DAN PAGE

# GRAPES TRANS-FORMED

## GENETIC ENGINEERING MAY OFFER DISEASE-PLAGUED GRAPEVINES A LIFELINE, BUT THE HURDLES ARE HIGH

BY LIZA GROSS

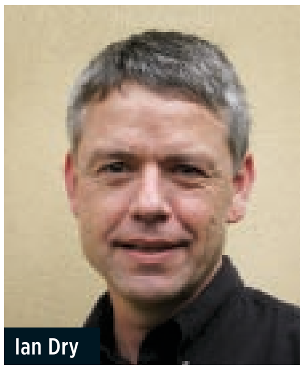
Grapegrowers face difficult questions as they try to protect their vines from disease. Is it better to use chemical treatments, with their financial and environmental costs? Or should growers risk public outcry and experiment with genetic engineering?

To preserve a variety's classic character, farmers have traditionally propagated grapevines (and other crops) as cuttings. But growing these genetically identical vines in single-variety vineyards within a winegrape monoculture (the industry standard) makes them highly vulnerable to disease. As a result, growers are forced to apply repeated chemical treatments to keep vines healthy and productive, at considerable economic and environmental expense. Many scientists believe genetic engineering could reduce these costs, but it faces stiff resistance from both vintners and consumers.

Failure to control fungal diseases such as powdery mildew and downy mildew—the biggest disease threats facing grapegrowers—can lead to stunted berry growth, reduced yields and off flavors in wine. In 2008, growers doused California grapevines with more than 18.5 million pounds of fungicides, representing more than 92 percent of all pesticides used in California vineyards. And though grapevines account for only about 8 percent of total crop acreage in Europe, a 2003 European Union–funded report revealed that their cultivation is responsible for 70 percent of fungicide use.

But if genetically modified crops are vilified as "Frankenfoods," the heavy use of chemicals is increasingly unpopular. In January 2009, the European Parliament voted to drastically reduce applications of highly toxic agricultural chemicals, requiring member states to implement "sustainable use of pesticides" by early 2011. The measure's revised safety criteria will likely outlaw many fungicides and compounds used to control grapevine pathogens.

That may force consumers to make tough choices. "You'll be faced with the prospect of drinking no wine, drinking organic wine at a higher price, or drinking low chemical–input, genetically engineered wine at a lower price," says Ian Dry, principal research scientist at CSIRO Plant Industry in South Australia.


Ian Dry

"YOU'LL BE FACED WITH THE PROSPECT OF DRINKING NO WINE, DRINKING ORGANIC WINE AT A HIGHER PRICE, OR DRINKING LOW CHEMICAL–INPUT, GENETICALLY ENGINEERED WINE AT A LOWER PRICE."

But even organic wines require copper and sulfur sprays—sulfur accounts for the lion's share of fungicide use—which at high concentrations can harm soil microbes and pollute groundwater. "If you think about it," Dry muses, "a genetically engineered wine with a resistance gene is really the ultimate organic vine."

Developing grapevines with inherent resistance to the various pests that haunt vineyards is a top priority for genetic engineering programs. Although fungal diseases are the most common grapevine malady, numerous insects, viruses and bacteria can also wreak havoc in vineyards.

In addition, new threats can appear without warning. French growers didn't worry about phylloxera until the tiny root louse showed up on vines imported from America in the 1860s. Despite its discovery in the late-19th century, Pierce's disease wasn't on the radar of Southern California vintners until the glassy-winged sharpshooter invaded Temecula Valley in the late 1990s. And just last year, Napa growers discovered a new pest in their midst: the European grapevine moth. This Italian native packs a triple punch in a single season, as three generations of larvae attack flowers, then developing berries and finally mature grapes, which then fall prey to botrytis bunch rot and other fungal infections.

Conventional plant breeders are trying to protect against such threats and reduce the need for chemicals by crossing the disease-plagued European *Vitis vinifera* vines, which make almost all the world's fine wines, with naturally hardy American species.

To make resistant rootstocks or scions (the vines grafted onto the rootstock) with conventional approaches, breeders germinate seeds from an American species that is resistant to a specific pest or disease, then cross-pollinate the flowering plants with a *Vitis vinifera* plant. Offspring that show resistance are then "backcrossed" to the vinifera plant over and over to wind up with a disease-resistant facsimile of the original.

"That works fine with wheat because you can do a couple of generations a year," explains CSIRO's Dry. "But with grapevines, normally it's about three years from the time you plant the seed to the time you get some flowers to do the crossing, so adding each generation, it's a lifetime's work."

Genetic engineering dramatically accelerates this process by inserting genes for resistance directly into a grapevine's genome. Researchers have two ways to do this. One technique co-opts a natural plant gene–delivery system used by the soil bacterium that causes crown gall disease. The other uses high-powered "gene guns" to bombard plant cells with tiny DNA-coated particles.

But genetic engineering's greatest advantage for wine grapes may be its potential to confer resistance without changing a variety's notable qualities—theoretically allowing wineries to call a modified variety by its well-known name.

Since 1995, more than 50 permits for trials on genetically modified, or "transgenic," grapes have been approved by the United States Animal and Plant Health Inspection Service. Other grapegrowing countries, including Chile, Germany, Australia and France, also have ongoing trials, most of which aim to evaluate disease resistance.

So far, results have been mixed. Some transgenic vines are showing promise in field trials, and small batches of genetically modified Riesling made in Germany proved indistinguishable from non-modified Rieslings in sensory tests. Progress has been hampered in part by scientific hurdles, but mostly by public resistance.

