# 2007 Research Report to the Michigan Grape & Wine Industry Council

**Proposal Title:**
Evaluating pre- and post-infection powdery mildew control strategies in wine grapes

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**Introduction; Priority Addressed:**
Powdery mildew, caused by the fungus *Uncinula necator*, is a disease that affects many wine grape varieties and is responsible for numerous fungicide applications during the season. Once powdery mildew has started, it is difficult to eradicate, since environmental conditions during most of the summer tend to be suitable for disease development. The powdery mildew fungus does not need free water, just moderate temperatures and moderate to high relative humidity to continue its development and spread. Several new fungicides have come on the market in recent years that (claim to) have powdery mildew activity, including Quintec, Endura, Pristine, Prev-Am, Oxidate, etc. Most of these products are considered reduced-risk, in that they have low mammalian and environmental toxicity. Using multiple chemistries in a disease control program is important to achieve optimal disease control and reduce the chances of fungicide resistance development in the powdery mildew pathogen, which is a real risk as shown by the occurrence of resistance to strobilurins in grape powdery mildew in New York. There are some suspected cases of resistance to sterol inhibitors in Michigan as well. In order to improve management recommendations and the ability of growers to control powdery mildew in Michigan, this proposal aims to evaluate various reduced-risk fungicides and fungicide programs for their efficacy in preventing and eradicating powdery mildew infections.

**Original goals and objectives of the project:**
The objectives of this proposal were to:

1) Determine the efficacy of contact fungicides in eradicating existing powdery mildew infections
2) Determine the efficacy of seasonal spray programs including reduced-risk chemistries for prevention of powdery mildew

**Project Period**: October 1, 2006 to September 30, 2007.

**Work accomplished during the period, including methods"**

***1) Determine the efficacy of contact fungicides in eradicating existing powdery mildew infections***

Experiment 1 (Clarksville)

A powdery mildew eradication experiment was conducted in a mature 'Chardonel' vineyard at the Clarksville Horticultural Experiment Station in Clarksville, MI. Vines were spaced at 6 x 10 ft and were cordon trained and hand pruned. Treatments were applied to 1-vine plots and were replicated 3 times in a randomized complete block design. Sprays were applied with an R&D Research $CO_2$ cart-styled sprayer equipped with six bottles (0.8 gal each), a twin gauge Norgren pressure regulator set at 55 psi, and a single XR TeeJet 8002VS nozzle on a 5-ft spray boom. Spray volume was equivalent to 100 gpa. Spray dates and approximate phenological stages were as follows: 19 Jul (early powdery mildew infection; bunch closure) and 6 Aug (advanced powdery mildew infection; pre-veraison). The following products were applied: Oxidate (hydrogen dioxide), Prev-Am (borax), Kaligreen (potassium bicarbonate), Cuprofix Ultra (basic copper sulfate), Sulforix (calcium polysulfide), JMS Stylet Oil (paraffinic oil), and C+G (food-grade organic acids – an experimental product that may be approved for organic production). Unsprayed and water sprayed vines served as controls. Disease was assessed on 8 Oct. Powdery mildew incidence (% clusters with at least one infected berry) and severity (% berries infected on diseased clusters only) were visually estimated on 10 randomly selected clusters per plot. On the same date, powdery mildew was also assessed on 10 randomly selected leaves per plot. Overall severity in each case was calculated as (incidence x severity)/100. In addition, cleistothecia were counted in five 6 x 10-mm areas per leaf on upper and lower leaf surfaces of using a dissecting microscope at 15X magnification. Vines were also monitored for phytotoxicity.

Experiment 2 (Traverse City)

A powdery mildew eradication experiment was conducted in a mature 'Pinot noir' vineyard at the Northwest Michigan Horticultural Research Station, Traverse City, MI. Vines were spaced at 6 x 9 ft and were cordon trained and hand pruned. Treatments were applied to one-vine plots that were replicated five times in a randomized complete block design. The following products were applied to mature 'Pinot noir' vines in Traverse City, MI: JMS Stylet Oil (paraffinic oil), Kaligreen (potassium bicarbonate), Oxidate (hydrogen dioxide), Prev-Am (sodium tetraborohydrate decahydrate), C+G (organic acids), Cuprofix (basic copper sulfate), Sulforix (calcium polysulfide), and Elite (tebuconazole). Treatments were applied at recommended rates to single-vine plots with a backpack sprayer on 13 September, 2007. About 20% of the leaf surface on average was covered with powdery mildew at the time of fungicide application. Treatments were replicated five times in a randomized complete block design. Spray volume was equivalent to about 935 L/ha. Unsprayed vines served as controls. Disease incidence and severity were visually assessed as described above immediately before, and 1 and 2 weeks after application on 20 randomly selected leaves per plot. Overall severity in each case was calculated as (incidence x severity)/100. On 17 October, cleistothecia were counted in five 6 x 10-mm areas per leaf on upper and lower leaf surfaces on 10 randomly collected leaves per plot. A dissecting microscope was used to count mature (black) and immature (yellow/brown) cleistothecia in each grid.

