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Improving management of powdery mildew

David Gadoury et al., summarized by Bibiana Guerra

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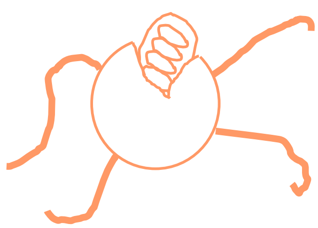
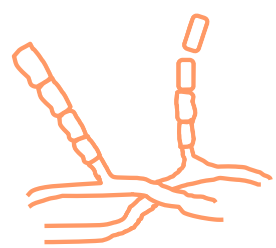
• With more than 20 years of experience in grape disease research and development of IPM programs, the goal of this research team was to develop an advisory system that would allow growers to improve their management of grapevine powdery mildew (*Uncinula necator*), the cause of significant grape losses in humid climates.

• Before we start familiarizing ourselves with the life cycle of the pathogen, here are a few terms common to most fungi:

- *cleistothecia:* overwintering sexual structures that contain the ascospores
- *ascospores:* spores released from the cleistothecia in the spring
- *conidia:* spores which form throughout the season on the whitish gray tissue (mycelium) growing on the surface of the leaves, as opposed to *ascospores*, which form before winter
- *mycelium*: whitish-gray fungal tissue formed by elongated fungal cells called hyphae
- *inoculum load:* amount of overwintering cleistothecia, normally trapped in the bark crevices after being washed from leaves by rain events
- *primary infection:* first infections from ascospore sporulation in the spring, as opposed to *secondary* (subsequent) infections.

Cleistothecia





Conidia

• **Fungi life cycle**: Powdery mildew overwinters as hyphae inside dormant buds and as cleistothecia in the bark. After budbreak, the fungus forms a mycelium on the leaves, which produce conidia that start disseminating. In spring, cleistothecia split and produce ascospores that go on to infect more green tissue and to produce more conidia. In late summer, new buds become infected before going dormant, and new cleistothecia are formed on the leaves and berries, both are ready to start a new cycle the following year.

• **When are *ascospores* released in relation to the vine phenology?** When researchers subjected cleistothecia to different temperatures in the lab, they found that cleistothecia release of ascospores was always completed well before budbreak, by January 1^{st}. They also found that the higher the overwintering temperatures, the lower the cleistothecia survival rate. The authors found a strong correlation between cleistothecia behavior in the lab and in the vineyard.

• **What determines the size of the overwintering *inoculum load*?** Cleistothecia need a certain amount of heat - or degree-days (DD accumulation) - to mature. The authors compared the time of the year cleistothecia were observed on the leaves with the amount of heat expected to be available for their maturation. They concluded that if cleistothecia were not formed on the foliage by September 15, they wouldn't have time to mature. Furthermore, they found September 7^{th} to be a key date after which chances of having damaging cleistothecia maturation were reduced to 50%. This date represents a good time to scout vineyards to assess inoculum loads, and if large, to plan a first spray aimed at reducing the inoculum.

• **How does timing and severity of *primary infections* affect subsequent disease development?** To learn how the disease spread, the authors purposely inoculated one vine with powdery mildew spores ("hot spot") and regularly sprayed the surrounding vines to protect them. However, they bagged a few clusters at increasing distances from the hot spot (un-sprayed "sentinel clusters") to get information on how the disease evolved. They found that "hot spots" that had been established early in the season (late May) produced more severe disease and were able to spread further than those established later (early June or late June). Another crucial finding was that a fungicide application (e.g. JMS Stylet oil or sulfur) applied pre-bloom would have killed most of these spores before they had a chance to sporulate.

• **How do spring cold temperatures affect progress of the disease?** Is the relatively limited spread of spores the result of increased *pathogen sensitivity* to cold temperatures, of increased *resistance of the vine* during cold events, or both? When researchers inoculated leaves that had been exposed to cold, their colonies were smaller than those of an unexposed control. A closer look at the genetic profile of cold-exposed versus unexposed leaf tissue revealed that genes associated with protection from powdery mildew infection appeared turned on ("upregulated") in the leaves exposed to cold.

• **What are the key warnings of a "bad year" for powdery mildew?** If only we could have an answer we would be able to use relaxed protection programs in mild years, and intensified ones to avoid disaster in severe years! After comparing historical data (1985 to 2007) of fruit infection of a highly sensitive cultivar (Rosette) with historical weather variables, the authors found a potential useful predictor: **rate of pan evaporation**. Pan evaporation is the rate at which water evaporates from an open pan in a standard location, which has the benefit of integrating into one measurement the effects of temperature, solar radiation, and wind speed. The authors found that low rates of pan evaporation were correlated with high disease severity. Furthermore, when pan evaporation was combined with a second variable - **fall degree-day accumulation** - the correlation was reinforced. This revealed a valuable "turning point" which allowed the authors to develop a "disease prediction model."

• **How does disease risk vary in different climates?** A *simulation model* is able to predict outcomes based on various levels of the variables used in the model. Using a simulation model and historical data for the two main variables in their model (pan evaporation rate, fall degree-day accumulation), the authors were able to predict the distribution of disease severity at three sites with different climates (New York, Washington, and South Australia). These model predictions were strikingly similar to historical records of disease for these sites. So through the use of historical disease and climatic data, the authors were able to validate their prediction model.

In summary, some of the relevant information found up to date in this study include:
_ the first half of September is a good time to assess the inoculum load and apply a first spray if needed
_ spore inoculations around late May spread further and were more damaging than those happening later
_ powdery mildew spores do not seem to spread very far, with widespread disease being rather the result of widely distributed spores traveling short distances
_ vines exposed to cold temperatures formed smaller colonies and developed less disease
_ low rates of pan evaporation (<250 in/day) and low amounts of accumulated fall DD (<600) are a good indicator of higher levels of disease.

The authors plan to further refine their model in future years. They hope to be able to start soon a pilot study in which growers will be provided with the forecasting model so they can incorporate this information into their management decisions.

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