Final Report to the Pennsylvania Wine Marketing and Research Board
for the 2012-2013 seasons for the project title:
Evaluation of Vapor Gard for sour and bunch rot control of wine grapes in Pennsylvania

PERSONNEL: Principal Investigator: Bryan Hed
Department of Plant Pathology, Penn State University
Lake Erie Regional Grape Research and Extension Center
662 Cemetery Road, North East, PA 16428;
Phone: 814-725-4601, ext. 203; fax: 814-725-8135; E-mail:bxh38@psu.edu

CoPIs: Jody Timer
Department of Entomology, Penn State University
Lake Erie Regional Grape Research and Extension Center
Email jht10@psu.edu

Dr. Noemi Halbrendt
Penn State Fruit Research and Extension Center
Phone: 717-677-6116, ext 222
290 University Drive, Biglerville, PA 17307-1330

Introduction
In 2011, wine grape growers in Pennsylvania expressed an interest in examining the effects of Vapor Gard on harvest rots, fruit maturity, and juice quality. According to the manufacturer, Miller Chemical and Fertilizer Corporation, Vapor Gard forms a clear, glossy, elastic film on plant surfaces that retards moisture loss, maintains healthy foliage, and may improve the quality of various fruit crops.

Objectives
This project proposed to examine the effects of Vapor Gard on crop health and quality in experimental and commercial wine grape vineyards in Pennsylvania. Our goal was to evaluate the effects of Vapor Gard applied at various timings and rates to grape varieties important to the Pennsylvania wine grape industry.
1. To determine the effects of early, mid, and late season applications of Vapor Gard on grape disease development, specifically powdery mildew and Botrytis bunch rot.
2. To determine the effects of Vapor Gard on fruit maturity, berry splitting, and juice quality.
3. To determine the effects of Vapor Gard on infestation by grape berry moth.

Trial setup, application, and evaluation in grower vineyards:
Vapor Gard was evaluated at label rate and timing and at two 'off label' rates and timings:
1) Label rate and timing (1% solution just before bunch closure)
2) Flower separation and again 2 weeks later, at 3% solution (for cluster loosening and rot control).
3) During ripening at 1%, for effects on berry splitting and juice quality.

At the Lake Erie Regional Grape Research and Extension Center (LERGREC) and the Fruit Research Station (FREC), Vapor Gard was also compared with leaf removal at 1) trace bloom and 2) at fruit set (currently recommended timing) to determine if Vapor Gard can mimic the beneficial effects of these treatments on bunch rot. Treatment effects were analyzed for significant differences

by an analysis of the variance via the General Linear Models function in MiniTab. The confidence interval for significant differences was set at $P \leq 0.05$.

Results 2012 and 2013

I) Treatment effects on late season bunch rots

Lake Erie Regional Grape Research and Extension Center (LERGREC): North East PA All Vapor Gard and leaf removal treatments were applied as amendments to a standard rot control program (check) consisting of 2 (2012) or 4 (2013) *Botrytis* specific fungicide applications. Treatments were applied to Chardonnay, Riesling, and Chambourcin. Berry splitting was not a particularly observable issue in 2012 and 2013, and since splitting is inevitably reflected as fruit rot it was not assessed separately from total bunch rot.

- *Chardonnay, Cluster rots:* Bunch rot disease pressure was greater in 2012 than in 2013. Almost all cluster rot was from *Botrytis* in both seasons and there was very little sour rot development, which is typical for the Lake Erie region. **Vapor Gard did not reduce bunch rot development at any rate or timing in either year when amended to the check: in 2012 and 2013, vines treated with Vapor Gard had 11-56 %, and 24-52% more rot than the check, respectively (the label rate and timing of Vapor Gard increased rots by 22 (2012) and 24% (2013)). However, the increases in rot were not statistically significant.** In both years, cluster zone leaf removal, either at trace bloom or just after fruit set, was the most effective way to reduce *Botrytis* bunch rot when amended to the check. For example, in 2012, both timings of leaf removal significantly reduced the incidence (percentage of clusters with rot) of bunch rot. However, only the trace bloom leaf removal timing significantly reduced the severity of bunch rot over the check (by almost 70%). In 2013, cluster zone leaf removal at trace bloom or just after fruit set, reduced bunch rot severity by 61 and 41%, respectively, when amended to the check, but the reductions were not statistically significant.

