

It's time to move on from the Powdery Mildew Risk Index (PMI)

Root Applied Sciences' Spore Traps vs. PMI

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Powdery mildew remains one of the world's most severe and persistent threats to grape production, with viticulturists using more chemicals to control this disease than any other vineyard problem. Traditionally, fungicide applications are timed at intervals according to the Powdery Mildew Risk Index (PMI), also known as the Gubler-Thomas risk index (Table 1). While this is an improvement from fixed interval fungicide applications, using the PMI can still result in inefficient use of fungicides when the pathogen is absent. This occurs because the PMI incorrectly assumes that powdery mildew spores are always present, leading to disease risk overestimation and recommendations for fungicide applications that are not needed.

Table 1. Suggested Spray Intervals by fungicide groups based on the UC DAVIS Powdery Mildew Index model (adapted from <https://www2.ipm.ucanr.edu/agriculture/grape/powdery-mildew/>)

Index	Pathogen status	Sulfur	Biologicals ¹ and SARs ²	Demethylation - inhibitors (DMI) ³	Strobilurins and Quinoline ⁴
0-30	Present	14-to 21-day	7-to 14-day	21-day or label interval	21-day or label interval
40-50	Present Spores every 15 days	10-to 17-day	7-day	21-day	21-day
>60	Present Spores every 5 days	7-day	Use not recommended	10-to 14-day	14-day

1. *Bacillus pumilis* (Sonata) and *Bacillus subtilis* (Serenade Max)

2. SAR = Systemic acquired resistance products

3. Tebuconazole (Elite), triflumizole (Viticure), and myclobutanil (Rally)

4. Trifloxystrobin (Flint), kresomix-methyl (Sovran), and pyraclostrobin/boscalid (Pristine)

In California, the PMI regularly overestimates the risk of powdery mildew and results in fungicide spray programs similar to fixed-interval spray programs, with applications every 7 days. As a result, after several years of working with the PMI, many grape growers feel this tool is not really working. "The PMI has prevented management failures due to powdery mildew for nearly 20 years; however, it is time for an improvement on this conservative approach. Today's growers have an advantage over their predecessors, and it is the ability to know when the pathogen is in the air before symptoms can be seen in the field," says Sarah Placella, Ph.D., CEO of Root Applied Sciences ("Root"). Root's patented technology monitors and captures powdery mildew spores using a series of in-field sensors that generate alerts of the pathogen's quantity so growers can spray fungicides only when necessary.

According to Root's scientific team and other plant pathology experts [1], it is clear that using the PMI leads to the over-application of fungicides when disease pressure is low (i.e., the density of the pathogen is low). However, growers can now monitor disease pressure using Root's technology and more accurately assess when and where interventions are needed. Root's technology allows growers to

[1] Modeling Uncertainty in Grapevine Powdery Mildew Epidemiology Using Fuzzy Logic. R. A. Choudhury, W. F. Mahaffee, N. McRoberts, and W. D. Gubler. Available online at <https://www.biorxiv.org/content/10.1101/264622v2.full>

manage the disease more precisely, stretching spray intervals when there is no threat and focusing scouting and cultural practices in hot spots.

The last two seasons in California were completely different in terms of disease pressure and provided a perfect scenario to illustrate why using the PMI to time sprays may not be the best approach for growers. The powdery mildew pressure was high in 2022, and Root sensors captured spores by the millions throughout the season (Figure 1A). On the contrary, the disease pressure was low in 2021, and spores were captured mainly during late June and July, with counts never reaching 1 million spores during these months (Figure 1C). Despite the difference in disease pressure, the PMI advised 13 and 14 sulfur sprays in 2022 and 2021, respectively (Figure 1B and 1D).

One may wonder if 14 sulfur sprays were necessary for 2021 when the pathogen's spore density in the air was low. The answer is "NO". In fact, Caleb Mosley, Matthiasson's Vineyard Manager and early adopter of Root's technology, sprayed only three times in 2021. "Determining when to begin fungicide applications is critical to every successful plant protection plan. Incorporating Root's sensors into our decision-making process has allowed me a high level of confidence that we are only applying materials at the onset of the growing season when it's absolutely necessary," says Mosley.