***2) Determine the efficacy of seasonal spray programs including reduced-risk chemistries for prevention of powdery mildew***

Experiment 1 (Lawton, 'Chancellor'):

The experiment was conducted in a mature commercial 'Chancellor' vineyard in Lawton, MI. Vines were spaced at 7 x 9 ft and were cordon-trained on a 2-wire trellis and hand pruned.

Treatments were applied to 3-vine plots and were replicated four times in a randomized complete block design. Sprays were applied with an R&D Research $CO_2$ cart-styled sprayer equipped with six bottles (0.8 gal each), a twin gauge Norgren pressure regulator set at 55 psi, and a single XR TeeJet 8002VS nozzle on a 5-ft spray boom. The following fungicides were evaluated in different programs (see Table 3): JMS Stylet Oil (paraffinic oil), Serenade Max (*Bacillus subtilis*) + Biotune (surfactant), Sonata (*Bacillus pumilis*) + Biotune, Vintage (fenarimol), Dithane (mancozeb), Pristine (pyraclostrobin + boscalid), Quintec (quinoxifen), Kaligreen (potassium bicarbonate), Nova (myclobutanil), Phostrol (phosphorous acid salts), Endura (boscalid), Prev-Am (borax), Abound (azoxystrobin), Ziram (ziram). Spray dates and approximate phenological stages were as follows: 17 Apr (dormant), 4 Jun (10 to16-in. shoot), 18 Jun (immediate pre-bloom), 29 Jun (small pea-sized fruit), 6 Jul (pea-sized fruit), 12 Jul (berry touch), 26 Jul (bunch closure), 10 Aug (veraison: 13º Brix), and 16 Aug. Spray volume was 40 gpa on 17 Apr, 4 Jun, and 18 Jun; and 50 gpa on 29 Jun, 6 Jul, 12 Jul, 26 Jul, 10 Aug, and 16 Aug. Total rainfall between sprays was 4.95, 0.02, 0.15, 0.07, 0.07, 0.64, 3.08, and 0.09 in., respectively. Disease was assessed on the center vine of each plot on 5 Sep. Powdery mildew incidence (% leaves exhibiting disease) and severity (% leaf area infected on diseased leaves only) were visually estimated on 25 randomly selected leaves per plot. Overall severity was calculated as (incidence x severity)/100.

Experiment 2 (Lawton, 'Aurore'):

The experiment was conducted in a mature commercial 'Aurore' vineyard in Lawton, MI. The main goal of this trial was to evaluate fungicides programs for control of Botrytis bunch rot and powdery mildew. Vines were spaced at 7 x 9 ft and were cordon-trained on a 2-wire trellis and hand pruned. Treatments were applied to 3-vine plots and were replicated four times in a randomized complete block design. Sprays were applied with an R&D Research $CO_2$ cart-styled sprayer equipped with six bottles (0.8 gal each), a twin gauge Norgren pressure regulator set at 55 psi, and a single XR TeeJet 8002VS nozzle on a 5-ft spray boom. The following fungicides were evaluated: Scala (pyrimethanil), Optineem (azadirachtin/neem oil), Endorse (polyoxin-D [an antibiotic made by *Streptomyces* sp.] zinc salt), Pristine (pyraclostrobin + boscalid), Distinguish (pyrimethanil + trifloxystrobin), and Vangard (cyprodinil). Spray volume was 40 gpa. Spray dates and approximate phenological stages were as follows: 3 May (budswell), 11 May (4-6 in. shoot), 24 May (10 in. shoot), 14 Jun (full bloom), 28 Jun (small pea-sized fruit), 12 Jul (berry touch), 26 Jul (bunch closure), and 8 Aug (veraison: 16º Brix). Unsprayed plots served as a control. Total rainfall between sprays was 0.89, 0.35, 2.53, 0.15, 0.14, 0.64, and 2.87 in., respectively. Disease was assessed on the center vine of each plot on 28 Aug (19.5º Brix). Powdery mildew incidence (% leaves exhibiting disease) and severity (% leaf area infected on diseased leaves only) were visually estimated on 25 randomly selected leaves per plot. Overall severity was calculated as (incidence x severity)/100.

