Influence of Environmental Conditions on Grape Foliar and Fruit Diseases and Their Management

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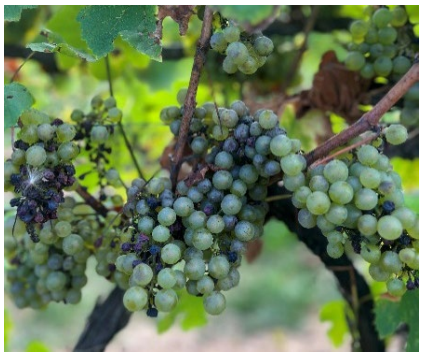

Introduction

The three combining factors that result in disease in a vineyard are:

1) A susceptible plant
2) The presence of a pathogen, and
3) Environmental conditions that either favor the pathogen's spread or reduce the plant's ability to ward off diseases.

The latter, favorable environmental conditions, is the primary factor that can influence key management decisions, including when, what, and how frequently to spray or implement other disease control tactics. In this fact sheet, we describe key windows of vine development, and key environmental conditions, that drive the severity of grape powdery mildew, grape downy mildew, Botrytis bunch rot, Phomopsis cane and leaf spot, black rot, and anthracnose diseases. This will highlight why some years are "tough" for the management of certain diseases, and why environmental conditions are critical to consider when developing disease management programs.

Considerations for Season-Long Vineyard Disease Management

Understanding the drivers of disease severity is critical in the design and review of disease management programs. When susceptible stages of vine development align with favorable environmental conditions for pathogen growth and disease development, intervention is required. These conditions will not only influence the timing of these interventions (i.e., when in the season to spray or perform canopy management activities), but also influence the frequency of these strategies (i.e., the intervals between sprays).

When designing base management programs, assume "average" conditions for your area and disease pressure, and design the timing, type, and frequency of sprays based on these average conditions. As the growing season progresses, observations of environmental conditions and vine phenology should be used to adjust the base program and respond to increased or decreased risk (i.e., earlier or more frequent intervention during periods of greater risk, or less frequent intervention if environmental conditions are not favorable).

When reviewing a spray program, whether it's for future planning or to identify where a program may have failed, consider vine development and environmental conditions during the growing season for which that program was developed. Identify whether the program aligned intervention strategies with the appropriate stage of plant development, and whether or not spray intervals were reflective of environmental conditions for the diseases targeted by those sprays.

Pro-Tip: If a spray program timing and intervals look to be appropriate, but a disease control failure occurred, that may indicate there was an error in the application of product(s) (e.g., insufficient water, poor sprayer calibration), or the presence of fungicide resistance in your pathogen population. If this is the case, it is necessary to review actual application practices (water volume, sprayer type, nozzle type, spray coverage). In addition, you may wish to collect samples of the pathogen population to test for pesticide resistance, if such tests are currently available.

The Diseases and Environmental Conditions Favoring Severity

Anthracnose - *Elsinoë ampelina*	
Phenological stages	E-L 7 to 26: Early shoot development through flowering. Disease expression may be delayed up to several weeks after infection.
Susceptibility	Most *Vitis species, including hybrids.* *Younger tissue is more susceptible than older tissue.*
Inoculum	Pathogen overwinters as sclerotia on infected canes, or as cluster mummies.
Environmental driving conditions	Initial spore release can occur during prolonged wet periods (24 hrs.) caused by dew or rain, when temperatures are above freezing. A shorter wetness period (3 to 4 hours) is required under optimal temperatures (25 to 30°C / 77 to 86°F).

