Epidemiology, management, and forecasting grapevine powdery mildew in Eastern Washington

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Washington's wine grape industry is relatively new having expanded from about 2,000 ha in 1985 to 17,000 ha in 2007. The varietal composition is about 60% red varietals to 40% white. Major red varietals include Merlot, Cabernet Sauvignon, Cabernet Franc, and Syrah with smaller proportions of Cabernet Franc, Malbec, and Sangiovese. Major white varieties include Pinot Grigio, Chardonnay, and Riesling.

The industry is centered in the arid regions east of the Cascade Mountains. Precipitation in Prosser, WA (the center of the wine producing region) is about 20–30 cm annually with the majority occurring during the dormant season. Some aerial diseases that plague vines in other regions are minor (e.g. botrytis bunch rot, phomopsis cane and leafspot) or nonexistent (e.g. downy mildew and black rot) in Washington. However, grapevine leaf roll (virus), crown call (*Agrobacterium vitis*) and powdery mildew can be problematic. Powdery mildew management drives the entire viniferous grape IPM system in the state and is therefore an expensive management proposition.

Pathogen biology and disease epidemiology

The disease is caused by the fungus *Erysiphe* (=*Uncinula*) *necator*. The disease cycle in Eastern Washington in similar to that reported in New York State, namely that perennation occurs only as chasmothecia (cleistothecia; ascocarps) and not as mycelium in dormant buds. Chasmothecia survive in exfoliating bark and sometimes on leaves on the vineyard floor. Ascospores are mature about 2 weeks prior to budburst and persist until early bloom. Ascospore release and primary infection occurs when $\geq$ 2.54 mm of precipitation is received when temperatures are $\geq$ 10°C. The disease can progress rapidly but is usually slowed by the high summer temperatures characteristic of the growing region.

Management techniques

The management of powdery mildew in the region involves the integration of vigor management, irrigation management, canopy adjustments, and in most cases an intensive fungicide program. Washington growers have at their disposal and extensive portfolio of fungicide products (Table 1).

Fungicide programs have been historically based on vine phenology although disease-forecasting models have been widely accepted. Fungicide programs are generally 'bloom-centered' meaning that the more efficacious synthetic fungicides are used most extensively through the bloom, the period of maximum susceptibility of fruit to infection by *E. necator*. PDSO and sulfur usage is normally confined to early-season before the bloom period. Washington producers are cognizant of the potential for the development of pathogen strains resistant to DMI and QoI compounds. WSU extension personnel have encouraged a 3:2 fungicide application pattern: no more than 3 applications of any one synthetic fungicide class per season and no more than 2 applications of a class in sequence. Tank mixes with sulfur or oils are widely used.

Disease forecasting

The Washington State University AgWeatherNet (AWN; http://weather.wsu.edu) provides access to raw data and value-added products (disease models, insect phenology models, frost warnings, and evapotranspiration models) from 117 weather stations located mostly in the irrigated regions of eastern Washington State providing weather data in near-real time. The success and extent of the network has promoted the adoption of weather-based powdery mildew management. The general trend towards weather-driven (as opposed to vine phenology) disease management has helped to reduce fungicide usage in Eastern Washington by 73% over the last decade.

Powdery mildew and Botrytis bunch rot are the two grape models currently available on AWN and the former is by far the most widely used. The grapevine powdery mildew model as applied is Eastern Washington is a modified version of the Gubler-Thomas Grapevine Powdery Mildew Risk Index. The model automatically assumes the presence of the pathogen. The Washington iteration of the model is comprised of three components: 1) a growing degree day algorithm that tracks degradation of the overwintered inoculum supply following budburst 2) a primary infection algorithm and 3) the Gubler-Thomas Risk Index.

Table 1. Commonly used fungicides in Washington wine grapes.

