GRAPE (*Vitis vinifera* 'Chardonnay')
Powdery Mildew; *Erysiphe necator*

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Efficacy of tank mixing biological fungicides with sulfur for management of grape powdery mildew, 2024.

Tank mixes of biological fungicides and micronized sulfur were used for grape powdery mildew (GPM) management of Chardonnay vines at the Botany and Plant Pathology Field Laboratory in Corvallis, Oregon. The treatments focused on evaluating whether tank mixes of two different biological fungicides and a low rate of Microthiol Disperss (MD, micronized sulfur) would provide better control than using the low rate of MD alone (Table 1).

Treatments (Table 1) were arranged in a randomized complete block design. A 50 gallon Pak-blast air blast sprayer (Rears Mfg., Coburg, OR) with TeeJet ceramic D3 discs and DC25 core nozzles was used to apply the treatments and operated using a Kubota M5N-111 tractor. The blocks used consisted of 'Chardonnay' planted in 1998 on *Vitis. rupestris* x *V. riparia* 101-14 rootstock with 7x8 ft spacing. A single buffer rootstock vine was trained between each set of treatment vines and a buffer row of rootstock vines separated each varietal row, which helped minimize plot-plot interference. Vines were trained to a Guyot (vertical shoot position) system and pruned from 10 January to 27 March. Shoot thinning by hand occurred from 1 May to 20 May and sucker removal by hand was continuous throughout the season. Shoots were cut above the top wire on 7 June and maintained at this height throughout the growing season. Fungicide treatments were applied every 7-10 days. Each treatment was replicated on 4 sets of 5 vines.

Table 1. Biological fungicide treatments applied to Chardonnay vines in 2024.

Treatment[x]
Non-treated control
2 lb MD/Acre
10 oz/Acre Serifel + 2 lb MD/Acre
1 Qt/Acre Double Nickel + 2 lb MD/Acre
1 Qt/Acre Double Nickel + 0.75Qt/Acre Humax + 2 lb MD/Acre

[x]Treatments applied at 80psi at approx. 430 PTO rpm and 3mph. MD = Microthiol Disperss.

Rainfall during the dormant season (Oct 2022 to March 2023) was 4.1 inches above normal while spring weather conditions were close to long term norms, however, precipitation dropped off rapidly at the end of April. Signs of powdery mildew were first found on 9 May as a flag shoot and additional infections were found on 13 May. Bloom took place from approximately 7 June to 18 June with most caps detaching from 8 June to 12 June.

Leaf and cluster data were taken on the middle three vines of each experimental plot by randomly examining either 25 clusters or leaves on both the east and west side of the row for a total of 50 units examined per plot. The incidence of powdery mildew on leaves was recorded weekly from 10 June through 5 August. The severity of powdery mildew on clusters was taken on 7 August. Leaf incidence data was analyzed by calculating the area under disease progress curve (AUDPC) which was calculated by multiplying the mean incidence from two observation dates by the number of days between observations ($\Sigma[Y_{i+1} + Y_i)/2][X_{i+1}-X_i]$ where Y_i is incidence of mildew at i*th* observation and X_i is the day of the i*th* observations) and adding together the values. AUDPCs were calculated using the agricolae package and modeled with a linear model. Cluster severity percentages were modeled using a generalized linear mixed model with block fitted as a random effect. Cluster severity treatment contrasts were conducted using the emmeans package and model fit was checked with the DHARMa package. Uncertainty was estimated using asymptotic 95% confidence intervals. The Tukey Honest Significant Difference (HSD) and Bonferroni P value adjustments were used. All data was analyzed in R version 4.0.3.

AUDPC values and percent infected berries were significantly higher in the non-treated plots than all fungicide treated plots. Among fungicide treatments, the plots treated with a mixture of Double Nickel + Humax + 2 lb MD/A resulted in the lowest observed AUDPC value, that was not significant than any of the other fungicide treatments when analyzed with a Tukey adjustment, but was significantly lower than the sulfur control when analyzed with the Bonferroni adjustment (Table 2). Cluster severity was similar in all three tank mixes and was significantly lower than application of sulfur alone when analyzed with either statistical adjustment.

Table 2. Area under disease progress curve (AUDPC, leaf disease) and percent infected berries from Chardonnay in 2024.

Treatment[x]	AUDPC		Percent Infected Berries[y]
	(HSD)[y]	(Bon)[z]	
Non-treated control	2770 (2477-3063) A	2770 (2359-3181) A	99.2 (98.5-99.6) A
2 lb MD/A	2029 (1736-2322) B	2029 (1618-2440) B	78.3 (65.5-87.3) B
10 oz/A Serifel + 2 lb MD/A	1684 (1391-1977) B	1684 (1273-2095) BC	57.3 (41.4-71.8) C
1 Qt/A Double Nickel + 2 lb MD/A	1667 (1374-1960) B	1667 (1256-2078) BC	52.9 (37.2-68.1) C
1 Qt/A Double Nickel + 0.75Qt/A Humax + 2 lb MD/A	1496 (1203-1789) B	1496 (1085-1907) C	56.3 (40.4-71.0) C

[x]All treatments were applied at 80psi at approximately 430rpm PTO. MD = Microthiol Disperss
[y]Estimates are followed by asymptotic 95% confidence intervals in parentheses. Treatments followed by different letters are significantly different than each other, marginal means contrast ($p<0.05$) with p values adjusted using Tukey (HSD) method.
[z]Estimates are followed by asymptotic 95% confidence intervals in parentheses. Treatments followed by different letters are significantly different than each other, marginal means contrast ($p<0.05$) with p values adjusted using Bonferroni method.

