

# New Nematode-resistant Grape Rootstocks are Nearing Release

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The UC Davis rootstock breeding program is preparing for release of its first rootstocks. These rootstocks were designed to provide broad and durable resistance to nematodes, to propagate well, and have good horticultural characters such as long internodes. This work has been made possible by the very generous support of the California Grape Rootstock Improvement Commission, which has provided about \$2 million in support over the past 13 years. Additional support has been received from the Fruit Tree, Nut Tree, and Grapevine Improvement Advisory Board, the California Table Grape Commission, and the American Vineyard Foundation.

In 1993 and 1994, many crosses were made with the goal of developing rootstocks with broad and durable nematode resistance, while improving horticultural characters such as rooting ability and shoot length. The parents of these crosses included a number of grape species known to be highly resistant to both root-knot and dagger nematodes. They included several forms of *Vitis arizonica*, *V. candicans*, *V. champinii*, *V. cinerea*, *V. rufotomentosa*, and *Muscadinia rotundifolia*. *Vitis riparia* and *V. rupestris* were used in the crosses to improve rooting. About 75 crosses were made, leading to the establishment of over 5,000 seedlings in the vineyard. In 1996 these plants were evaluated for shoot growth, internode length, and the presence of laterals. One thousand selections were chosen, and that winter they were tested for their ability to root from dormant two-node cuttings. The best 100 were advanced to nematode testing.

In preparation for nematode testing, we obtained soil samples from Mike McKenry that contained populations of root-knot nematodes capable of feeding and damaging Harmony rootstock. Peter Cousins (PhD student in my lab at that time) isolated two strains of root-knot nematode (RKN) that fed well on Harmony; we named these strains HarmA and HarmC. Kris Lowe (a more recent PhD student) characterized these strains as *Meloidogyne arenaria* and *M. incognita*, respectively. We also obtained a standard strain of *M. incognita* termed R3, capable of damaging grapes, but not able to feed on Harmony or Freedom. Next, we identified several sites in Napa Valley with high populations of *Xiphinema index*, the dagger nematode vector of fanleaf degeneration, to use for the resistance screens.

We then began optimizing nematode screening procedures. Observing galls that form as a result of RKN feeding can be difficult. Peter Cousins modified an egg mass staining technique that was developed for RKN on tomato so that we could see egg masses on the roots and therefore know that RKNs had penetrated and fed on the roots. We then teamed with Howard Ferris and his

technician, Liang Zheng, from the Department of Nematology at UC Davis, and began large scale screening for nematode resistance. Root-knot nematode resistance was evaluated by counting the number of stained egg masses produced on a root system after inoculation with 1,500 juvenile nematodes; those without egg masses were assumed to be resistant. Dagger nematode resistance was determined by counting the number of galled roots after inoculation with 150 nematodes. We also tested for resistance against citrus (*Tylenchulus semipenetrans*), lesion (*Pratylenchus vulnus*) and ring (*Mecriciconema xenoplax*) nematode in separate pot studies using either 2- or 4-inch plastic pots.

The first round of testing examined the ability of the 100 selections to resist RKN R3. Selections that resisted R3 feeding were then tested for resistance to HarmA and HarmC, followed by testing for resistance to the dagger nematode. This second round of screening identified 33 selections with strong resistance to each of the four nematode strains. These 33 selections were then tested against a combined inoculum using the four nematodes (R3, HarmA, HarmC and dagger), which resulted in a group of 14 selections with broad resistance. These 14 selections were also tested for resistance to citrus, lesion and ring nematodes.

Finally, these selections were tested at elevated temperatures to each of the nematodes (R3, HarmA, HarmC and dagger) to evaluate the durability of their RKN resistance. Resistance to RKN strains has been shown to breakdown at higher temperatures (about 80°F) in tomato and other crops. The 14 selections were tested to determine whether their RKN resistance was based on a similar temperature sensitive mechanism. The selections were tested at four temperatures 75, 80, 86 and 90 °F (24, 27, 30, and 32 °C), using Colombard as the susceptible control and Harmony as the standard. At 80°F, Harmony's moderate resistance to HarmA is dramatically affected and it becomes as susceptible as Colombard.

Six selections emerged from this screening and are now being considered for release. Five of these rootstocks have been planted in field trials in sites with severe chronic nematode pressure. The sixth selection, 8909-05, was not planted in the first round of trials because I had assumed it would not propagate well, due to its *M. rotundifolia* parentage. However, we have been successfully bench-grafting it over the last two years. We have also evaluated the rooting angles generated from herbaceous cuttings as a rough approximation of rooting depth and therefore ability to induce vigor. We have studies underway across a wide range of rootstocks to better establish this correlation between rooting angles from herbaceous and dormant cuttings, and known vigor levels in commercial rootstock standards.

It will take years to determine which sites each of these rootstock selections are best suited to, but they have unparalleled levels of resistance to nematodes and should excel in sites with single and mixed nematode species infestations. We are currently testing these selections in large pots filled with vineyard soil from sites with severe nematode infestation as a final test before release. These soils have high levels of RKN as well as ring nematode, lesion nematode and *Xiphinema americanum*. We planted Harmony in 4 inch pots using one of these soils and recovered over 100 RKN egg masses in seven weeks.

