Grapes 101

Downy Mildew is caused by an Oomycete. What's an Oomycete? Why does it matter?

By Katie Gold.

The big 5 diseases that Eastern growers need to manage (powdery mildew, downy mildew, black rot, phomopsis, and *botrytis* bunch rot) have been referred to in the past as "fungal diseases." But one of them is not a fungal pathogen at all. Downy mildew is an "oomycete." Its biology, reproduction, and management set it apart from the "true fungi." The distinction is not only of academic interest – but also is important when it comes to management.

So what's an oomycete, and why aren't they considered to be fungi?

One of the groups of organisms that cause many serious plant diseases are known as the *Oomycota* or oomycetes, sometimes referred to as "lower fungi," or "water molds."

Oomycetes were long thought to be fungi because in many regards, they look and behave like true fungi. Like fungi, oomycetes obtain their nutrients via absorption, and many produce the filamentous threads known as mycelium characteristic of many fungi.

Despite these similarities, the *Oomycota* are now classified as a distinct group based on their unique biological characteristics that differentiate them from true fungi. These biological differences yield important considerations for on-farm management.

This article will cover a basic introduction to oomycetes, how they differ from true fungi in terms of biology and management, and then introduce grapevine's most important oomycete disease, downy mildew, and its management.

Biology of the Oomycetes

You may be surprised to learn that true fungi, such as the organisms that cause powdery mildew, black rot, phomopsis, and botrytis, are more closely related to animals than they are to oomycetes (**Figure 1)**! *Oomycota* contains more than 800 species that range from opportunistic decayers (saprophytes) to outright parasites of both plants and animals. The plant diseases they cause include seedling blights, damping-off, root rots, foliar blights, and downy mildews.

Oomycete-caused diseases have had massive impacts on human agriculture and society, and are even responsible for giving birth to the discipline of plant pathology. Potato late blight, the notorious plant disease responsible for the Irish potato famine, in which over 1 million people died and 1.5 million emigrated, is caused by the oomycete *Phytophthora infestans*, which is Latin for "plant destroyer."

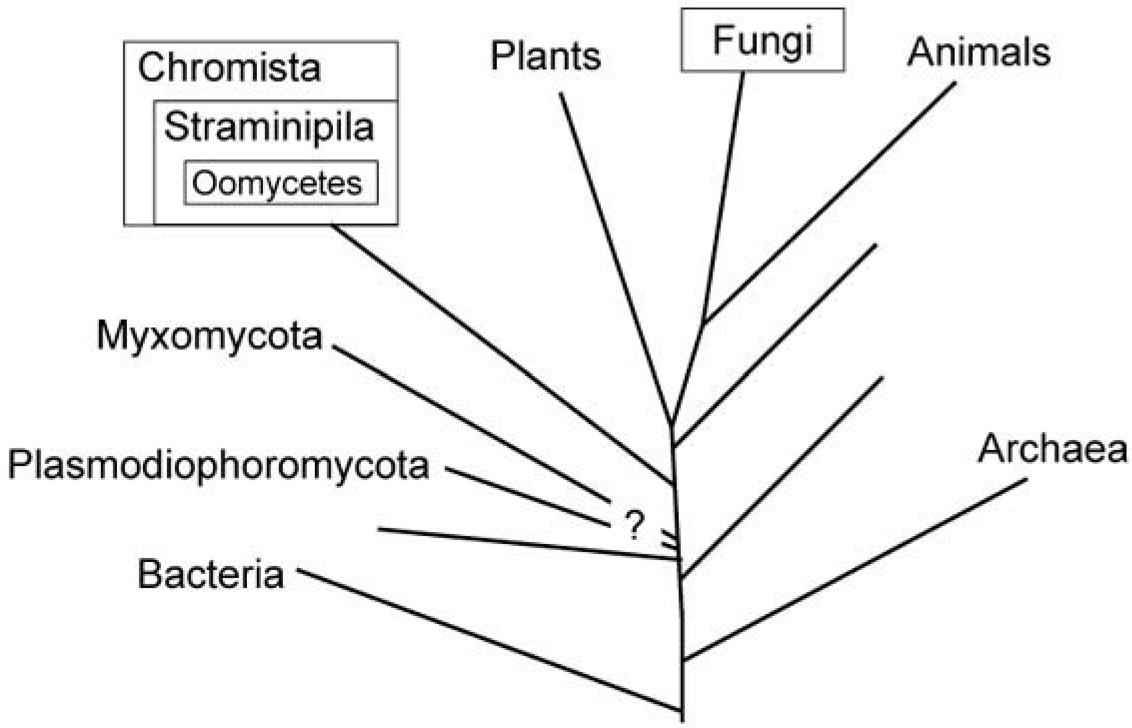

Figure 1. *Family tree (called a cladogram by scientists) showing the relationships of the major groups of organisms traditionally referred to as fungi. Oomycota is evolutionarily distinct from the true Fungi and branched off from plants and animals early in evolution. True fungi are more closely related to animals than to plants. Diagram courtesy A. Baudoin.*

The founding father of plant pathology, Anton de Bary, lived during this era and studied P. *infestans* extensively. In fact, this oomycete disease is responsible for my presence as a grape pathologist in New York today. This is because my great-great-great grandparents emigrated to the United States from Ireland in the 1840s to escape the potato famine.

