Introduction of disease and insect resistance

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U.C. grape breeding, led by Dr. H.P. Olmo, has produced 24 commercial varieties.

Nearly all cultivated grape varieties, of which several thousand are grown commercially, derive their excellence in fruit quality from the *Vitis vinifera* grape. Although long considered a single species native to the temperate zone of Middle Asia, the vinifera is more of a complex of several ecospecies. Outlying relict populations also exist in some of the principal river basins of the Mediterranean area, and of the Rhine, Mostar, and Danube valleys. However, the role of these populations in the origin of cultivated forms is questionable.

The vinifera's contributions to fruit quality are large cluster size with many berries, thin and tender skin not separating from the pulp, firm and juicy berry flesh, diversity in berry shape, attractive and bright colors, high sugar content and low acidity, neutral or mild flavors, no unpleasant tasting or toxic constituents, small seeds few in number or seedless, and uniform maturity with good berry adherence to the stem. The value of these qualities varies with the use of a particular fruit. For example, large berries are desirable for handling and eating in table grapes, but not desirable in wine-making because they have less concentrated flavor.

Cultivated varieties moved westward into Europe with the spread of Christianity, as wine was necessary in the celebration of the Mass. The vine could be quickly and easily propagated by dormant cuttings or by layering. The only factor restricting its spread was low winter temperatures, as diseases and insects were of no major concern.

The vinifera was introduced into the New World through Columbus' first voyage of discovery in 1492, and then repeatedly by other Spanish and Portuguese explorers. Importations occurred in the colonies along the eastern coast of the United States. The abundance of native grapevines, chiefly *Vitis labrusca*, led colonists to believe that the imported European vines would be quickly established and that American vineyards would soon rival the vineyards of Europe. Many plantings were tried on a commercial scale but the new imports languished and died, although a few well-to-do growers prolonged the life of their grapevines by building greenhouses or "graperies."

Commercial grape culture in the United States had its first success with the discovery of a variety called the 'Alexander', discovered near Philadelphia by the gardener of Governor William Penn. Supposedly a seedling of a wild labrusca, Alexander most likely was a chance hybrid with vinifera grown in the neighborhood. The most famous of the many other chance seedlings is the 'Concord' from Massachusetts, first exhibited in 1853, which also has an infusion of vinifera parentage.

These exotic American varieties soon aroused curiosity in Europe and were taken there. With them undoubtedly went the American pests that were to ravage the vinifera across Europe and that ultimately explained the earlier failure of this vine in the eastern and midwestern United States. Powdery mildew went first in 1845, phylloxera or root louse in 1865, downy mildew in 1878, and black rot in 1885—and the vinifera vine was highly susceptible to all of them. Phylloxera could not be controlled in Europe, and the only recourse was importation of the resistant American native species. All the destroyed vineyards had to be planted with vinifera vines grafted onto rootstocks tolerant to the insect.

The vinifera vine introduced by the Spanish missionaries in the late 1700s has been successfully grown in California. When phylloxera first appeared in Sonoma County, we followed the French grafting method to combat it. Powdery mildew, the most important fungus disease, is universally present and controlled by frequent sulfur dusting. Black rot and downy mildew do not occur here because of the dry, rainless summers.

A more serious and deadly plague

in cultivated grapes

is Pierce's disease, virus-like in nature and carried by sharpshooter leafhoppers. There is no known control. A number of nematode species are a problem in California and require the use of special rootstocks.

A major interest of breeders is development of new varieties with disease and insect resistance, so that grape production can be more economical and not have to rely entirely on pesticides or grafting. Finding the best sources of resistance requires testing large collections of the native species so as to retain the desirable factors for fruit quality.

The *Vitis* species collection maintained at Davis represents practically all of the grapes found in North America. These have been given preliminary screening for tolerance to several diseases and insects as well as for climatic adaptation. For example, the native fox grape (*V. labrusca*) of the northeastern states grows weakly, its foliage scalds, and fruit matures poorly in the hot, dry Central Valley. However, it is an excellent source for resistance to powdery mildew, and for moderate tolerance to Pierce's disease.

Of all the North American species observed at Davis from the standpoint of disease and insect resistance, V. *rotundifolia* or muscadine is the most interesting. The range of this native of the humid southeast extends from Delaware to central Florida and westward to Texas and Oklahoma. The species is the only native that has given rise to a commercial grape industry. Its oldest variety, 'Scuppernong', was discovered on Roanoke Island, North Carolina, before 1700, and has exceptional fruit quality.

The vine is slow to establish but becomes very vigorous and is long lived. It has great potential value for its tolerance—or in some cases immunity—to the most important diseases and insects of cultivated vinifera.

The rotundifolia is so different in morphology that the botanist Small considers it to belong to the genus *Muscadinia*. We think this separation from other *Vitus* grapes is justified. There is also a consistent difference in chromosome number: *Vitis*, $2n = 38$; *Muscadinia*, $2n = 40$. Unsuccessful attempts to cross the two were first started at Davis in 1942 by using the earlier blossoming vinifera as the pollen parent. By reversing the cross, seeds were obtained and 304 vines planted in the vineyard in 1950. They were true hybrids since their chromosome number was $2n = 39$. The vines were very vigorous and healthy but no seeded fruits were obtained.

In the interim, we imported several of the North Carolina hybrids of the VxR combination, from which a few progeny had been obtained. Cytogenetic study of this material helped to explain the sterility of the Davis pairings: one basic set of chromosomes was different in each species and remained unpaired; only 13 chromosomes of each species were alike enough to pair. The irregular distribution of the extra sets of $6 + 7$ could account for the sterility.

When the vinifera variety used as female was changed, some hybrids did give an occasional berry with seeds. Selection of the most fertile derivatives and continued backcrossing to vinifera have now resulted in fully fertile hybrids of vinifera type. With sterility and low fruitfulness no longer barriers, selection has proceeded to obtain vines resistant to powderly mildew.

Some of this material has been tested in Florida for resistance to Pierce's disease. At least one selection appears sound after 6 years, much longer than any vinifera tested. The fertile VR hybrids are also being used by breeders here and abroad to select for resistance to other pests.

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The Department of Viticulture and Enology, U.C. Davis, maintains the world's largest and most complete collection of grapevines. From this rich source, university plant breeders have drawn the germplasm to produce distinctive wine grape varieties such as Emerald Riesling, Carnelian, Ruby Cabernet, Rubired, Royalty, Flora, Helena, and—most recently—Carmine and Centurian. Among the table grapes originating here are Perlette, Delight, Queen, Gold, and Beauty Seedless and Ruby Seedless. A canning variety of grape, Canner, and the Concord-type Niabell and Early Niabell for juice, also came from Davis efforts.

In the Davis collection, the European or vinifera varieties, some obtained as early as the 1880s, number about 2,000. Present are virtually all the important wine, table, and raisin grapes in world culture. The French hybrids, widely used for their hardiness and disease resistance, comprise one of the largest single collections anywhere.

Acquisitions now largely unavailable from original sources include Russian, Greek, and Middle Asian varieties. The Davis collection has been the most complete source of the Munson and earlier hybrids of the Southwest, which now are being reestablished in Dennison, Texas.

The Davis native species collection is the most complete in the world. The 25 known North American wild species of vinifera are present, and there are wild and cultivated forms of the native rotundifolia (muscadines) of the Southeast. Also at Davis, as the result of U.C. field collecting, is the only known grouping of wild Mexican *Vitis*.