Black rot - *Guignardia bidwellii*	
Phenological stages	E-L 7 to 32: Early shoot growth to bunch closure, depending on overwintering inoculum depletion.
Susceptibility	*Vitis vinifera*, *Vitis labrusca*, and hybrid cultivars Young foliar tissue near actively growing shoot tips. Inflorescence & fruit: leading up to bloom and until approximately 2 to 3 weeks post-bloom Fruit infection is the major concern. Fruit is resistant to infection 2 to 3 weeks post-bloom. Disease typically does not manifest on fruit until berry development.
Inoculum	Pathogen overwinters on previous year's dried berries (cluster mummies). Amount of overwintering cluster debris *significantly* influences the following-season disease pressure.
Environmental driving conditions	Rain events initiate spore release. Infection requires prolonged periods of leaf wetness: • 6 hours at optimal temperature (26.5°C / 80°F) • 12 hours at moderate temperatures (13°C / 55°F or 32°C / 90°F) • 24 hours at cooler temperature (10°C / 50°F)

Botrytis bunch rot - *Botrytis cinerea*	
Phenological stages & Susceptibility	E-L 23 to 27: Flowering to fruit set, when flower debris can be colonized by the pathogen. E-L 32: At bunch closure, flower debris can become entrapped in clusters. E-L 36 to harvest: Mid to late veraison, particularly tight-clustered varieties or clones, or highly aromatic varieties.
Inoculum	Pathogen overwinters as sclerotia on mummified clusters. Can also survive in the environment on other plant debris.
Environmental driving conditions	Availability of decaying plant debris or sugar in ripening fruit is a primary driver for fungal growth. High relative humidity (>90%) and moderate temperatures (20 to 25°C / 70 to 77°F) are also factors.

Downy mildew - *Plasmopara viticola*	
Phenological stages & Susceptibility	Vegetative growth: can be infected at any point during the growing season, although older leaves are slightly more resistant to infection. Inflorescence & fruit: clusters are susceptible from rachis elongation to approximately 3 to 4 weeks post-bloom; duration of susceptibility varies widely, influenced by cultivar and bloom conditions.
Inoculum	Pathogen overwinters as oospores on grapevine leaf debris on the vineyard floor.
Environmental driving conditions	Initial infection requires free moisture and open leaf stomata. Infections are common as a result of nighttime rains (exceeding 10 mm or 3/8 inch), when temperatures are at least 10°C / 50°F. Secondary infection requires high relative humidity (98%) and moderate temperature (optimal at 19°C / 66°F).

Phomopsis cane & leaf spot - *Phomopsis viticola*	
Phenological stages & Susceptibility	Early shoot development through early bloom: fungus infects green tissue, and spores are released when shoots begin growing in spring. Disease is monocyclic, so there is only one major infection window to consider.
Inoculum	Pathogen overwinters on dead plant material. The amount of overwintering infected plant debris in the vineyard will significantly influence disease pressure the following season.
Environmental driving conditions	Infections are driven by high relative humidity (>90%) for multiple consecutive days; prolonged periods of leaf wetness increases disease severity. Optimal temperatures for fungal growth are 16 to 20°C / 61 to 68°F.

Powdery mildew - *Erysiphe necator*	
Phenological stages & Susceptibility	Vegetative growth: Green shoots and younger leaves are susceptible to infections. Young leaves are those that are either carbohydrate sinks or are transitioning from a sink to a source. Young leaves that are covered in dense leaf hair have a reduced risk of infection. Inflorescence & fruit: Clusters are susceptible from early rachis elongation (EL-12), until approximately 3 weeks post 100% bloom.
Inoculum	In most climates, the fungus overwinters as ascospores in chasmothecia. In areas with warm winters (USDA plant hardiness zones 8 to 10), the fungus can overwinter in dormant buds. The fungus colonizes shoots as they grow, resulting in early, severe disease outbreaks.
Environmental driving conditions	Initial infections in the spring (from ascospores) require the presence of free moisture from rain, heavy dew, or fog. Subsequent in-season infections do not have this moisture requirement. Moderate temperature and moderate to high humidity favor high disease severity. Optimal growth occurs at 25°C/ 77°F. Cold (<8°C/ 46°F) or hot (>35°C / 95°F) temperatures and very low relative humidity (below 30%) can significantly reduce disease development and severity.