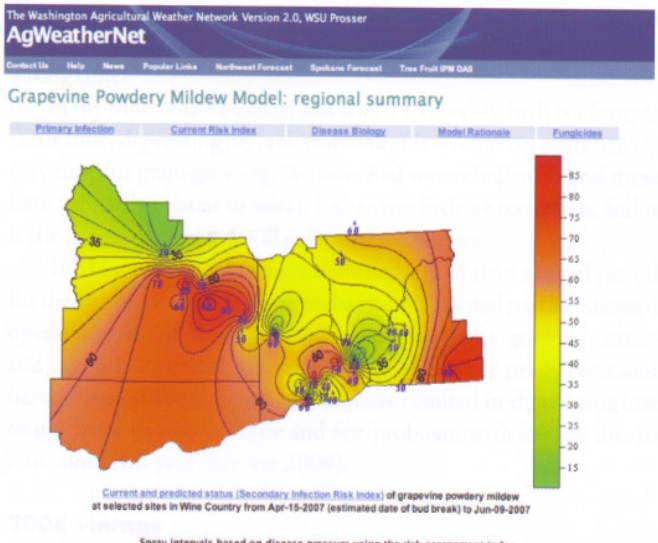
Fungicide Class	Common Name	Trade Name (US)	Trade Name (Aust.)
DMI	myclobutanil	Rally	Mycloss
	fenarimol	Rubigan	Rubigan
	triflumizole	Procure	n/a
	tebunconazole	Elite	Folicur
QoI (strobilurin)	trifloxystrobin	Flint	Flint
	pyraclostrobin/ boscalid	Pristine	Cabrio
	kresoxim-methyl	Sovran	Stroby (not registered for grapes)
Quinoline	quinoxyfen	Quintec	Legend
PDSO	Parrafinic oil	JMS Stylet oil	n/a
		Other narrow-range oils	
Sulfur	wettable and flowable sulfurs	Various	Various
Carbonates	potassium bicarbonate	Armicarb, Kaligreen	Eco-carb

Component 1
The causal agent of grapevine powdery mildew survives winter as cleistothecia in Eastern Washington. Cleistothecia persist until 750 growing degree days (base 50°F; 10°C) have accumulated after budburst.

Component 2
Studies in New York and Eastern Washington have demonstrated that cleistothecia require 0.1 inch (2.54 mm) precipitation or greater at 50°F (10°C) or greater in order to release ascospores. Component 2 of the grapevine mildew model is a temperature/precipitation algorithm that looks for these conditions between budburst and when 750 growing degree-days have accumulated. If the aforementioned temperature and moisture requirements are met within the specified time frame, it is assumed that primary infection occurs and the Gubler-Thomas Risk Index (component 3) is initiated.

Component 3.
The Gubler-Thomas Risk Index ranges between 0–100 where indices of 0–30, 40–50, and 60–100 indicate low, moderate, or high disease pressure, respectively. The index measures how rapidly the fungus is reproducing and is used to provide general guidelines regarding the interval between fungicide applications.

The model outputs are characterised by innovative graphical user interfaces. Clients can choose between regional summaries, site-specific abbreviated summaries, and full model outputs. Navigation to the various model outputs and decision-support information is accomplished by navigation bars (Figures 1–2). This implementation of this feature means that the client is never more than a single 'mouse click' away from more detailed model and decision-support information. The regional summary (Figure 1) is a color contour map of the Gubler-Thomas Index in the main wine-producing counties in Washington.



Spray intervals based on disease pressure using the risk assessment index

Index	Disease pressure	Pathogen status	Suggested spray schedule: Biologicals[1] and SARs[2]	Sulfur	Sterol-inhibitors[3]	Strobilurins[4] and quinolines[5]
0-30	low	present	7- to 14-day interval	14- to 21-day interval	21-day interval or label interval	21-day interval or label interval
30-60	intermediate	reproduces every 15 days	7-day interval	10- to 17-day interval	21-day interval	21-day interval
60 or above	high	reproduces every 5 days	use not recommended	7-day interval	10- to 14-day interval	14-day interval

[1] *Bacillus pumilis* (Sonata) and *Bacillus subtilis* (Serenade)
[2] SAR = Systemic acquired resistance products (AuxiGro, Messenger)
[3] tebuconazole (Elite), triflumizole (Procure), myclobutanil (Rally), fenarimol (Rubigan), and triadimefon (Bayleton)
[4] azoxystrobin (Abound), trifoxystrobin (Flint), kresoxim-methyl (Sovran), and pyraclostrobin/boscalid (Pristine)
[5] quinoxyfen(Quintec)

Figure 1. Contour map indicating regional disease pressure in Washington's wine country. Warm colors indicate areas of high disease pressure and short intervals between fungicide applications.

Site-specific model outputs are available as summary outputs and full-model outputs. Information included in the summary outputs includes date of primary infection, date of disease onset, current disease pressure, and predicted disease pressure 5 and 8 days from the current day. Full model outputs include all information in the summary outputs in addition to predicted daily disease pressure up to 10 days from the current day (Figure 2–3).