- *Riesling, Cluster rots:* **Vapor Gard was applied only at flower separation and 2 weeks later, at 3% solution (treatment 1 above: for cluster loosening) in 2012 and 2013. This treatment reduced rots by 5% in 2012, and by 74% in 2013 when amended to the check, but the reductions were never significant.** In 2012 and 2013, leaf removal reduced rots by 34 and 74% (trace bloom timing) and 46 and 29% (just after fruit set) when amended to the check, but none of these reductions were statistically significant.

- *Chambourcin:* Chambourcin typically produces large clusters that require thinning to reduce crop and improve fruit quality; an expensive operation. In 2012, Vapor Gard was applied to Chambourcin at flower separation and again 2 weeks later, at 3% solution (off label; for effects on crop thinning). This treatment was compared to an untreated check. Although powdery mildew on fruit was not affected by treatment, **Vapor Gard significantly reduced cluster weight (by 32%) and fruit set (by 25%).** We did observe a slight degree of phytotoxicity (necrotic spotting) on leaves directly sprayed with 3% Vapor Gard.

Erie County commercial vineyard, *Cabernet Franc:* In 2012, Vapor Gard was applied at label rate and timing and compared to no Vapor Gard. All other spray applications for disease, insects, and weed control were made by the grower. Diseases and insects were exceptionally well controlled in this vineyard and there was no rot on fruit to rate.

Fruit Research and Extension Center (FREC): All Vapor Gard and leaf removal treatments were applied as amendments to a standard rot control program (check) consisting of 4 *Botrytis* specific fungicide applications; bloom, pre-close, pre-veraison, and pre-harvest. Treatments were applied to 4 premium wine varieties: Cabernet Franc, Chardonnay, Pinot Noir, and Riesling. Cluster rot on all varieties was from a combination of *Botrytis*, sour rot organisms, and ripe rot (total rot). In both years, cluster rots at harvest were very low in Cabernet Franc, moderate in Chardonnay, and most severe in Pinot Noir and Riesling. Cluster rot pressure was much heavier in 2012 than in 2013. **In general, Vapor Gard applications provided little, if any, improvement in rot control on these varieties.**

- *Cabernet Franc, cluster rots:* In both years, cluster rots were extremely low on Cab Franc (0-1% crop loss), when compared to the other 3 varieties. Vapor Gard, amended to the check, did not reduce the incidence or severity of total rot development at any rate or timing.
- *Chardonnay, cluster rots:* in 2012, losses to cluster rots ranged from 7-14% among treatments. Vapor Gard treatments increased cluster rots by 0-39% when amended to the check, but the differences were not significant. Cluster zone leaf removal actually increased cluster rots, but was directly associated with a significant increase in ripe rot rather than *Botrytis* or sour rot. In 2013, cluster rots were at very low levels in all treatments (less than 1%) and none of the treatments significantly reduced total rot when amended to the check.
- *Pinot Noir, cluster rots*: Rots at harvest were most severe on this variety (75-90% crop loss among treatments). In 2012, Vapor Gard treatments increased the severity of total rot development by 0-13% when amended to the check, but none of the increases were significant. Leaf removal resulted in small and insignificant decreases in rot. In 2013, Vapor Gard reduced total rots by 2-55% when amended to the check, but the reductions were not significant.
- *Riesling, cluster rots*: In 2012, rots at harvest took a heavy toll on Riesling as well (65-88% crop loss among treatments), but Vapor Gard, amended to the sprayed check, significantly reduced the severity of total rot development at all rates and timings, when amended to the check. However, the reductions were small, ranging from 10-26% (1% solution at pre-close and veraison). Cluster zone leaf removal also significantly reduced total rot severity when amended to the check. The early leaf removal timing (at trace bloom) was the most effective amendment (31 % reduction), being significantly more effective than all other amendments except Vapor Gard at 1% solution at pre-close and veraison. In 2013, rot levels were much lower (1-3%) and Vapor Gard treatments reduced rots by 0-60%, but the reductions were not significant.

