterial canker. Because of their high vigor, fruit maturity is delayed which may be a problem for late harvested varieties in higher rainfall areas. In low chill years, Carmel trees on peach almond hybrids bloom a little earlier and have better overlap with Nonpareil trees on Nemaguard.

Another peach x almond hybrid is Paramount (also known as GF 677). GF 677 is the most widely planted almond and stone fruit rootstock in Europe but has only recently been tested in California. It does not appear to be as tolerant to rootknot nematode or as susceptible to ring nematode as the more familiar peach x almond hybrid rootstocks. In a Stanislaus County rootstock trial, it is less vigorous than the other peach x almond hybrids.

Atlas and Viking, two complex hybrid rootstocks with peach, almond, plum and apricot parentage, are also tolerant of alkaline soil compared to Nemaguard and Lovell. Although they may not be quite as tolerant as the peach x almond hybrid rootstocks, they can handle heavy soil and most root diseases better and may therefore be better choices in some areas. Atlas has had relatively high yield efficiency in U.C. field trials.

Krymsk 86 (described above) and another new rootstock called Ishtara (see oak root fungus tolerance below) have been shown in European trials to perform well in alkaline soils. They have not yet been adequately tested in California alkaline soils.

**Bacterial Canker.** Bacterial canker can be a major problem in orchards replanted in sandy soils. The severity of bacterial canker is highly correlated with ring nematode populations. While we know of no rootstock immune to bacterial canker, Lovell has proven to be much more tolerant than Nemaguard. Unfortunately, Lovell is highly susceptible to rootknot nematode and can have a hard time getting started in infested soils. Viking rootstock is at least as tolerant to bacterial canker as Lovell, is resistant to rootknot nematode, and tends to be more vigorous and slightly higher yielding than Lovell.

Peach x almond hybrid rootstocks, particularly Hansen, are very susceptible to bacterial canker and should not be planted in second generation orchards with the potential for ring nematodes. Other rootstocks are currently being evaluated for resistance to bacterial canker but need further testing before they can be recommended.

**Oak Root Fungus (*Armillaria mellea*).** Oak root fungus is a devastating disease that can persist in the soil on or in roots of affected hosts for many years. Marianna 2624 plum rootstock is traditionally used in *Armillaria* infested areas and can survive very well as long as the soil does not remain overly wet. Marianna can grow acceptably in heavier soils but tends to be stunted in sandy soils, especially under flood irrigation.

Although it is too soon to know for certain, a plum x peach hybrid rootstock out of France called Ishtara has emerged as a possible alternative to Marianna 2624 in oak root fungus spots. This peach x plum hybrid has better vigor than Marianna 2624, doesn't sucker much and so far looks to be compatible with tested almond varieties. Ishtara was also shown to be resistant to *Phytophthora megasperma* in Dr. Browne's screening tests. There is some concern that anchorage of Ishtara rooted trees may be inferior to Lovell or Marianna 2624.

**Anchorage.** Good anchorage is especially important with young trees growing in areas with high winds. Anchorage is generally best in rootstocks with large, deep root systems like peach x almond hybrid rootstocks. There is some speculation that the new Krymsk 86 rootstock may have better anchorage than peach rootstocks based on the size and structure of its root system.

In the spring of 2001, a rootstock trial conducted by former Kern County Farm Advisor, Mario Viveros, was subjected to a fierce Santa Ana wind storm where winds blew more than 75 MPH for 5 hours along with 1.75 inches of rain. In those five hours, 58% of the 6<sup>th</sup>-leaf almond trees on Nemaguard blew over. In contrast, only 13% of the trees on Bright's hybrid, 9% on Hansen and 4% on Viking were lost.

**"Heart rot".** Poor anchorage shouldn't be confused with the problem of older trees falling over due to a decayed root system. "Heart rot" is the term often used to describe the problem that occurs when root and crown tissue of older trees are colonized by various wood decay fungi. These fungi, some of which form "conks" or other "mushroom" structures on the trunks, utilize the cellulose and hemicellulose (carbohydrates) within the infected wood. This significantly weakens the structural strength of the root system, increasing the risk of the tree falling over. Tree loss due to heart rot is a leading contributor to orchard decline.

While there is little formal "data" evaluating the tolerance of almond rootstocks to wood decay fungi, observations indicate that trees on Marianna plum appear to be significantly less affected than trees on peach rootstocks. It is possible that other plum or peach x plum hybrid rootstocks may be tolerant to this disease complex but we just don't know yet.

As noted above, peach x almond hybrid rootstocks are extremely susceptible to crown gall. Crown galls can serve as entry points for infection by heart rot fungi. It is unknown whether susceptibility to crown gall will lead to increased levels of heart rot and thus more blow over of older trees on peach x almond hybrid rootstocks. As current U.C. rootstock field trials age, more data on heart rot tolerance can be collected.

**Most vigorous not necessarily the best.** Don't assume that planting the most vigorous rootstock will automatically lead to the biggest yields. You are better off choosing the

appropriate rootstock to overcome potential soil problems that may exist in your orchard. Comparable yields can be obtained with moderately vigorous rootstocks by increasing the number of trees per acre and planting them a little more densely. Denser planting will help keep trees a little smaller which has many benefits.

Choose the appropriate rootstock to defend against substandard yields. In most cases, almond orchards with the appropriate varieties and rootstock, proper preplant preparation, and adequate care should be able to routinely achieve 3000 pounds per acre or more. The secret to high yields is filling the orchard with canopy. Weak areas or missing trees reduce the yield potential of your orchard. Choosing the appropriate rootstock will go a long way toward reducing the number of weak spots in your orchard and maximizing your yield potential.

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