Favorite reports and 'push' technologies

Grape IPM professionals in Washington are a highly mobile and 'wired' collection of individuals. Most are web 'savvy' and also make intense use of cellular phones. Early in the development phase of AgWeatherNet's value-added product portfolio our beta testers expressed the desire for automation of repetitive web-intensive tasks (e.g. configuring and executing a model) and delivery of model outputs directly to cellular phones. The former was accomplished by creating a 'Favorite Reports' kernel where clients can configure a report to run multiple models at single collection sites, single models at multiple sites, and multiple models and multiple sites simply by clicking the mouse. This saves clients the time involved in reconfiguring a model during every visit to the AgWeatherNet website. Clients can also choose to have model outputs automatically 'pushed' to them at user-specified intervals via automated email or (to cell phones) via text messaging (Figure 4).

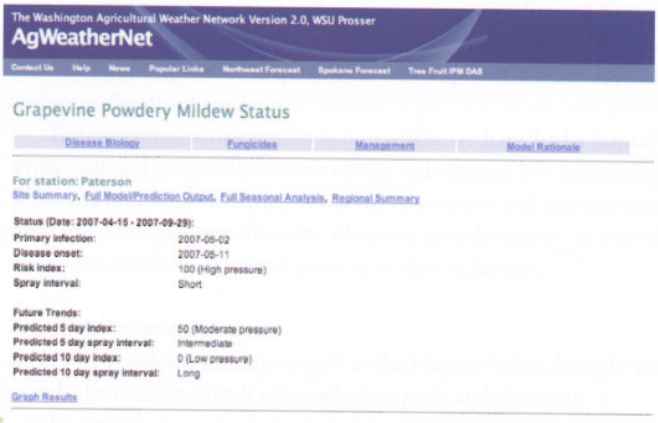


Figure 2. Summary outputs for grapevine powdery mildew model.

Fungicide Spectrum for Management of Powdery Mildew of Grape

Trade Name	Common Name	Class	Mildew Efficacy	Resistance Risk	Effect on beneficials	Label
Abound	azoxystrobin	strobilurin	Fair	High	Safe	x
Armicarb	potassium bicarbonate	bicarbonate	Fair*	L	Harmful	x
Elite	tebunconazole	DMI (triazole)	Good	High	Safe	x
Flint	trifloxystrobin	strobilurin	Excellent	High	Safe	x
JMS Stylet Oil	light summer oil	Petroleum spray oil	Excellent	Low	Harmful	x
Kaligreen	potassium bicarbonate	bicarbonate	Fair*	Low	Harmful	x
Microthiol Disperss	flowable sulfur	sulfur	Good*	Low	Harmful	x
Pristine	pyraclostrobin-boscalid	strobilurin +	Excellent	High	Safe	x
Procure	triflumizole	DMI	Good	High	Safe	x
Quintec	Quinoxyfen	Quinoline	Excellent	High	Safe	x
Rally	myclobutanil	DMI (triazole)	Good	High	Safe	x
Rubigan	fenarimol	DMI (pyrimidine)	Fair	High	Safe	x
Sovran	kresoxim-methyl	QoI	Excellent	High	Safe	x

Figure 3. Fungicide spectrum for grapevine mildew management in Eastern Washington.

The latter was accomplished by customizing the information contained in the aforementioned summary outputs to fit in a standard text message. A third type of 'push' technology is the automated delivery of synthesised voice outputs to voice messaging mailboxes.

References

Grove, G.G. (2004) Perennation of *Uncinula necator* in vineyards of Eastern Washington. Plant Dis. 88: 242–247.

Gubler, W. D., Rademacher, M. R., Vasquez, S. J., and Thomas, C. S. (1999) Control of powdery mildew using the UC Davis powdery mildew risk index. Online. APSnet Feature Story, January 1999. American Phytopathological Society, St. Paul, MN.

Thomas, C. S, Gubler, W. D., and Leavitt, G. (1994) Field testing of a powdery mildew disease forecast model on grapes in California. Phytopathology 84: 1070.

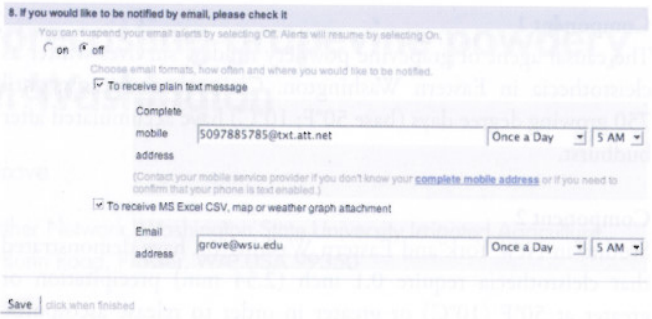


Figure 4. Configuration screen for AgWeatherNet 'push' outputs. Note that several types of outputs are available.