**Summary of the expenditures during the period**.

| Budget category | Original Budget ($) | Expenditures ($) |
|---|---|---|
| Salary | 6,850 | 7,384.62 |
| Fringe | 2,808 | 2,871.68 |
| Travel | 700 | 0.00 |
| Materials and supplies | 300 | 473.84 |
| Other direct costs | 300 | 300.00 |
| Total | 10,958 | 11,030.14* |

*The overdraft will be corrected by JVE.

**Results and conclusions of the project**

***1) Determine the efficacy of contact fungicides in eradicating existing powdery mildew infections***

Experiment 1

Powdery mildew got a fairly late start in the season. On 19 Jul (bunch closure), powdery mildew symptoms were becoming apparent while on 8 Aug (pre-veraison) the disease was fairly advanced on the leaves. Water did not have any effect on powdery mildew infection on the foliage or fruit (Table 1 and 2). Oxidate also was generally ineffective as an eradicant for powdery mildew. The early sprays appeared consistently more effective than the late sprays. In each case, C+G (organic acids) was the most effective, followed by JMS Stylet Oil which was not significantly different from C+G. In case of the late sprays, Sulforix was also statistically equivalent to C+G and JMS Stylet Oil. In general, Prev-Am, Kaligreen, and Cuprofix were intermediate in their efficacy when applied during early infection but not very effective or ineffective when applied on advanced infections. These data show that a single spray of an effective eradicant fungicide can provide significant control of the disease when applied mid to late-season, even when applied to the fruit. This shows that eradicant sprays may be used as rescue treatments if powdery mildew has started to become established. A high spray volume may be needed, however, to obtain sufficient coverage. Whether the amount of control achieved in this trial was commercially acceptable is debatable as even low levels (3-5%) of fruit infection are known to have detrimental effects on wine quality. However, additional eradicant sprays or an integrated program with protectant and curative fungicides probably would have improved in control. The number of cleistothecia produced on leaves (Table 3) was not statistically different between treatments, but tended to be lowest in the JMS Stylet Oil, C+G, and Sulforix treatments. Since counts were made rather late in the season, it is likely that many of the cleistothecia had already been washed off by rain. In future trials, we will count cleistothecia earlier in the season.

**Table 1**. Evaluation of fungicide for eradicative activity against foliar powdery mildew infection in 'Chardonel' grapevines in Clarksville, MI, in 2007.

| | Powdery mildew – leaf infection | | | | | |
|---|---|---|---|---|---|---|
| | Spray applied on 19 Jul[z] | | | Spray applied on 6 Aug[z] | | |
| Treatment, rate/A | Incidence (%) | Overall Severity (%) | Control [%][x] | Incidence (%) | Overall severity (%) | Control [%] |
| Untreated | 100.0 a[y] | 47.5 a | | 100.0 a | 44.5 ab | |
| Water only | 100.0 a | 46.6 ab | [1.9] | 100.0 a | 44.6 ab | [-0.2] |
| Oxidate 1.0% (v/v) | 100.0 a | 37.3 bc | [21.5] | 100.0 a | 43.0 abc | [3.4] |
| Prev-Am 0.4% (v/v) | 100.0 a | 35.1 c | [26.1] | 100.0 a | 50.3 a | [-13.3] |
| Kaligreen 5 lb | 96.7 ab | 30.5 cd | [35.8] | 100.0 a | 50.9 a | [-14.4] |
| Cuprofix Ultra 1.5 lb | 86.7 bc | 24.7 de | [48.0] | 100.0 a | 30.0 bcd | [32.6] |
| Sulforix 1 gal | 93.3 abc | 21.9 de | [53.9] | 96.7 a | 26.3 cde | [40.9] |
| JMS Stylet Oil 1 gal | 83.3 c | 19.4 ef | [59.2] | 93.3 a | 23.3 de | [47.6] |
| C+G 0.53% (v/v) | 66.7 d | 10.1 f | [78.7] | 80.0 b | 10.9 e | [75.5] |

[z]Spray date: Early spray was applied on 19 Jul (early powdery mildew infection; bunch closure); late spray was applied 6 Aug (late powdery mildew infection).

[y]Column means followed by the same letter are not significantly different according to Fisher's Protected LSD test ($P \leq 0.05$).

[x]Bracketed values denote percent control relative to the untreated control.

