Vine Mealybug Control Trial 2009

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Test Location: Domaine Chandon Carneros Ranch

Test Crop: *Vitis vinifera* L. cv. Pinot Noir clone 13 grafted on 140R rootstock
Planted 1995 at 6 ft by 8 ft vine by row spacing and trained to bilateral cordons on a VSP trellis. Grown for sparkling wine production

Species targeted: Vine Mealybug, *Planococcus ficus*

Experimental Design: Twelve treatments were replicated four times in a randomized complete block design. The trial took place in a vineyard block on a slope and experimental blocks were selected to account for the gradient of changes in soils down the slope. Treatments were randomly distributed within each experimental block. Treatments were applied to contiguous four-vine sets, and efficacy data were only collected from the center two vines.

Plot Selection: Vine mealybugs (VMB) on 691 vines were counted for one minute per vine on April 25 to establish distribution and severity of the infestation. Vines were categorized as having 0, 1, 2-10 or >10 VMB found in the one minute count. Contiguous four-vine sets (plots) were selected to incorporate vines with more than two VMB found on the center two vines, and at least one VMB found on the outer two vines. Data were only collected from the two center vines of each plot.

Treatment Timing and Rates:

Table 1. Product application details. All products applied were registered for use in California vineyards in 2009 and were applied at or below label rates.

Treatment	Product	Rate per Acre		Application Method	Application Date 2009
1	Admire Pro	14	fl oz	Chemigation	May 13
2	Applaud 70 DF	12	dry oz	Foliar	May 18
	Applaud 70 DF	12	dry oz	Foliar	June 26
3	Assail 30SG	5	dry oz	Foliar	May 18
4	Clutch 2.13 SC	5	fl oz	Foliar	May 18
5	Movento†	6	fl oz	Foliar	May 19
6	Platinum 75 SG	5.67	dry oz	Chemigation	May 13
7	Platinum 75 SG	2.67	dry oz	Chemigation	May 13
	Platinum 75 SG	2.67	dry oz	Chemigation	June 15
8	Platinum 75 SG	4	dry oz	Chemigation	May 13
	Movento†	6	fl oz	Foliar	May 19
9	Platinum 75 SG	5.67	dry oz	Chemigation	May 13
	Movento†	6	fl oz	Foliar	May 19
10	Venom	6	oz dry	Chemigation	May 13
11	Venom	3	oz dry	Foliar	May 18
12	Control				

†Movento was applied with MSO adjuvant at 0.25 % of the total tank volume.

Table 2. Product Chemistry and Mode of Action.

Product	Active Ingredient	IRAC Group†	
Admire Pro	Imidacloprid	4A	Neonicotinoid
Applaud 70 DF	Buprofezin	16	Moulting disruptor; inhibits formation of chitin
Assail 30SG	Acetamiprid	4A	Neonicotinoid
Clutch 2.13 SC	Clothianidin	4A	Neonicotinoid
Movento	Spirotetramat	23	Lipid biosynthesis inhibitor
Platinum 75 SG	Thiamethoxam	4A	Neonicotinoid
Venom	Dinotefuran	4A	Neonicotinoid

†Insecticide Resistance Action Committee, http://www.irac-online.org/

Foliar Application Methods:

Foliar products were applied using Stihl gasoline powered backpack airblast sprayers and water volume equivalent to 100 gal ac^{-1}. Both sides of the treated vines were sprayed, and sprays were directed for coverage of the trunk, cordon and canopy with emphasis on basal leaves.

Soil Application Methods:

At a commercial scale, chemigation products are applied through irrigation systems for uptake by plant roots. At the small scale of this trial, conventional application through the irrigation system was not possible so products were applied directly to the wetted soil beneath drip emitters. Equivalent per-vine product rates were mixed with 50 mL of water and dispensed from a syringe to the soil.

Chemigation treatments are most effective when applied early-season, before soil moisture becomes depleted. The soil had previously received a total of eight hours of irrigation between April 30 and May 8 and was pre-irrigated for three hours on May 12, the day before application. Soil was sampled at 14” depth beneath emitters and in the row middle on the day of application prior to the irrigation for product application. Samples were collected using a core sampler and oven dried to determine volumetric wetness. One soil sample was collected in each location (Table 3).

Table 3. Soil moisture at 14" depth prior to chemigation.

Sampling Location		% Volumetric Soil Moisture
Top of Slope	Beneath Emitter	36.3%
	Row Middle	22.4%
Bottom of Slope	Beneath Emitter	26.9%
	Row Middle	16.0%

The day of application, irrigation occurred for one hour prior to product application, and continued for six hours after application to transport product into the root zone. Each vine was irrigated by a single 4 L hr^{-1} drip emitter. Early in the six hour period, malfunctioning emitters in the trial plots were replaced with new emitters.

