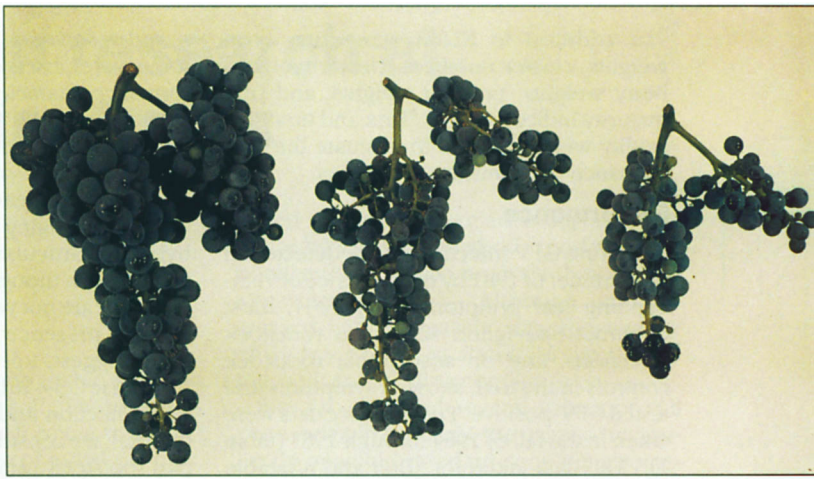

Symptoms of grapevine fanleaf virus disease may appear as yellow mosaic (photo at left), as vein banding, or as fanleaf deformation. Grape clusters on infected vines may have few, poorly developed berries, such as on AXR#1 and St. George varieties (middle and right, above). The healthy cluster at left is 043-43, a UC-patented variety resistant to dagger nematode feeding.

Resistant rootstocks may control fanleaf degeneration of grapevines

M. Andrew Walker ❑ James A. Wolpert ❑ Edward P. Vilas ❑ Austin C. Goheen ❑ Lloyd A. Lider

Two rootstock selections were found to be highly resistant to feeding by the dagger nematode, carrier of the disease, in large-scale Napa Valley tests and are being recommended for planting in infested vineyards.

Infectious degeneration caused by grapevine fanleaf virus (GFV) is one of the most serious viral diseases facing grape growers in California, and worldwide. The virus is transmitted by *Xiphinema index*, the dagger nematode. Infectious degeneration has three characteristic leaf symptoms—vein-banding, yellow mosaic, and fanleaf deformation. The disease causes double nodes and short internodes on canes, giving them a zigzag appearance. Berry set is greatly reduced, leading to clusters with few berries, many of them poorly developed. As the disease progresses, fruit yields often are reduced to less than 20% of those in uninfected vineyards.

The discovery of the dagger nematode vector in 1958 opened a way to control infectious degeneration. Fumigants and nematicides were used at first to destroy nematode populations. These materials didn't work well against the dagger nematode, however, because of poor penetration in vineyard soils. GFV-infected grape roots can survive in the soil for many years, acting as a food source for the dagger nematode and as a virus reservoir. This characteristic made holding the land fallow an ineffective control. The next logical step was to breed a rootstock resistant to the GFV-*X. index* disease complex.

Testing for field resistance

The search, which began in the 1960s, revealed several species resistant to dagger nematode feeding. They formed the parentage of a series of crosses known as the Lider selections. After screening and evaluation, the Lider selections underwent a large-scale field test in Rutherford in the Napa Valley. Virus-free Cabernet Sauvignon was the scion on all 60 rootstocks tested. Vines growing at the site had been removed because of infectious degeneration, and dagger nematode was present in large numbers. Popular coastal rootstocks, such as AXR#1 and St. George, and a newer root-knot nematode-resistant stock, Harmony, were also tested. Planting began in 1979, and monitoring for GFV started 2 years later.