**Table 2**. Evaluation of fungicide for eradicative activity against powdery mildew infection of fruit of 'Chardonel' grapevines in Clarksville, MI, in 2007.

| | Powdery mildew – fruit infection | | | | | |
|---|---|---|---|---|---|---|
| | Spray applied on 19 Jul[z] | | | Spray applied on 6 Aug[z] | | |
| Treatment, rate/A | Incidence (%) | Overall Severity (%) | Control [%][x] | Incidence (%) | Overall severity (%) | Control [%] |
| Untreated | 100.0 a[y] | 44.6 a | | 100.0 ns | 42.1 ab | |
| Water only | 100.0 a | 44.1 ab | [1.1] | 96.7 | 44.0 a | [-4.5] |
| Oxidate 1.0% (v/v) | 100.0 a | 36.5 abc | [18.2] | 100.0 | 40.5 abc | [3.8] |
| Prev-Am 0.4% (v/v) | 93.3 a | 33.8 bcd | [24.2] | 90.0 | 27.0 cd | [36.9] |
| Kaligreen 5 lb | 93.3 a | 32.9 cd | [26.2] | 93.3 | 35.3 abcd | [16.1] |
| Cuprofix Ultra 1.5 lb | 90.0 a | 25.4 de | [43.0] | 93.3 | 28.7 bcd | [31.8] |
| Sulforix 1 gal | 90.0 a | 19.7 e | [55.8] | 93.3 | 23.7 de | [43.7] |
| JMS Stylet Oil 1 gal | 70.0 b | 18.6 ef | [58.3] | 93.3 | 21.7 de | [48.5] |
| C+G 0.53% (v/v) | 73.3 b | 8.3 f | [81.4] | 70.0 | 11.6 e | [72.4] |

[z]Spray date: Early spray was applied on 19 Jul (early powdery mildew infection; bunch closure); late spray was applied 6 Aug (advanced powdery mildew infection).

[y]Column means followed by the same letter are not significantly different according to Fisher's Protected LSD test ($P \leq 0.05$).

[x]Bracketed values denote percent control relative to the untreated control.

**Table 3**. The number of mature cleistothecia on powdery mildew infected leaves (on five 60-mm$^2$ sections per leaf) of 'Chardonel' grapevines in Clarksville, MI, in 2007 two months after fungicide application.

| | Number of cleistothecia on foliage | | |
|---|---|---|---|
| Treatment, rate/A | Upper leaf surface | Lower leaf surface | Total |
| Untreated | 12.9 NS** | 10.8 NS | 23.7 NS |
| Prev-Am 0.4% (v/v) | 12.8 | 9.6 | 22.4 |
| Oxidate 1.0% (v/v) | 9.1 | 12.2 | 21.3 |
| Water only | 12.7 | 8.2 | 20.9 |
| Cuprofix Ultra 1.5 lb | 11.5 | 7.5 | 19.0 |
| Kaligreen 5 lb | 8.1 | 9.9 | 18.0 |
| Sulforix 1 gal | 10.5 | 7.4 | 17.9 |
| C+G 0.53% (v/v) | 11.0 | 6.7 | 17.7 |
| JMS Stylet Oil 1 gal | 10.2 | 6.6 | 16.7 |

*Cleistothecia were counted in five 6 x 10-mm areas per leaf on upper and lower leaf surfaces using a dissecting microscope at 15X magnification

**NS = not significantly different according to Fisher's Protected LSD test ($P \leq 0.05$).

Experiment 2 (Traverse City)

Powdery mildew showed up rather late in the season. Sprays were applied on 19 Sep when 20% of the leaf area was infected on average. Background levels of disease were somewhat variable in the plot (Figure 1) but these differences were not statistically significant. One week after application of fungicides, JMS Stylet Oil had reduced powdery mildew severity the most (by 75% compared to the untreated control), followed by C+G (59%) and Sulforix (53%). These treatments did not differ significantly from each other. Disease severity in the Elite, Oxidate, Cuprofix, and Prev-Am treatments was not significantly different from the untreated control. Kaligreen significantly reduced disease severity but was not as good as JMS Stylet Oil. After 2 weeks, disease severity in the untreated control had more than doubled. By comparison, JMS Stylet Oil, C+G, Sulforix, and Kaligreen had 88%, 82%, 73%, and 79%, less disease, respectively, and these treatments did not differ significantly from each other. Other fungicides were less effective.