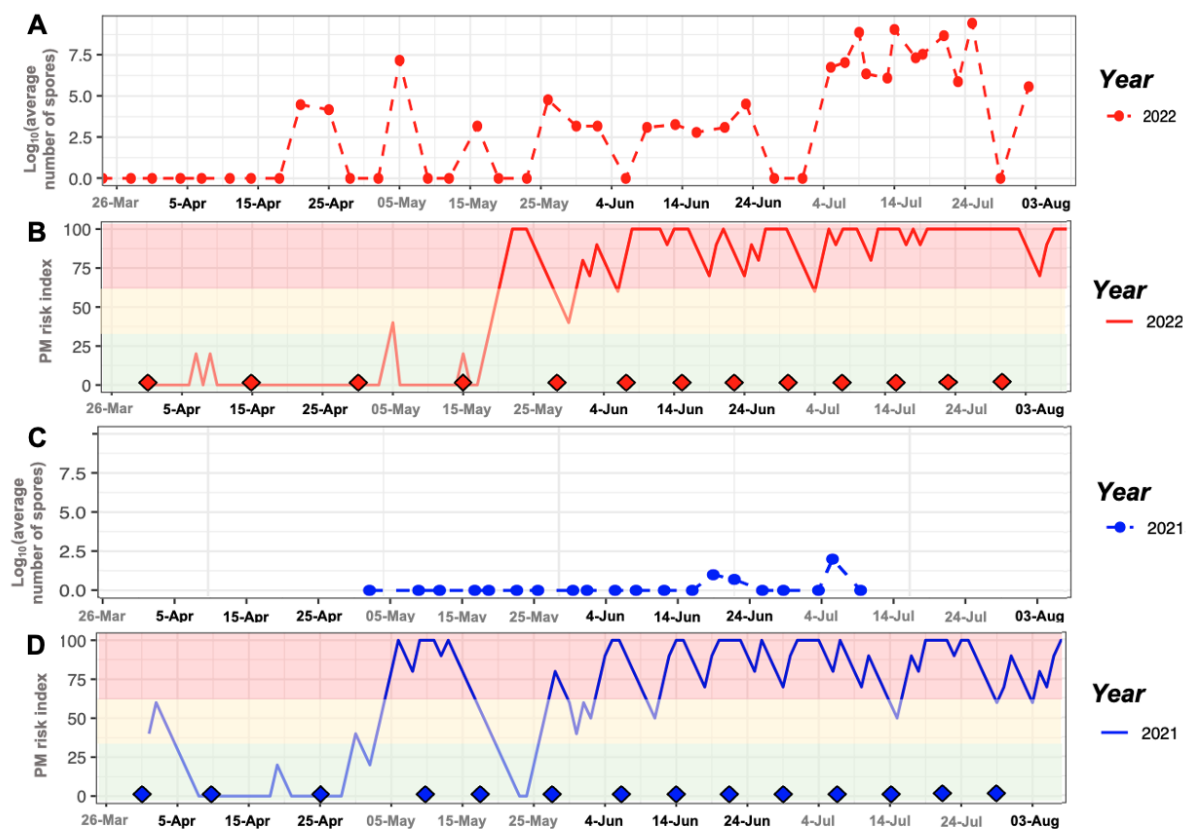


Figure 1. Average number of spores quantified using Root sensors at Doña vineyards located in the Carneros AVA in (A) 2022 (C) 2021. The Y-axis in these plots has been log-transformed to visualize changes in the average number of spores more easily. **Powdery** mildew risk index at Doña vineyards located in the Carneros AVA in (A) 2022 (C) 2021. Diamonds represent sulfur sprays adjusted according to the PM risk index as follows: applications every 15-days with values between 0-30, applications every 10-days with values between 30-60 and applications every 7-days with values above 60.

In 2022, the reverse happened; the PMI was low while Root's sensors detected tens of thousands of spores. Growers working with Root were able to initiate their sprays at the right time early and tamp down on the pathogen before it got out of control. Later in May, the PMI correlated better with the high disease pressure observed by Root (Figures 1A and B). However, even in this high-pressure year, Root's technology helped many growers to cut a few sprays, and all managed the disease more effectively. "It was a super high-pressure year in our region, but we didn't feel it because we had reliable data and knew what we needed to do" - says Meghan Siemers, Sustainability Manager at Gundlach Bundschu, who cut 40% of her sulfur sprays in her first year working with Root. While many growers reported among the highest powdery mildew pressure in decades, Root's customers generally assessed 2022 as average powdery mildew pressure because they were able to appropriately time early sprays to tamp down the fungus before it took hold.

The financial benefits of using an improved system to optimize the timing of sprays are also substantial, as reducing sprays reduced the per-acre management cost of fungicide applications to control powdery mildew, from an average of \$700 per acre in fungicide applications to roughly \$490; a savings of approximately \$210 per acre for Root's customers in 2022. However, the benefits are not only financially favorable, they are also environmentally and sustainably appealing. Using fewer fungicides results in labor and energy savings (*e.g.*, fuel) as fewer tractor passes are needed to apply fungicides.

Additionally, Root's data helps growers scout more efficiently and get regular feedback on their program, giving them the confidence to manage more sustainably. "Yeah, I cut a few sprays, but the greater value was seeing Root's data from the vineyards twice a week. I knew there was powdery mildew, but I also knew the levels were below a comfortable threshold. So, I was able to spray with more biologicals knowing that if powdery mildew wasn't being well controlled, I would know in time to adjust our spray program. In the end, I was able to get through the whole season using biologicals on most of my blocks," said Tony Chapman, Director of Winegrowing at the Donum Estate. Like Root, many other companies that work with in-field sensors are helping growers dive into a new area of data-driven farming to mitigate agricultural issues related to labor shortages, water, and sustainability.