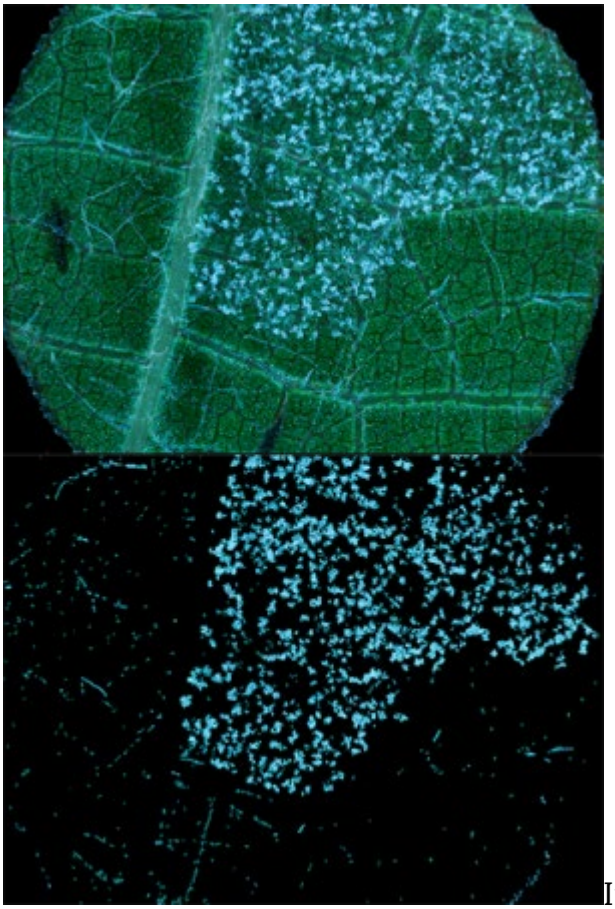
Research in Plain English

Single and multiple phenotype QTL analyses of downy mildew resistance in interspecific grapevines
(Looking for durable downy mildew resistance in grapes)

Research in Plain English provides brief, non-technical summaries of journal articles by Cornell faculty, students, and staff.

Authors: Konstantin Divilov, Paola Barba, Lance Cadle-Davidson and Bruce Reisch
Theoretical and Applied Genetics, 131 (5), pages 1133-1143. DOI: 10.1007/s00122-018-3065-y. May 2018.

Summary by Janet van Zoeren


Images of a grape leaf disk, showing downy mildew symptoms. Above, as seen by the eye in a typical photograph. Below, as "seen" and processed by the phenotyping robot.

The Takeaway.

- The authors found five new genes that are associated with durable resistance to downy mildew.
- These associations were consistent across two years, three lineages, and varying experimental design protocols.
- The newly discovered downy mildew resistance genes will help breeders incorporate resistance in new grape strains.

Background. Grapevine downy mildew (DM) is a frequent cause of yield loss in eastern vineyards. In general, *Vitis vinifera* grape cultivars are highly susceptible to DM, while native *Vitis* species often are resistant. In order to more efficiently breed resistant interspecific hybrids, researchers are working to map the genes associated with resistance. Grapevine resistance to DM can be quantified based (A) on the degree to which the pathogen is able to sporulate on a leaf, (B) the "hypersensitive response" of the grape leaf (a grape resistance mechanism in which leaf cell death prevents pathogens from spreading), and (C) the density of leaf trichomes (which have been shown to physically impede pathogens).

Developing varieties with disease resistance could provide an important integrated disease management tool; however, many pathogens, including the one that causes DM, are quickly able to adapt to overcome the plant's defenses. A strategy to maintain durable disease resistance is to use quantitative trait loci (QTL), which relies on multiple genes, each controlling different plant responses to defend again a pathogen.

To date, genes known to be associated with downy mildew resistance in grapes are mainly under single gene control. Sustainable DM resistance requires the locating of QTL markers for resistance. *The research described here used multiple lineages, years of data, and experimental designs to find QTL associated with DM resistance in interspecific hybrid grapes.*

Experiment. Four lineages of grape were used: (1) *Vitis rupestris* crossed with 'Horizon' (a complex interspecific hybrid), (2) 'Horizon' crossed with *V. cinerea*, (3) a susceptible control (either 'Chardonnay' or 'Cabernet Sauvignon'), and (4) a resistant control (either *V. rupestris* or *V. cinerea*). The controls were included to be sure the DM strain could infect the susceptible cultivars, and to establish a baseline of resistance against which to evaluate the two crossed lineages. The Horizon x *cinerea* lineage consisted of vines both with and without trichome hairs on the undersides of their leaves (which are expected to contribute to DM resistance), whereas the *rupestris* x Horizon lineage did not have trichomes.

From each lineage, 1 cm diameter leaf disks were sterilized, placed on 1% agar to prevent desiccation, and then inoculated with DM.

DM resistance was quantified through the following traits: (1) visual ratings of sporulation on a scale of 1 to 5, (2) computer vision ratings of percent sporulation, (3) computer vision ratings of percent of leaf covered in trichomes (only relevant in the 'Horizon' x *cinerea* lineage), and (4) human vision ratings of "hypersensitive response" (leaf cell death to prevent DM from spreading).

Modeling was used to determine the heritability of each DM resistance trait (whether the trait's expression is mainly due to genetics or environmental factors), as well as to find the loci (sections of genetic code) most likely associated with the resistance traits.

Results. *Heritability*. Heritability of all resistance traits (sporulation, hyper sensitive response, and trichome density) was moderately high, indicating that these traits are largely determined by the plants' genetics, and only partially a factor of environmental conditions. For that reason, downy mildew in grapes is a likely candidate for breeding into new cultivars.

QTL associated with DM resistance. Using the two experimental lineages and three DM resistance traits (described above), 16 sets of markers were found to be associated with DM resistance. Many of those were found to overlap with each other, and using statistical modeling these were condensed into 5 QTLs that could be confirmed with a high degree of confidence to be associated with resistance. One of these is associated with trichome density, while the other four are associated with impaired DM sporulation and increased grapevine hypersensitive response (disease defense).

Conclusions and practical considerations. The study provides evidence for five QTL associated with DM resistance in grape. These provide resistance through two different mechanisms (physical defense – trichomes, and non-physical defense – hypersensitive response). Grapevine breeders are already testing these newly identified genes for use in breeding DM resistance into new grape lineages, with the intention of providing more durable resistance by stacking physical and non-physical defense traits together in the same cultivar.

Janet van Zoeren is an extension support specialist with the statewide viticulture extension program, in the Section of Horticulture, based at Cornell AgriTech in Geneva, NY.