Environmental conditions at different stages favorable for these diseases

Phenology Stage	Temperature	Humidity / Moisture	Diseases of Concern
Budbreak to immediate prebloom (E-L 4 to E-L17)	Cool	Wet	Anthracnose Phomopsis cane and leaf spot
		Dry	
	Warm	Wet	Anthracnose Black rot Phomopsis cane and leaf spot Downy mildew
		Dry	
Prebloom to fruit set (E-L 17 to E-L 27)	Cool	Wet	Anthracnose Black rot Botrytis bunch rot Downy mildew Phomopsis cane and leaf spot Powdery mildew
		Dry	Powdery mildew*
	Warm	Wet	Anthracnose Black rot Botrytis bunch rot Downy mildew Phomopsis cane and leaf spot Powdery mildew
		Dry	Powdery mildew*
Fruit set to bunch closure (E-L 27 to E-L 32)	Cool	Wet	Black rot Botrytis bunch rot Downy mildew Powdery mildew
		Dry	Powdery mildew*
	Warm	Wet	Black rot Botrytis bunch rot Downy mildew Powdery mildew
		Dry	Powdery mildew*
Bunch closure to harvest (E-L 32 to E-L 38)	Cool	Wet	Botrytis bunch rot Downy mildew (foliar) Powdery mildew (foliar)
		Dry	Powdery mildew (foliar)*
	Warm	Wet	Botrytis bunch rot Downy mildew (foliar) Powdery mildew (foliar)
		Dry	
Post-harvest to leaf fall (E-L 38 – E-L 47)	Cool	Wet	
		Dry	
	Warm	Wet	Downy mildew (foliar) Black rot (foliar) Phomopsis (foliar)
		Dry	Powdery mildew* (foliar)

Note that several diseases have specific temperature, moisture, or relative humidity thresholds, described in-text. **With temperature and humidity / moisture, the descriptive terms are relative to conditions that are common during those key times-of-season** (vine development stages based on modified Eichorn-Lorenz).
*In this case, "Dry" means lack of measurable precipitation. Moderate to high humidity increases disease severity.

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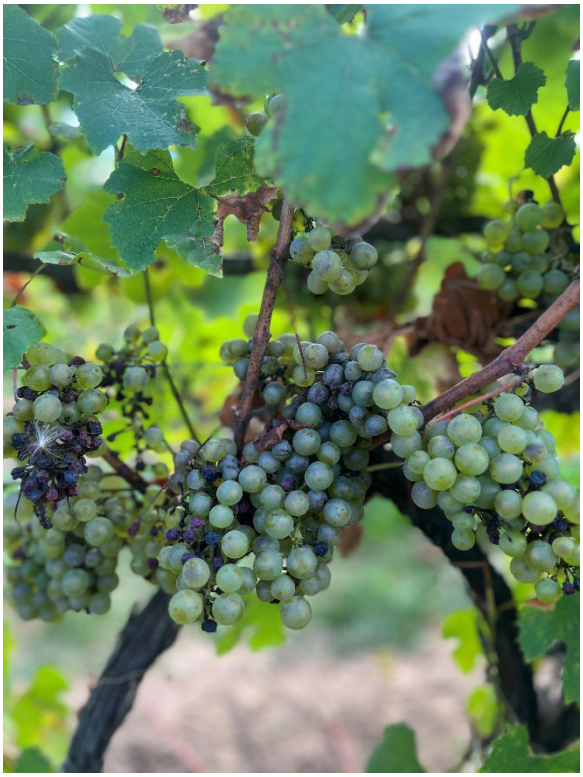
Resources

In addition to the peer-reviewed resources below, most Land-Grant Universities develop pest and disease management guidelines and factsheets. Check your local University's Extension Publications resources, or consult with Extension Specialists or Educators specializing in viticulture or small fruits pathology for region-specific information.

Wilcox, W.F., W.D. Gubler, and J.K. Uyemoto (eds). 2015. Compendium of Grape Diseases, Disorders, and Pests – 2nd edition. The American Phytopathological Society, St. Paul, MN, USA. 232 p.

"Grapevine growth stages – The modified E-L system" Viticulture 1 – Resources. 2nd edition 2004. Eds. Dry, P. and Coombe, B. (Winetitles) Link to Modified E-L System Reference Figure →

Modified E-L Reference Figure



V. vinifera cv. Chardonnay with downy, powdery and Botrytis bunch rot (K. Gold)

Black rot *Guignardia bidwellii* (M. Moyer)