II) Treatment effects on cluster morphology were determined among treatments at the Lake Erie Regional Grape Research and Extension Center (LERGREC) in North East PA. Samples of clusters were dissected and assessed for effects on cluster weight, fruit set (berries per cluster), and compactness (berries per length (cm) of cluster). In 2012 and 2013, there were no significant effects of any of the Vapor Gard or leaf removal treatments on any of these parameters.

III) Treatment effects on juice quality. Fruit from clusters used for cluster morphology were used for juice quality determination (brix, pH, and acidity) on the Chardonnay and Riesling trials at LERGREC. In 2012, there were no significant effects of Vapor Gard or leaf removal on any of these parameters of any variety. In 2013, there were no significant effects of Vapor Gard or leaf removal on Chardonnay, but on Riesling, trace bloom leaf removal significantly raised the pH when compared to the check.

IV) Treatment effects on yield per vine and return bloom in Chardonnay at LERGREC. Yield was assessed by weighing all clusters per plot at harvest. In both years, there were no significant treatment effects on yield per vine. Return bloom was assessed by counting the number of clusters formed per shoot after completing shoot adjustment (shoot thinning) the spring following treatment. In 2013, there were no significant treatment effects of Vapor Gard or leaf removal amended to the check. In 2014, no assessment of return bloom (from the 2013 applications) could be made as Chardonnay vines were severely damaged by winter minimum temperatures.

V) Treatments effects on Grape Berry Moth infestation. Vapor Gard was tested for efficacy against grape berry moth (GBM) during the 2012 and 2013 growing season.
During the 2012 growing season, the experimental design for evaluation of grape berry moth control consisted of small-plot treatments each composed of two panels (6 vines) of Concord grapes in a random block design. These treatments were replicated four times, with two panels left between each treatment. Treatments were applied to every replication except the untreated check. The treatments consisted of Vapor Gard 3% being sprayed according to the degree day timing grape berry moth prediction model for GBM emergence. The on-site weather station was used for degree days, which were calculated on the NEWA website using the wild grape bloom as the biofix. The first treatment was sprayed only one time to coincide with the first full generation emergence of GBM. The second treatment was sprayed twice, timed to coincide with the first and second GBM generational emergence. The third treatment was sprayed three times to coincide with the first, second, and third full generations of grape berry moth emergence. Vapor Gard at 3% was applied on 6/29/2012, 7/30/2014, and 9/2/2012, using a covered boom sprayer at 100 gal/acre. All sprays were applied at a pH of 6.0. Vapor Gard was applied immediately after mixing.

Twenty clusters were randomly harvested for each replication to assess grape berry moth damage two weeks after the treatments were applied, allowing time for egg laying and larva emergence. Number of damaged berries (incidence) and number of damaged clusters (severity) were reported. Generally the grape berry moth damage this season in the Lake Erie region was below average. Data was analyzed by ANOVA and the means separated by both Least Significant Difference (LSD) at $P \leq 0.05$. All analyses were done using SAS V.9.1 (2002-2003). There was very little GBM damage in any of the experimental plots after the first or the second spray and there were no significant differences between treatments in those assessments. Evaluations of damage after the third spray was analyzed found no significant differences between treatments; however, there was significance between all treatments and the control. When comparing straight percentages it was noted that the damage did not increase between only early applications and the three applications over the growing season. This may indicate that Vapor Gard has some secondary beneficial efficacy for GBM control. Further evaluations should be conducted using this type of spray timing if Vapor Gard is to be used for secondary insect control.