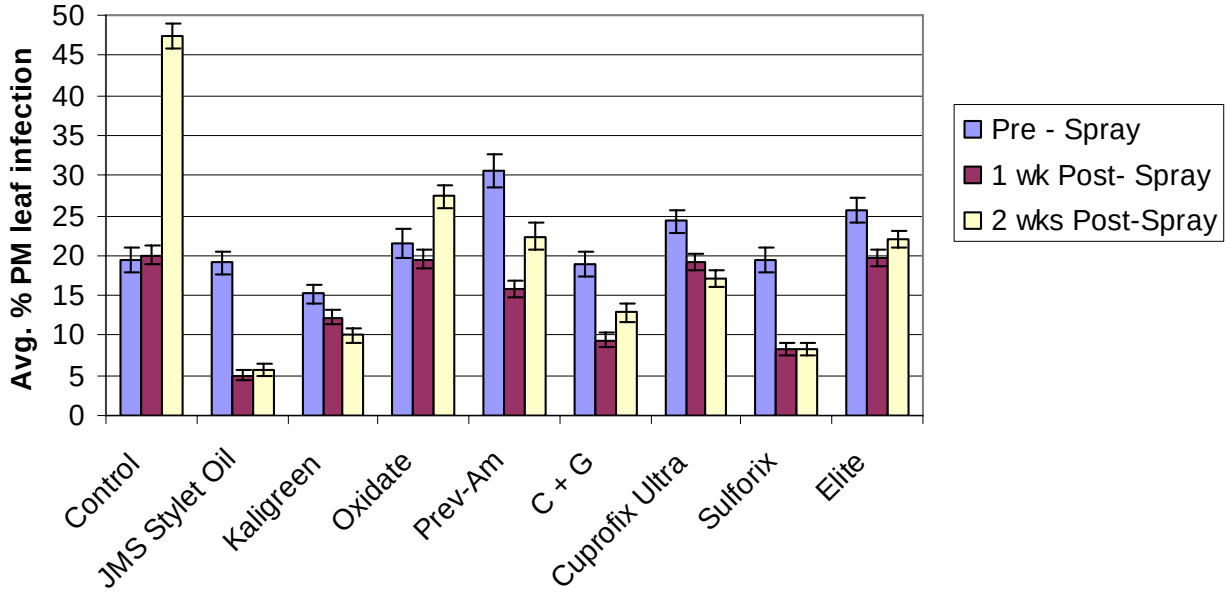


**Figure 1**. Powdery mildew severity (% leaf area infected) on 'Pinot noir' vines in Traverse City, MI, immediately before and 1 and 2 weeks after application of fungicides.

There were large numbers of cleistothecia on the leaves by October 17 due to the warm, dry fall. Most cleistothecia were mature (=black) by that time (Table 4). About 10,000 cleistothecia per leaf were estimated in the untreated control. Cleistothecia were present on both leaf surfaces and were actually more numerous on the lower leaf surface, probably because a rain storm had washed off cleistothecia from the upper leaf surfaces a few days earlier. This emphasizes that there may be an optimum time to count cleistothecia, e.g., after most cleistothecia have formed but before they get washed off by rain. This may be a bit of a balancing act and will require close monitoring. The epidemiological significance of cleistothecia on the lower leaf surface is not clear as they may or may not be washed off by rain and may end up landing on the ground with the leaves as they drop. This needs to be investigated in future research. In any case, we were able to detect significant differences between the treatment. The total number of mature cleistothecia per leaf was reduced most by Sulforix (82%), Elite (78%), Kaligreen (70%), C+G (66%); these treatments were statistically similar. Cuprorix appeared to inhibit cleistothecium formation better on the upper leaf surface than the lower leaf surface. The total number of immature cleistothecia

was most reduced by Elite, probably due to its systemic activity, but most treatments were not statistically different from Elite. Overall, the results from this trial indicate that a late-season fungicide application can reduce foliar powdery mildew severity and cleistothecium formation.

**Table 4**. The number of cleistothecia on powdery mildew-infected leaves of 'Pinot noir' grapevines in Traverse City, MI, in 2007 one month after fungicide application.

| | Average number of cleistothecia on foliage* | | | | | |
|---|---|---|---|---|---|---|
| | Mature cleistothecia | | | Immature cleistothecia | | |
| Treatment, rate/A | Top | Bottom | Total | Top | Bottom | Total |
| Untreated | 51.4 a** | 238.9 a | 290.3 a | 12.2 a | 19.4 a | 31.6 a |
| Prev-Am 0.4% (v/v) | 21.3 ab | 178.6 ab | 199.9 b | 9.8 ab | 14.6 ab | 24.4 ab |
| Oxidate 1.0% (v/v) | 27.0 a | 143.3 bc | 170.3 bc | 8.1 abc | 14.5 ab | 22.6 abc |
| Cuprofix Ultra 1.5 lb | 4.3 c | 120.2 bcd | 124.5 cd | 0.7 d | 9.7 b | 10.4 c |
| JMS Stylet Oil 1 gal | 11.1 bc | 112.5 cde | 123.6 cd | 5.5 abc | 14.1 ab | 19.6 abc |
| C+G 0.53% (v/v) | 9.2 bc | 90.3 cde | 99.5 de | 5.1 abc | 10.9 ab | 16.0 bc |
| Kaligreen 5 lb | 5.8 c | 80.1 cde | 85.9 de | 2.5 cd | 8.7 b | 11.2 bc |
| Elite 4 oz | 4.7 c | 60.2 de | 64.9 de | 2.9 bcd | 6.6 b | 9.5 c |
| Sulforix 1 gal | 3.7 c | 48.9 e | 52.6 e | 5.6 abc | 13.9 ab | 19.5 abc |