Spray volume applied for fungicide treatments was relatively consistent at 60 GPA for the entire growing season (Figure 1). The amount of Serifel applied over the course of the season ranged from 11.0 oz/A to 13.8 oz/A, well within the label rate range of 4 oz to 16oz/A. The amount of Double Nickel applied over the course of the season ranged from 1.1 Qt/A to 1.4 Qt/A in both Double Nickel tank mixes, which was within the recommended rate range of 1 Qt/A to 6 Qt/A. (Figure 2). For all fungicide treated vines the amount of MD applied in the tank mixes was fairly consistent, ranging from 2.2 lb/A to 2.8 lb/A (Figure 3).

Tank mixing biological fungicides with a below label rate of sulfur allows for testing of the fungicides while not overwhelming them with the high amount of powdery mildew pressure in the research vineyard. While there were no significant differences between the sulfur control and the biological fungicide mixes in the leaf (AUDPC) data when a Tukey adjustment was made, when a Bonferroni adjustment was applied, the Double Nickel mix with Humax resulted in significantly lower disease than when sulfur was used alone. Humax is humic acid, which was hypothesized to decrease UV degradation of Double Nickel active compounds. While that tank mix did not result in a significantly lower AUDPC value than when Humax was not added to the Double Nickel mix, the lower AUDPC relative to the sulfur control did indicate that as a whole, the Double Nickel and Humax combination did provide an additional benefit to manage leaf infections over sulfur alone. Additionally, all three fungicide mixes resulted in significantly lower cluster severity than just sulfur alone. This indicated that each mix did augment the control of GPM on clusters over sulfur alone.

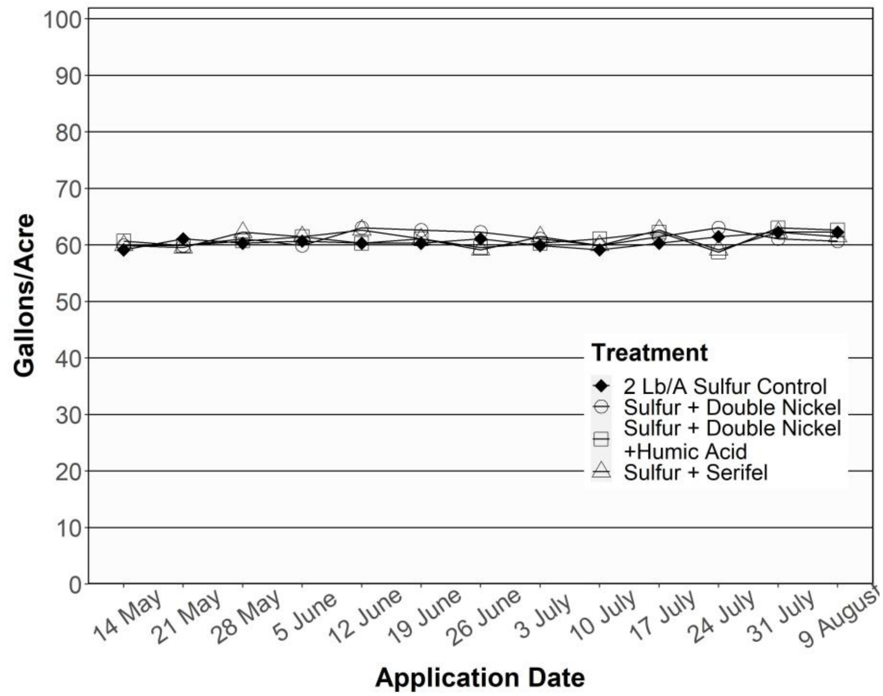

Figure 1. Spray volumes applied to vines in the Chardonnay tank mix trial.

Double nickel is a biological fungicide product that acts on pathogens by producing anti-fungal and anti-bacterial compounds, triggering the plant systemic acquired resistance (SAR) immune response, and competitively excluding pathogens from the leaf surface. The quantity of a biological fungicide applied has been observed to influence the disease levels, and can sometimes be counterintuitive, such as a higher rate of the product leading to more disease, or a lower rate of the product leading to less disease. In this experiment the lowest label rate of Double Nickel was selected after consultation with pesticide company representatives that advised that the lower rate led to more effective disease control than higher rates. While this rate did lead to lower infection severity on clusters than using sulfur alone, clusters were still more than half covered by GPM, on average. This contrasts with similar experiments conducted in adjacent rows of grapes where the highest label rate of Serenade ASO was used or a moderate rate of Theia was used, and less than 20% cluster severity was observed on standard mode treatments. Using a higher rate of Double Nickel may have resulted in better disease control and should be tested in future years.