Treatment	**Incidence**	**Severity**
Vapor Gard 1st generation	0.498 B 0.71%	8.33 B 7.69%
Vapor Gard 1st and 2nd generation	0.540 B 0.13%	9.52 B 2.88%
Vapor Gard 1st, 2nd, and 3rd generations	0.453 B 0.30%	7.14 B 4.81%
Check	3.723 A 2.52%	46.43 A 28.85%

Means followed by the same letter in columns are not significantly different.

During the 2013 growing season the GBM experiment was set up in the same small plots used in 2012, however, the spray timings were applied at the same time and strength as the evaluations for the sour and bunch rots trial, to replicate the potential secondary advantage of Vapor Gard against GBM. Treatment one was Vapor Gard at 3% at pre-bloom with a second application two weeks later Treatment two consisted of Vapor Gard 1% applied just before bunch closing. Treatment three consisted of Vapor Gard at 1% applied during ripening. GBM damage regionally, in 2013, was average. Treatment four was the untreated control. Results were analyzed using the methods described above.

There were no significant differences between treatments with the first assessment on July 7th.

Treatment	**Incidence**	**Severity**
Pre-bloom + 2 wks.	0.00 A	1.19 B
Bunch closing	0.024 AB	1.19 B
Ripening	0.060 AB	5.95 AB
Untreated control	0.071 A	7.14 A

Evaluations made on 8/30. Means followed by the same letter in columns are not significantly different.

Treatment	**Incidence**	**Severity**
Pre-bloom + 2 wks.	1.26 AB	10.72 AB
Bunch closing	0.61 BC	5.95 B
Ripening	0.52 C	3.57 B
Untreated control	1.43 A	17.86 A

Evaluations made on 9/30. Means followed by the same letter in columns are not significantly different.

The second and third assessment indicates that the bunch-closing spray timing was more effective than the pre-bloom spray timing. This spray timing usually coincides with the degree-day model timing for spray application. This experiment suggests that Vapor Gard shows some efficacy for grape berry moth control.

VI) Effect of Vapor Gard on susceptibility to Botrytis were determined in 2013 through laboratory inoculation of field treated berries with spores of *Botrytis* and examination of subsequent levels of rot per treatment. Samples of healthy berries (24 per plot) were collected from the south side of the trellis at veraison (8 brix), 2 weeks later (15 brix), 2 weeks later (18 brix) and just before harvest (20 brix), from berries sprayed with Vapor Gard (1% at pre-closure (label rate and timing)), and check treatment plots. Berries were surface sterilized in the laboratory, rinsed in sterile water, inoculated with spores of *Botrytis* (grown and maintained in sterile culture on potato dextrose agar in the lab) and enclosed in moist chambers at room temperature (21C) and 100% relative humidity for one week. Subsequently, berry samples were rated for incidence of Botrytis fruit rot. *Botrytis* susceptibility (incidence of rot) was very low at 8 brix, but began rising at 15 brix and jumped dramatically in samples at 18 and 20 brix. There were no differences in susceptibility at 8, 18, and 20 brix, but at 15 brix, berries treated with Vapor Gard developed significantly higher levels of *Botrytis* than untreated berries (5.6% versus 1.4% rot).

We also compared the susceptibility of berries exposed to direct sunlight (as a result of cluster zone leaf removal at trace bloom or after fruit set) to berries in the check plots. Berries that were exposed to sunlight through leaf removal exhibited 70-80% lower susceptibility than those of the check at the 18 and 20 brix sampling times. This provides further evidence of the benefits of cluster zone leaf removal for the control of harvest bunch rot.

Itemization of expenditures over two growing seasons:

Total Budget: 4/1/12 to 6/30/14	Amount ($)
Salaries and wages:	$16,033
Fringe benefits	$3,676
Compensation to participating growers (honoraria)	$600
Supplies	$675
Travel and lodging	$2,600
Purchased Services	$600
Total:	**$24,184**