Evaluation Procedures

In-season VMB population assessment:

Vine mealybugs were counted on the center two vines per plot beginning about 2 weeks after all vines had received at least one application of material. Two minute counts per vine were taken on five dates between June 1 and August 3. Mechanical counters were used to assist tallying, and all life stages excluding eggs, adult males or parasitized mummies were counted. Each replication was evaluated by one person to eliminate sampling bias.

Harvest cluster assessment:

Two weeks before commercial harvest, VMB populations were evaluated in clusters. On August 13 and 14, five clusters were sampled from each of the two center vines of all experimental plots for a total of 480 clusters. Sampling preference was given to clusters touching the cordon. In the event where no clusters touched the cordon, preference was given to basal clusters.

Clusters were transported to the laboratory in individual paper bags and dissected. Vine mealybugs in each cluster were counted using dissecting microscopes and mechanical counters. Some clusters examined contained many more mealybugs than could be counted with any degree of accuracy or timeliness. These clusters were categorized as having more than 100 mealybugs.

Statistical Analysis:

In-season VMB population assessment:

Vine mealybug populations counted during in-season two-minute counts were analyzed for treatment differences using ANOVA (Table 4). Plot averages were transformed with square transformations to correct departures from normality. Tukey's HSD test was used to reveal mean separations (Table 5).

Table 4. F-test P values for in-season two-minute timed VMB counts

	June 1	June 22	July 6	July 20	August 3
Model	0.0005**	0.0000**	0.0000**	0.0000**	0.0000**
Treatment	0.0004**	0.0000**	0.0000**	0.0000**	0.0000**
Replication	0.0726 ns	0.0275*	0.0680 ns	0.0159*	0.1521 ns

* Significant at α=0.05
** Significant at α=0.01
ns Not significant

Harvest cluster assessment:

Vine mealybugs in severely infested clusters were not counted past 100 insects. Because of this limit, the data are not continuous and cannot be analyzed by ANOVA. After vine mealybugs in each cluster were counted, the same cluster population data were represented using two categorical rating systems: cluster damage ratings and VMB population ratings.

These categorical data were analyzed using the chi-square test to determine if the number of clusters in each category was independent of the treatment. In this trial, the chi-square analysis was used to test the assumption that there is no relationship between treatments and the number of clusters in each damage category. If no relationship exists, then the number of clusters in the categories is independent of treatment.

Cluster Damage Ratings

Clusters were placed into four damage rating categories from 0 to 3 established by Walt Bentley[a] and Monica Cooper[b] corresponding to 0 mealybugs in a cluster, 1 to 10, 11 to 50, and greater than 50 mealybugs per cluster respectively (Figure 2). The chi-square test statistic to determine if there is a relationship between cluster damage ratings, and treatment was 337.535 and is significant at α=0.01 (p=0.0000). This indicates the cluster damage ratings are NOT independent of treatment.

VMB Population Ratings

Clusters were placed in 11 population categories based on mealybug counts, up to 100 per cluster, with the first category being 0 to 9 mealybugs per cluster, continuing with increments of 10, with category 10 having 90 to 99 mealybugs per cluster and category 11 having 100 or more mealybugs (Figure 3). The chi-square test statistic to determine if there is a relationship between VMB population ratings and treatment is 386.550 and is

[a] IPM Advisor, UC Statewide IPM Program
[b] Viticulture Farm Advisor and County Director, UCCE Napa County

significant at $\alpha=0.01$ ($p=0.0000$). This indicates VMB population ratings are NOT independent of treatment.

These significant chi-square tests indicate only that there is a relationship between the treatments and the number of clusters in categories; the test does not indicate if treatments are significantly different from each other. Significant differences among treatments can be seen in the analysis of the two-minute timed counts using ANOVA.

Results and Discussion:

Strategies to combat VMB on the North Coast have shifted from eradication efforts to integrated pest management. As the vine mealybug has at least 3.5 generations in this region, season-long control is necessary to control insect populations in order to minimize spread and maintain relatively uninfested clusters.

VMB counts decreased in many of the experimental plots between June 20 and August 3. These decreases were most likely caused by parasitism, as many mealybug mummies were found both on vines and in clusters. These mummies were not tallied during counts; however, *Anagyrus pseudococci* parasitoids emerged from several mummies collected during cluster dissection.

Imidacloprid *(Admire)*

Admire failed to provide adequate VMB control. The maximum label rate was applied in a single application. There was no significant difference in populations between Admire treated plots and the control plots at any date during the growing season with the exception of June 1, the first sampling date (Table 5). At harvest, 97.5% of the Admire treated clusters sampled contained VMB, although 27.5% had 10 or fewer mealybugs (damage category 0 and 1) (Figure 2).

Buprofezin *(Applaud)*

Two applications of Applaud proved to be effective for significant reduction of VMB populations. At all dates except June 1, VMB populations were significantly lower in the Applaud treated plots than the control plots (Table 5). At harvest, 42.5% of the clusters sampled contained no VMB, and 50% were in damage category 1 (Figure 2).