*Cleistothecia were counted in five 6 x 10-mm areas per leaf on upper and lower leaf surfaces

** Column means followed by the same letter are not significantly different according to Fisher's Protected LSD test ($P \leq 0.05$).

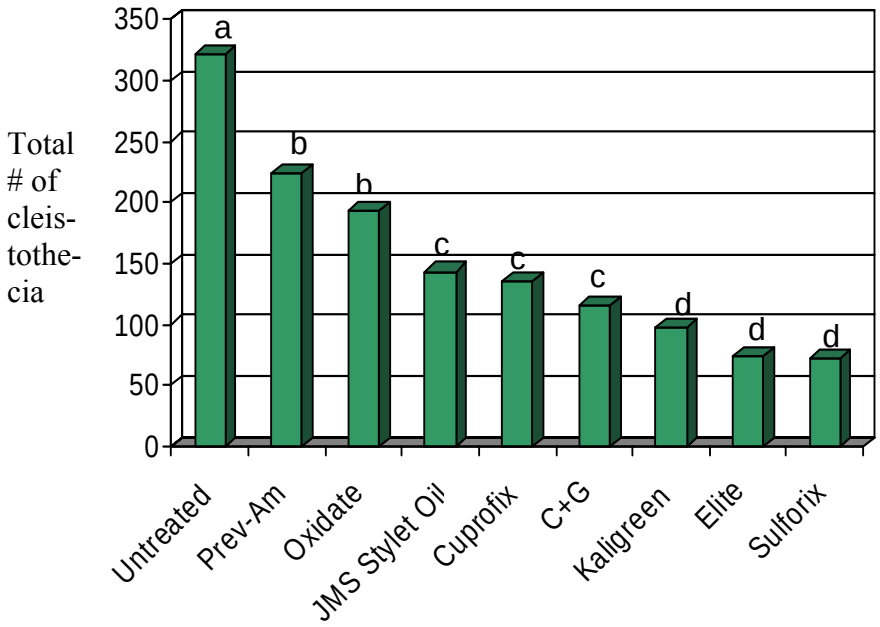


**Figure 2**. Total number of cleistothecia (mature and immature) on powdery mildew-infected leaves (five 60-mm$^2$ sections per leaf) of 'Pinot noir' vines in Traverse City, MI, one month after application of fungicides.

### *2) Determine the efficacy of seasonal spray programs including reduced-risk chemistries for prevention of powdery mildew*

Experiment 1 (Lawton, 'Chancellor')

In the 'Chancellor' grapes, powdery mildew showed up rather late in the season and disease pressure was moderate. All treatments significantly reduced powdery mildew incidence, severity and overall severity (Table 5). However, the "organic" programs (JMS Stylet Oil/Serenade/Sonata

**Table 5**. Efficacy of preventive fungicide programs against foliar powdery mildew infection of "Chancellor" grapevines in Lawton, MI, in 2007.