Spore Types Set Oomycetes Apart

While many morphological and biological differences between oomycetes and true fungi are important for taxonomy and academic study, the most important ones affecting management are the types of spores they produce.

Oomycetes are sometimes referred to as having a "spore for all seasons." They produce three unique types of spores than no true fungi can produce: oospores, sporangia, and zoospores (**Figure 2**).

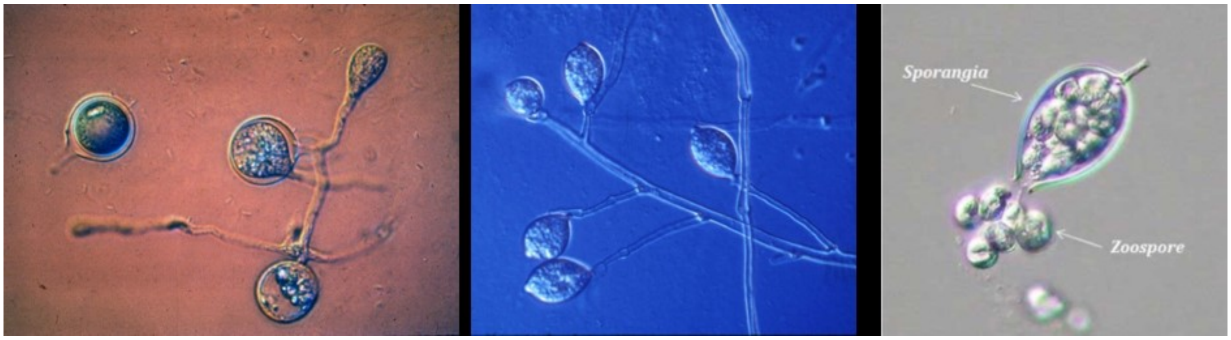

***Figure 2**. Examples of the three spore types produced by oomycetes: oospores (left, W.E. Fry), sporangia (center, W.E. Fry), and zoospores (right, F. Brooks).*

- O*ospores* are long lived, winter survival spores that persist in soil and leaf litter. Oospores can live for years in the soil in such abundance that common sanitation practices can have no impact on them. Oospores are frequently responsible for the first infections of a season.
- *Sporangia* are short-lived, aerially dispersed spores, that can be produced multiple times within a season, often resulting in cascading epidemics. They house and carry the third spore type, zoospores, from host to host. Sporangia can be produced both from primary infections caused by oospores and secondary infections caused by the other spore types. In some oomycete species, sporangia can directly germinate and penetrate the host tissue to cause infection without releasing zoospores.
- *Zoospores* are even shorter lived, water-dispersed spores produced by sporangia once they have landed on a conducive host. With enough free water present, sporangia will burst to release zoospores, each of which can initiate its own infection on the leaf surface. Zoospores dry out easily and rarely survive longer than 2-3 hours after release. Not all oomycetes produce these spores, but most do.

Oomycetes are much more aggressive by structure and function which yields their notorious "explosive" growth potential under conducive environmental conditions. With a spore for all seasons and surfaces (oospores for soil, sporangia for air, and zoospores for water), it's no wonder that oomycetes can cause such destructive disease.

Management

Specialty chemistries (oomycides) are often required for oomycete management. Oomycete pathogens are generally susceptible to broad spectrum fungicides, such as chlorothalonil, mancozeb, captan, and copper, but vary in their susceptibility to systemic fungicides. This variation is in great part due to their inherent biology.

Certain chemistries are only active against oomycetes, targeting biological features that true fungi don't have. Examples include mefenoxam (Ridomil), ethaboxam (Elumin), mandipropamid (Revus), and oxathiapiprolin (Orondis).

The opposite is true as well – certain classes of fungicides have no activity on oomycetes because they target biological components that only true fungi have.

An important example of this are the DMI (demethylation inhibitors, FRAC 3) fungicides such as difenoconazole (the "Top" in Revus Top), propiconazole, and tebuconazole. These fungicides target ergosterol, an important component of fungal cell membranes. Oomycetes do not have ergosterol in their cell membranes, making them immune to DMI fungicides. Like fungicides, all oomycides have varying levels of risk for resistance development, so it is essential to follow issued best practices for resistance stewardship when crafting a spray program.

Grapevine Downy Mildew

In eastern grape production, our most important and notorious oomycete disease is grapevine downy mildew, caused by *Plasmopara viticola* (**Figure 3**). This pathogen thrives in our warm, humid Eastern climate, and is rarely seen in the dry Western production regions.