The grape species *Vitis rotundifolia* was thought to be resistant to dagger nematode feeding when the Rutherford plot was conceived. It is very different from the rest of the species in *Vitis*, so much so that it is now considered to be in a separate subgenus, *Muscadinia* (some botanists even consider *Muscadinia* to be a separate genus). *Vitis rotundifolia* appears to be resistant or immune to most pests that attack wine grapes (*V. vinifera*), including dagger nematodes, phylloxera, and powdery mildew. It is even resistant to GFV when graft-inoculated. This resistance is probably due to host specificity of these pests for *vinifera*, and *vinifera*-like *Vitis* species.

Because we hoped *rotundifolia* would be resistant to dagger nematode, we included in the rootstock trial several *vinifera* X *rotundifolia* (VR) hybrids produced by H. P. Olmo in 1948 at the University of California, Davis. Two of these hybrids, O39-16 and O43-43, have field resistance to infectious degeneration.

Screening for the presence of grape fanleaf virus was done with an enzyme-linked immunosorbent assay (ELISA), in which purified GFV was injected into a rabbit. Six to eight weeks later, the rabbit's blood was drawn and tested for the presence of GFV antibodies extracted. These antibodies act as extremely sensitive and specific detectors of GFV.

In addition to ELISA screening, crop weights, cluster numbers, cluster weights, berry weights, pruning weights, and fruit maturity indices such as °Brix and titratable acidity were recorded to evaluate the performance of promising rootstocks.

Performance

The first GFV infections were detected in the summer of 1981 by the presence of vein-banding leaf symptoms. By 1984, most Cabernet Sauvignon scions on rootstock selections, and on susceptible rootstock controls in the trial, showed symptoms and tested GFV-positive. Performance data were taken in the fall of 1984 through 1987 (table 1). The data taken for °Brix and titratable acidity were not significantly different among the rootstocks and are not shown. Variability in °Brix and titratable acidity readings occurred from year to year, but this was due to varying levels of maturity at harvest.

The VR hybrid rootstocks, O39-16 and O43-43, excelled in this trial. Cabernet Sauvignon vines on these stocks produced larger crops with excellent clusters and greater berry weights than did scions on the three standard rootstocks. Performance of the three standard rootstocks was affected by infectious degeneration, as seen in their reduced yields, smaller clusters and berries, and lower pruning weights.

GFV was first detected in O43-43 in 1985, when one replicate tested positive with ELISA. By 1987, all the O43-43 replicates tested positive, and vein-banding leaf symptoms were observed. Yield and other performance characteristics were not affected when compared with O39-16, however. O39-16 was free of virus until the spring of 1988, and then one of its replicates had positive ELISA readings.

It is encouraging that crop yields of the VR hybrids (particularly O43-43) were not affected, even though they tested positive for GFV. We are not yet sure of the implications of virus presence without reduced yields, but it suggests tolerance of fanleaf virus.

Because O39-16 had the smallest degree of GFV infection and highest performance in this trial, we consider it to be the better of the two rootstock candidates. However, O43-43 tolerates GFV infection very well and should not be disregarded. Both O39-16 and O43-43 are currently undergoing more stringent testing in various GFV-infested vineyards in Napa, Sonoma, San Joaquin, Kern, and Madera counties and will continue to be examined at the Rutherford site. These trials should demonstrate not only the level of performance we can expect from the rootstocks, but also what happens when dagger nematodes are confronted solely with tolerant rootstocks.

VR hybrids have also been tested for resistance to other root pests. In laboratory and field studies, Granett, Goheen, and Lider (*California Agriculture*, January-February 1987) found that O39-16 was immune to biotype B phylloxera, but that O43-43 was moderately susceptible. Earlier work at UC Davis judged O43-43 as resistant to phylloxera and to root-knot nematodes and showed that VR hybrids performed well as rootstocks.