| | | Powdery mildew on leaf blade | | | |
|---|---|---|---|---|---|
| Treatment, rate/A | Application timing[z] | Incidence (%) | Severity (%)[x] | Overall severity (%)[w] | Control [%][v] |
| Untreated | | 76 a[y] | 30.6 a | 23.2 a | |
| JMS Stylet Oil 1 gal<br>Serenade Max 3 lb + Biotune 0.125% v/v<br>Sonata 4 qt + Biotune 0.125% v/v | 1, 3, 4, 6, 7, 8 | 59 b | 20.6 b | 12.2 b | [47.4] |
| Vintage SC 3 fl oz + Dithane Rainshield 3lb<br>Pristine 38WG 10 oz<br>Quintec 3 fl oz | 2, 3, 4, 6, 7, 8 | 58 b | 16.1 bc | 9.6 bc | [58.6] |
| Vintage SC 3 fl oz + Dithane Rainshield 3 lb<br>Pristine 38WG 10 oz<br>Quintec 3 fl oz | 2, 3, 6, 8<br>4, 7, | 57 bc | 11.0 cde | 6.3 cd | [72.8] |
| JMS Stylet Oil 1 gal<br>Kaligreen 5 lb<br>Serenade Max 3 lb + Biotune 0.125% v/v | 1, 6,<br>2, 7, 8<br>3, 4, | 54 bc | 22.3 b | 12.9 b | [44.4] |
| Nova 40W 3 oz + Dithane Rainshield 3 lb<br>Quintec 4 fl oz + Phostrol 4 pt<br>Endura 4.5 oz | 2, 3,<br>4, 6,<br>7, 8 | 53 bc | 10.9 cde | 5.6 d | [75.9] |
| Vintage SC 3 fl oz + Dithane Rainshield 3lb<br>Quintec 3 fl oz + Phostrol 4 pt<br>Vintage SC 4 fl oz | 2, 3, 4, 6, 7, 8 | 49 bcd | 8.7 de | 4.3 de | [81.5] |
| Prev-Am 0.4% v/v | 2, 3, 4, 6, 7, 8 | 49 bcd | 11.6 cd | 5.8 d | [75.0] |
| Vintage SC 3 fl oz + Dithane Rainshield 3 lb<br>Abound 10 oz<br>Quintec 3 fl oz<br>Endura 4.5 oz | 2, 3, 6, 4, 7, 8 | 38 de | 7.1 de | 2.7 ef | [88.4] |
| Elite 4 oz + Dithane Rainshield 3 lb<br>Pristine 38WG 10 oz<br>Elite 45WP 6 oz + Ziram 76DF 3 lb<br>Elite 45WP 4 oz + Phostrol, 4 pt | 2, 3, 4, 6, 7, 8 | 30 ef | 6.1 e | 1.8 f | [92.2] |
| Vintage SC 4 fl oz + Dithane Rainshield 3 lb<br>Pristine 38WG 10 oz<br>Vintage SC 6 fl oz + Ziram 76DF 3lb<br>Vintage SC 4 fl oz + Phostrol 4 pt | 2, 3, 4, 6, 7, 8 | 25 f | 6.8 de | 1.7 f | [92.7] |

[z]Spray dates: 1 = 17 Apr (dormant); 2 = 4 Jun (10–16 in. shoot); 3 = 18 Jun (immediate pre-bloom); 4 = 29 Jun (small pea-sized fruit); 5 = 6 Jul (pea-sized fruit); 6 = 12 Jul (berry touch); 7 = 26 Jul (bunch closure); 8 = 10 Aug (veraison: 13º Brix).

[y]Column means followed by the same letter are not significantly different according to Fisher's Protected LSD test ($P \leq 0.05$).

[x]Values shown are actual means; statistical analysis was performed on arcsine-transformed data.

[w]Values shown are actual means; statistical analysis was performed on square root-transformed data.

[v]Bracketed values denote percent control relative to the untreated check.

and JMS Stylet Oil/Kaligreen/Serenade) were the least effective, and the Elite and Vintage programs tank-mixed with Dithane, Ziram or Phostrol were the most effective. It appears that adding a protectant fungicide, such as Ziram, can significantly improve powdery mildew control. (In previous trials we have noted efficacy of Ziram on powdery mildew, while Phostrol had moderate to poor efficacy against powdery mildew). Prev-Am (borax) by itself was moderate to good in its efficacy against powdery mildew, providing 75% disease control. The programs with Quintec sprays later in the season were not as effective as we expected and we wonder if the 3-oz rate was sufficient. Under high disease pressure, Quintec may need to be applied at the 4-oz rate. When Vintage (4 oz) was substituted for Quintec for the last three sprays of the season, powdery mildew control was significantly improved. Programs with Endura applied last in the season also worked well.

Experiment 2

This experiment was aimed at controlling Botrytis bunch rot and powdery mildew. Powdery mildew pressure was fairly high. Pristine/Vangard was the most effective in controlling powdery mildew, but the high rate of Gantec Green, both rates of Endorse, and Distinguish were statistically similar (Table 6). The high rate of Gantec Green performed significantly better than the low rate. Scala provided the least control of foliar powdery mildew. If Scala is used for Botrytis bunch rot control, it will provide powdery mildew suppression.