Not only can downy mildew result in significant crop loss if unmanaged, mismanaged downy mildew can result in total vine loss, making it unique from the other early-season fungal diseases in this regard. Like many of its oomycete brethren, such as Potato Late Blight, the disease associated with the Irish potato famine, grapevine downy mildew is known for its explosive growth potential. Under the right conditions, downy mildew infections can "explode" and defoliate grapevines prematurely, making them more susceptible to winter injury/kill.

Figure 3. *Examples of foliar (left & right) and cluster (center) grapevine downy mildew. Photos by K. Gold.*

Severe downy mildew pressure in the prior season will result in an abundance of primary inoculum, oospores, to control in the following year's early season.

Early season, primary infections begin when oospores spread from soil and leaf litter on the ground to young leaves and clusters, beginning about 2-3 weeks prior to bloom. Suckers or volunteer seedlings are often the first infected because they're closest to the ground.

Unfortunately, sanitation and dormant sprays have no effect on downy mildew oospores, but early season cultural management for other diseases provides an opportunity to scout for these primary infections to see if your management to date has been effective.

Once established, the infections (lesions) caused by oospores can produce secondary inoculum, sporangia, after 7-10 days. These lesions will produce sporangia season-long whenever conditions become conducive, resulting in cascading late season epidemics. Sporangia release is triggered by warm, humid nights with rain shortly thereafter. Without rain, most sporangia will stay in place and die the next day when exposed to bright sunlight. However, sporangia can survive and remain infectious for several days between rainfalls if conditions remain cloudy. When the sporangia land on a leaf surface they will burst and release zoospores, the water spores, to infect when there is sufficient free water on the leaf surface.

Varietal Susceptibility and Chemical Control

All V. *vinifera* clusters are highly susceptible beginning first appearance through approximately 4-5 weeks post-bloom. Berries become resistant to direct downy mildew infection at this time, but pedicels and foliage will remain susceptible long after. Concord is only slightly susceptible to downy mildew.

Practices that encourage air circulation and speed drying time can reduce disease pressure, but will not replace the need for chemical control. A variety of products ranging from protectants to systemics are labeled for grapevine downy mildew control in New York (**Table 1**). All systemic chemistries for downy mildew management are prone to resistance development and should be used in rotation within a sound, integrated pest management program.

Table 1.

Fungicides and oomycides labeled for grapevine downy mildew control in New York.

PRODUCT	METHOD	TYPE	EFFICACY
Mancozeb	Contact	Protectant	Good

Table 1. Fungicides and oomycides labeled for grapevine downy mildew control in New York.			
PRODUCT	**METHOD**	**TYPE**	**EFFICACY**
Captan	Contact	Protectant	Good
Ranman	Contact	Protectant, Anti-Sporulant	Good
Copper	Contact	Protectant	Good
Ziram	Contact	Protectant	Moderate
Ridomil	Systemic	Post-Infection, Protectant, Anti-Sporulant	Excellent
Revus/Revus Top	Translaminar	Post-infection, Protectant(?), Anti-Sporulant(?)	Excellent
Zampro	Translaminar/Systemic	Post-Infection, Protectant, Anti-Sporulant	Good
Phosphoric Acid	Systemic	Post-Infection, Protectant, Anti-Sporulant	Good
Lifegard	Biopesticide	Defense Activator	Good/Moderate

Protectants used to control Phomopsis and/or black rot early in the season, such as mancozeb and captan, will also provide good preventative control of downy mildew. Ziram provides moderate control of downy mildew, but is not as effective as mancozeb and captan.

Copper provides good control, but it should be noted that that copper can cause injury to the foliage at the time of season when downy mildew management is most essential (succulent leaves). Zampro, Revus, and Revus Top (the mandipropamid component) provide excellent downy mildew control. Ranman provides good control.

Phosphorous acid (PA) products (such as Phostrol) provide good preventative and post-infection control ("kick-back"). As a caveat, overuse of phostrol as a curative has led to reports of slippage. Phostrol should be used with caution as a curative on mild infections and NOT USED on moderate to severe infections. Ridomil remains the best oomycide ever developed for downy mildew control, but is extremely prone to resistance development (and expensive), and should never be used more than once per season. Ridomil should NOT be applied to raging infections, as this increases the likelihood of resistance development.

Conclusion

Downy mildew is unique among grape disease-causing organisms in being an oomycete, and not a fungus. This means that its methods of reproduction and spread differ from diseases caused by true fungi. Systemic fungicides that are active against downy mildew (oomycides) have different targets than those that are active against true fungi. Likewise, not all fungicides that can control true fungi are capable of controlling downy mildew and oomycetes. This is increasingly important, as climate change is increasingly producing more intense rainfall and warmer temperatures – environmental conditions that favor downy mildew, particularly late in the growing season. Downy mildew is becoming the key disease organism in regions with significant summer precipitation, and understanding its biology as an oomycete is important for its successful management.

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