The most resistant selection of the group is 8909-05. This selection came from a group of 16 *V. rupestris* x *M. rotundifolia* seed populations that Harold Olmo gave me when I was hired. Recently, we discovered that almost all of these seedlings were not the result of intended crosses, but instead the result of pollen contamination from grape species he collected in Mexico. Many of



8909-05

these selections have exceptional resistance to Pierce's disease and to the dagger nematode. 8909-05 is one of the true *M. rotundifolia*

hybrids and may possess the ability to tolerate fanleaf virus infection in the manner of O39-16. This tolerance is critical since resistance to *X. index* feeding does not prevent vectoring of and infection by fanleaf virus. We are working to demonstrate that 8909-05 is capable of

preventing fanleaf disease. Herbaceous cuttings of 8909-05 produce relatively few roots at a slower pace than the other selections, and they have deep rooting angles, although not as deep as O39-16.

9363-16 acquires its nematode resistance from *V. rufo-tomentosa* and *V. champinii* 'Dog Ridge'. It appears most like *V. rufo-tomentosa* with its lobed leaves, but they are relatively hairless, a trait from *V. riparia*. It propagates well, and produces roots with relatively shallow rooting angles. 9363-16 is a good mothervine and has excellent nematode resistance, although it is susceptible to ring nematode.



9363-16

9365-43 has nematode resistance from *V. rufo-tomentosa*, *V. champinii* 'Dog Ridge' and c9038—a wild collection from Texas that appears to contain *V. monticola*, a species with exceptional drought and mineral tolerance. *Vitis monticola* is the only *Vitis* species that is truly drought tolerant and grows on pure limestone on mesquite and juniper in central Texas. 9365-43 looks like a form of *V. champinii* and produces moderate vigor mothervines with long canes and moderate lateral production. Cuttings root very well and their rooting angles are intermediate in depth. It has excellent nematode resistance and has moderate resistance to ring nematode. 9365-85 is a sibling of 9365-43, but appears much more *V. riparia*-like. This appearance may translate into reduced vigor, but the rooting angles of the two siblings are similar. 9365-85's nematode resistance is slightly lower than 9365-43, but it is a more vigorous mothervine.



9365-43

9407-14 has strong and broad nematode resistance from *V. champinii* ‘Ramsey’, and c9021, a *V. champinii/monticola* selection from central Texas. However, it is susceptible to ring nematodes.



The mothervine resembles a glossy-leaved version of this latter species, but the mothervine is relatively weak, although the canes are long, straight and have limited lateral production. Cuttings produce moderately-sized roots with relatively deep rooting angles.

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9449-27 is the last of the selections and probably will not be released due to relatively poor rooting. It is a cross of *V. rufotomentosa* and *V. cinerea*, and looks like a good hybrid between these two species, with *V. aestivalis*-like leaves that lobe when the shoots are weak or shaded. It has been used as a parent in many other crosses for diversity and complex nematode resistance.

The lack of fallow and crop rotation in vineyards are the key factors leading to nematode’s impact on poor vineyard establishment and reduced longevity. These rootstock selections were designed to durably resist a broad range of nematodes, enabling their use in infested sites without the use of nematicides or fallow. They also present a diverse range of nematode resistant rootstocks for choices in rotating rootstocks when vineyards are replanted. 🍇

**Table 1.** Parentage and nematode resistance of rootstock candidates currently undergoing certification testing at FPS. Combined testing involved the standard strain of *Meloidogyne incognita* (root-knot nematode), two aggressive Harmony/Freedom strains, and dagger nematode *Xiphinema index*.

Selection	Parentage	Characteristics
9363-16	( <i>V. rufotomentosa</i> x (Dog Ridge x Riparia Gloire)) x Riparia Gloire	No galls in combined testing, resists lesion nematodes and has moderate resistance to citrus, but susceptible to ring nematodes. Good mothervine with long canes and internodes and limited lateral production. Mature leaves are three- to five-lobed and have some similarity to <i>V. aestivalis</i> .
9365-43	( <i>V. rufotomentosa</i> x (Dog Ridge x Riparia Gloire)) x <i>V. champinii</i> c9038 (probably <i>V. candicans</i> x <i>V. monticola</i> )	No galls in combined testing, resists lesion and citrus nematodes, has moderate resistance to ring nematodes. Mothervine has moderate vigor, but long canes with good internode length, moderate number of laterals. Mature leaves resemble <i>V. champinii</i> . Female flowers.
9365-85	( <i>V. rufotomentosa</i> x (Dog Ridge x Riparia Gloire)) x <i>V. champinii</i> c9038 (probably <i>V. candicans</i> x <i>V. monticola</i> )	Less than one root gall in combined testing, resists citrus and lesion nematodes, and has moderate resistance to ring nematode. Good mothervine with long canes and internodes and few laterals. Mature leaves resemble <i>V. riparia</i> . Male flowers.
9407-14	(Ramsey x Riparia Gloire) x <i>V. champinii</i> c9021 (probably <i>V. candicans</i> x <i>V. monticola</i> / <i>V. berlandieri</i> )	No galls in combined testing, resists citrus and lesion nematode, but susceptible to ring nematodes. Weak mothervine, but long internodes, good canes. Mature leaves resemble glossy <i>V. champinii/monticola</i> . Male flowers.
9449-27	<i>V. rufotomentosa</i> x <i>V. cinerea</i> c9008	One gall in combined testing, resists citrus and lesion and has moderate ring nematode resistance. Strong mothervine, moderate rooting ability. Mature leaves resemble <i>V. rufotomentosa</i> with the quilting of <i>V. cinerea</i> ; lots of hair and bicolor leaf surfaces. Shade and lateral leaves can be three- to five-lobed. Male flowers.
8909-05	<i>V. rupestris</i> x <i>M. rotundifolia</i>	No galls in combined testing, resists citrus, lesion and ring nematode. Less easy to medium propagation ability. May have fanleaf tolerance. Leaves are shiny and intermediate between <i>V. rupestris</i> and <i>M. rotundifolia</i> . Sterile flowers.