A good rootstock must meet certain primary qualifications, such as resistance to a particular pest or stress and ability to root and graft successfully with *vinifera* scions. Pure *rotundifolia* is notoriously difficult to root and difficult to graft using dormant cuttings. Rooting has been achieved only under mist propagation with green-shoot tips. Grafting between *rotundifolia* and *vinifera* has been most successful when green (nondormant) wood was used. Because of their *rotundifolia* parentage, the VR hybrids are more difficult to root than traditional rootstocks. In our experiments, however, IBA (indole butyric acid) treatments induced excellent rooting when followed by warm callusing box conditions before dormant bench grafting. When these procedures were followed, rooting success approached 100%. Standard grafting practices have not created problems with the VR hybrids.

Conclusions

O39-16 and O43-43 have been patented by the University of California and are available through grape rootstock nurseries for use in GFV-infested vineyards. Their long-term use is still under study, but preliminary data suggest that they be recommended for use and distribution as rootstocks providing field resistance to infectious degeneration.

Resistance to infectious degeneration is complex and could act at several levels. It could result from the root's ability to prevent nematode feeding, or root cells' ability to limit or stop GFV spread. An ideal rootstock would be resistant not only to the feeding of dagger nematode but also to GFV, providing two levels of resistance. Then, even a chance probing and transmission of GFV by the nematode would not result in disease because the rootstock would be able to prevent or limit spread of the virus. Researchers at UC Davis are continuing to look for resistance to GFV with the hope of crossing GFV-resistant plants with known sources of dagger nematode resistance to produce the next generation of rootstocks to combat infectious degeneration.

TABLE 1. Performance of Cabernet Sauvignon scions on selected rootstocks growing on a GFV-infested site in the Napa Valley

Year and rootstock	Yield/ vine	Clusters/ vine	Pruning weight	Berry weight	ELISA results*
	lb		*lb*	*g*	
1984:					
O39-16	22.9	83	10.4	1.02	All vines virus-free
O43-43	22.6	68	7.2	1.09	All vines virus-free
AxR#1	19.1	103	5.7	0.81	1 -, 1 +, 2 ++ vines
Harmony	11.0	88	6.3	0.85	1-, 4 ++ vines
St. George	7.5	68	3.0	0.76	All vines ++
1985:					
O39-16	26.9	134	9.6	1.07	All vines virus-free
O43-43	24.4	95	7.9	1.12	1 ++ vine
AxR#1	14.7	112	6.6	0.85	2 +, 2 ++ vines
Harmony	8.1	83	4.7	0.81	1 -, 4 ++ vines
St. George	4.9	70	3.0	0.76	All vines ++
1986:					
O39-16	35.2	148	13.7	1.22	All vines virus-free
O43-43	28.2	98	7.4	1.29	2 +, 1 ++ vines
AxR#1	14.8	125	6.7	0.89	1 +, 3 ++ vines
Harmony	9.4	108	6.7	0.90	All vines ++
St. George	7.0	98	5.0	0.89	All vines ++
1987:					
O39-16	20.6	113	14.7	1.28	All vines virus-free◊
O43-43	24.6	109	8.2	1.23	1 +, 2++ vines
AxR#1	15.7	110	5.6	0.98	All vines ++
Harmony	8.0	76	5.5	0.95	All vines ++
St. George	5.9	59	5.4	0.87	All vines ++

NOTE: Values given are means of three to five single-vine replicates.
* ELISA values (-) = negative, (+) = moderate virus titer, (++) = high virus titer.
◊ One vine of four replicates with a moderate virus titer in spring 1988.

M. Andrew Walker is Graduate Student, Department of Viticulture and Enology, University of California, Davis; James A. Wolpert is Extension Viticulturist, and Edward P. Vilas is Staff Research Associate, Department of Viticulture and Enology Extension, UC Davis; Austin C. Goheen is Research Plant Pathologist, U.S. Department of Agriculture-Agricultural Research Service, retired; and Lloyd A. Lider is Professor, Emeritus, Department of Viticulture and Enology.