Consumer concerns focus on safety and whether GM vines might contaminate wild or organic vines. Organic vintners worry that the cultivation of GM grapevines could compromise their organic certifications. Keenly aware of such concerns, the Wine Institute, the California wine industry's leading advocate, asserts that "no genetically modified organisms be used in the production of California wine."

Moët & Chandon was an early supporter of genetic engineering technology. The famed Champagne producer teamed up with the French government in the '80s to explore its potential in the vineyard and participated in one of the first transgenic field trials in 1996.

The trial, led by Olivier Lemaire, a researcher at the National Institute for Agronomic Research in Colmar, France, tested GM rootstocks' ability to tolerate grapevine fanleaf virus under vineyard conditions. Fanleaf disease can slash crop yields—up to 80 percent for vulnerable varieties like Chardonnay and Pinot Noir—by killing flowers and preventing fruit formation, and produces high-acid, low-sugar grapes that make poor quality wines.

Because no wild or cultivated grape shows natural

INRA'S LEMAIRE HAS WORKED EXCLUSIVELY WITH ROOTSTOCK TO DEVELOP VIRUS RESISTANCE. ALTHOUGH THE ROOTSTOCK WOULD BE TRANSGENIC, THE GRAFTED SCION WOULD NOT, WHICH HE HOPED WOULD QUIET CRITICISM.


Olivier Lemaire


A plot of genetically modified grapevines in Alsace before an August attack (left), and after (right). The sign left by perpetrators translates as: "[The] wrong solution for the wrong problem."

LEFT: INRA; RIGHT: PHOTOPQR/L'ALSACE/JF FREY

resistance to fanleaf virus—or to the 55 other viruses that infect grapes—conventional breeding isn't an option. Even chemicals aren't reliable. Lemaire thinks genetic engineering offers the best shot at controlling these debilitating pathogens.

Lemaire's group inserted a gene segment from the virus into the genome of a rootstock used to grow white grape varieties. The technique works like a vaccine, exposing the plant to viral pathogens to stimulate its natural defenses.

"We are working exclusively with the rootstock to develop rootstock-mediated resistance," Lemaire says. By making the rootstock "immune" to the virus, transmitted by tiny soil-dwelling worms, Lemaire hopes to protect the grafted scion. Although the rootstock is transgenic, a grower can use Chardonnay or Shiraz or any scion of preference and keep the fruit and wine traditional. It's an approach Lemaire hoped would be less objectionable.

Three strains of transgenic rootstocks were showing good resistance to virus infection, but public concerns about growing GM plants in an open vineyard forced an end to the trial in 1999.

Lemaire, working with grapevine virologist Marc Fuchs, took the three promising rootstock lines and grafted 70 nonmodified grapevines onto them in a new field experiment—this time within the confines of INRA's grounds in Alsace. He thought the move would appease critics. He was mistaken.

In September 2009, a man sneaked into INRA's experimental plots and cut every transgenic plant just under the graft junction between the rootstock and scion. The plants had been growing for three years, with promising results. Lemaire re-grafted non-GM scions onto the rootstocks to try again. But this past August, activists uprooted and destroyed the vines. The researchers lost seven years of work and about 1.2 million euros. (See "French Activists Destroy Experimental Vineyard," www.winespectator.com/121510.)

Moët & Chandon no longer invests in genetic research, says spokesperson Jean Berchon, but maintains ties with INRA researchers "just in case." Lack of consumer and political support for the technology remains a major obstacle to using it, he says. "In Europe, few people actually seem ready to try."

While the global market for biotech agriculture continues to grow—in 2008, more than 300 million acres were planted to GM crops such as corn and soy—the future for GM grapevines remains uncertain. One stumbling block is whether wines made from GM grapes could be labeled and sold under classic varietal names. The only known evaluation of wine produced from GM vines, the GM Riesling made in Germany, supports scientists' predictions that genetic engineering methods wouldn't harm wine quality.

As part of a multiyear experiment started in 1999, to test GM Riesling grapes' resistance to fungal pathogens, small batches of GM Riesling were compared with unmodified Riesling, says Rudolf Eibach, a researcher at the Institute of Grapevine Breeding in Siebeldingen, Germany. "Wines were tasted together and it was found over several years that an organoleptic [sensory] differentiation of the individual variants was not possible."

Ironically, the GM Riesling vines, engineered with barley genes that attack fungal cells, proved just as vulnerable to infection as the unmodified vines. As a result, researchers pulled all 600 GM vines that had been planted in two locations in Rhineland Palatinate, the heart of German wine country.

Another strategy, which takes genes only from other grape species, may prove more promising. Dry takes this approach to transfer resistance genes from a mildew-resistant American species into vulnerable Shiraz and Chardonnay vines without "taking the bad genes" associated with American vines' off flavors. And because he's working only with grape genes, "the thing we produce is about as close to a natural grapevine as we can get."

Dry thinks this strategy might even pass muster with the International Organization of Vine and Wine, which oversees varietal authenticity. But at this point, no one is growing genetically engineered grapevines commercially to test this possibility.

Bruce Reisch, professor of grapevine breeding and genetics at Cornell University, is testing transgenic Chardonnay vines for crown gall resistance in field trials, but he's focusing less on genetic engineering. GE trials require far more funding and labor than conventional trials to quarantine the vines, prevent cross-pollination with other grapes, and keep the berries away from hungry wildlife.

Reisch thinks the market might eventually accommodate transgenic grapes if they were the only defense against pest and disease pressures, and cites as an example the odious Pierce's disease. Once a vine is infected, nothing can save it. Should it become a serious problem again, "and other methods to control it fall flat," he says, "I think people will begin to accept it."

*Liza Gross is a freelance journalist based in Kensington, Calif.*