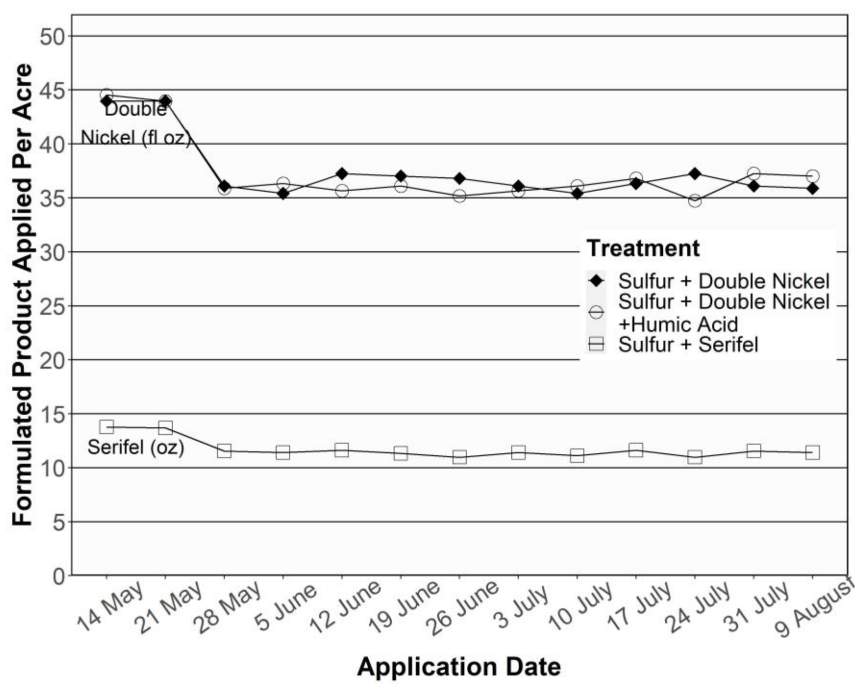

Figure 2. The amount of biological fungicide applied to Chardonnay vines during each application.

Studies conducted in the lab on Double Nickel mixes with 3 lb/A, 5 lb/A, and 7 lb/A Microthiol rates showed that Microthiol at 5 lb/A and 7 lb/A resulted in significantly higher CFU numbers than when Double Nickel was mixed with 3 lb/A Microthiol or just water (data not shown). Microthiol at 2 lb/A, as in this study, was not tested. Future experiments could investigate how different rates of Microthiol or other products influence the viability of the biological fungicide active organisms. Additionally, future studies could be done examining the effect of different rates of biological fungicides on disease levels.

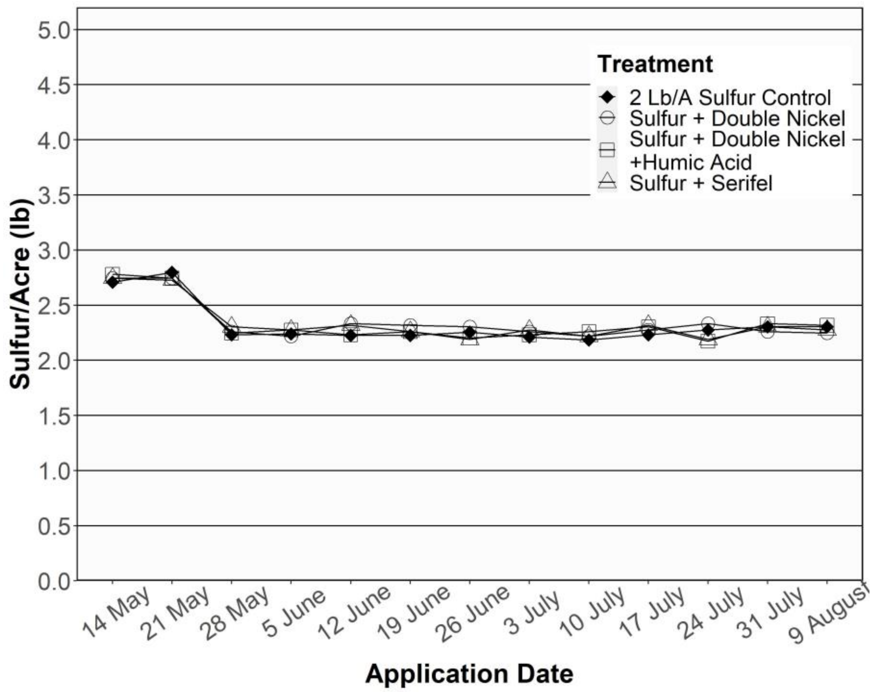

Figure 3. The amount of Microthiol Disperss applied to Chardonnay vines during each application.