**Table 6**. Efficacy of preventive fungicide programs against foliar powdery mildew infection of "Aurore" grapevines in Lawton, MI, in 2007.

| | | Powdery mildew on leaf blade | | | |
|---|---|---|---|---|---|
| Treatment, rate/A | Application timing[z] | Incidence (%) | Severity (%) | Overall severity (%) | Control [%][v] |
| Untreated | | 85.0 a[y] | 40.0[x] a | 33.9 a[w] | |
| Scala 60SC 18 fl oz | 4, 6, 8 | 71.0 ab | 21.8 b | 15.5 b | [54.3] |
| Gantec Green 1.16 ml<br>Gantec Green 2.32 ml<br>Gantec Green 4.64 ml | 2, 3, 5,<br>1, 4, 7,<br>6, 8 | 67.0 b | 17.7 b | 12.1 b | [64.3] |
| Endorse 28 oz | 4, 5, 6, 7, 8 | 47.0 c | 8.1 c | 3.9 c | [88.5] |
| Distinguish 18 fl oz | 4, 6, 8 | 41.0 c | 8.5 c | 3.3 c | [90.3] |
| Endorse 70 oz | 4, 5, 6, 7, 8 | 40.0 c | 6.6 cd | 2.7 c | [92.0] |
| Gantec Green 9.28 ml<br>Gantec Green 18.56 ml<br>Gantec Green 37.12 ml | 2, 3, 5,<br>1, 4, 7<br>6, 8 | 38.0 c | 6.1 cd | 2.3 c | [93.2] |
| Pristine 38WG 12.5 fl oz<br>Vangard 75WG 10 oz | 4, 6,<br>8 | 32.0 c | 4.8 d | 1.5 c | [95.6] |

[z]Spray dates: 1 = 3 May (budswell), 2 = 11 May (4-6 in. shoot), 3 = 24 May (10 in. shoot), 4 = 14 Jun (full bloom), 5 = 28 Jun (small pea-sized fruit), 6 = 12 Jul (berry touch), 7 = 26 Jul (bunch closure), and 8 = 8 Aug (veraison: 16º Brix).

[y]Column means followed by the same letter are not significantly different according to Fisher's Protected LSD test ($P \leq 0.05$).

[x]Values shown are means actual means; statistical analysis was performed on log(x)-transformed data.

[w]Data did not pass Bartlett's test for homogeneity of variance even after transformation; assumptions of the ANOVA may have been violated.

[v]Bracketed values denote percent control relative to the untreated check.

Endorse is based on a natural antibiotic produced by *Streptomyces*, a soil bacterium; currently it is labeled for disease control in turf grasses. Gantec Green is a neem oil product that is not yet labeled on any crop but has the potential to be approved for organic production. Distinguish is a pre-mix of Scala and Flint and is currently labeled for disease control in almonds, pistachios and potatoes. It will probably be labeled for disease control in grapes in 2009 and has a broader spectrum of control than either Scala or Flint alone.

**Overall conclusions**
This research has shown that fungicides can be used for eradication of existing powdery mildew colonies as well as reduction of overwintering inoculum. In both locations, JMS Stylet Oil, Sulforix, and C+G were most effective at reducing existing powdery mildew infections. For cleistothecium reduction, Sulforix, Elite, and Kaligreen were most effective. C+G is an experimental and not yet labeled for use on crops; however, it looks like it will be approved for use in organic production in future. JMS Stylet Oil and Kaligreen can both be used in organic vineyards, but JMS Stylet Oil has the potential to reduce photosynthesis and brix accumulation if applied multiple times. Sulforix can be used on non-sulfur sensitive varieties. High spray volumes (100 gal/acre) may be needed to achieve good coverage when applied late in the season.

Conclusions from the preventive programs are that "organic" programs provide significant disease control but do not hold up as well as preventive programs when disease pressure is high. Programs that incorporated SI fungicides and Ziram later in the season performed better than programs that relied on Quintec and Pristine for late-season sprays. If Quintec is used, the higher rate (4 oz) may be more effective. Fungicides like Endorse, Distinguish, and Gantec Green may be good fungicide options for powdery mildew control in grapes in the future, including for organic vineyards.

**Communications Activities, Accomplishments, and Impacts**:
Portions of this research were presented in the Wine Grape Session at the Great Lakes Expo in Grand Rapids, MI, in December 2007, at the Northwest Michigan Orchard Show in Traverse City, MI in January 2008; and at the Southwest Horticulture Days in Benton Harbor, MI on 6-7 Feb, 2007. This research will also be presented at the Grape IPM Day at the Northwest Michigan Horticultural Research Station in Traverse City, MI, on 4 April, 2008 and various upcoming grape meetings during the 2008 growing season, including Viticulture Day. The data have also been used to adjust recommendations for disease management in grapes in E-154, the Michigan Fruit Management Guide.

A poster abstract has been submitted for the Annual Meeting of the American Phytopathological Society to be held in Minneapolis, MN, 26-30 July 2008. The title is: **Efficacy of fungicides in eradicating powdery mildew and reducing cleistothecium formation on grape leaves,** by: Annemiek C. Schilder, Nikki L. Rothwell, Karen L. Powers, and Myron D. Anderson, Michigan State University.

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