Acetamiprid *(Assail)*

During the growing season, Assail appeared to provide inadequate control of VMB (Figure 1). There was no significant difference in VMB populations on Assail treated plots and the control plots on June 1, June 22, July 6 or July 20 (Table 5). However, near the end of the growing season, populations on Assail treated plots dropped (Figure 1); with VMB populations significantly lower than on control plots on August 3 (Table 5).

At harvest, 82.5% of the clusters sampled contained VMB, and 50% were in damage category 0 and 1. These two categories represent the lowest level of cluster damage, and plots treated with Assail yielded the greatest percentage of clusters in these categories of all neonicotinoids tested (Figure 2). Only a single foliar application of 5 oz ac^{-1} Assail was evaluated in this trial. A registration change to two applications for a total of 10.3 oz ac^{-1} per season was pending at the time of application.

Clothianidin *(Clutch)*
Foliar applied Clutch failed to provide adequate VMB control. VMB populations on Clutch treated plots were not statistically different than populations on control plots at any of the five dates sampled (Table 5). At harvest, 100% of the clusters sampled contained VMB, although 20% of the clusters were in damage category 1 (Figure 2). Clutch treated plots had the most clusters with more than 100 mealybugs per cluster of all treatments except controls (Figure 3).

Spirotetramat *(Movento)*
Movento provided season-long VMB control. The maximum label rate for Movento control of mealybugs is 8 oz ac^{-1}, however 6 oz ac^{-1} proved effective. At all dates sampled, plots treated with Movento had significantly fewer mealybugs than control plots (Table 5). At harvest, 35% of the clusters sampled contained VMB, and all of these clusters were in damage category 1 (Figure 2).

Note: In 2009 at the time this trial was conducted, Movento was registered. However, in March 2010 an order vacating the registration is pending, and re-registration is under review.

Thiamethoxam *(Platinum)*
Platinum was applied both as a single full-rate application, and as two half-rate applications separated by one month. In plots treated with a single full-rate Platinum application there was no significant reduction in VMB populations on June 1, June 22, and July 6; however, on the last two sample dates, July 20 and August 3, VMB populations were significantly lower than on control plots.

In the single full-rate Platinum treatment, 95% of the clusters sampled contained VMB at harvest. Whereas 27.5% of the clusters sampled contained 10 or fewer mealybugs, 32.5% of the clusters were in damage category 3 and were severely infested with over 50 mealybugs per cluster (Figure 2).

The split half-rate Platinum treatment provided less effective control than the single full-rate application. VMB populations were significantly lower than populations on control vines only on August 3 (Table 5). Cluster damage was extensive with 100% of clusters containing VMB and as with the single full-rate Platinum treatment, 27.5% of the clusters sampled contained 10 or fewer mealybugs; however 42.5% were severely infested with over 50 mealybugs per cluster (Figure 2).

Two treatments incorporated Platinum applications in conjunction with Movento. Platinum at 4 oz ac^{-1} and at the full rate, 5.67 oz ac^{-1} were each combined with 6 oz ac^{-1} Movento. Neither treatment significantly reduced VMB populations any further than Movento alone (Table 5). At harvest, 42.5% and 50% of the clusters sampled contained

VMB in plots treated with Movento plus low rate and full rate of Platinum respectively. In each treatment, all infested clusters were in damage category 1 (Figure 2).

Dinotefuran *(Venom)*
Venom was applied both as a foliar spray and also to the soil for root uptake. Soil applied Venom did not provide significant population suppression on June 1, June 22, or July 6; however populations were significantly lower than on control plots on July 20 and August 3 (Table 5). At harvest, 92.5% of clusters contained VMB; 15% of the clusters contained 10 or fewer mealybugs and 40% were highly infested with over 50 mealybugs per cluster (Figure 2).

During the growing season, VMB populations on plots treated with foliar Venom application were not significantly different than populations on control plots at any sampling date. At harvest, 97.5% of clusters contained VMB and 65% were severely infested with more than 50 VMB per cluster.

Only a single foliar application of 3 oz ac^{-1} Venom was evaluated in this trial and the label indicates that a total of 6 oz ac^{-1} can be applied in one season.

Conclusion:
High populations of vine mealybug pose potential economic loss in winegrapes. Post harvest transport of VMB infested clusters and subsequent winery pomace disposal provide opportunity for spread of VMB to previously non-infested areas. Population suppression in clusters at harvest is a primary goal of an IPM control program both to reduce crop damage and loss, and to decrease likelihood of new infestations.

Of all products and combinations tested, the insect growth regulator Applaud and Movento, a lipid biosynthesis inhibitor, provided the most effective VMB control with two and one applications per season respectively. Platinum, when combined with Movento did not provide more effective control than Movento alone. No single neonicotinoid provided control similar to Applaud or Movento.

Of the neonicotinoids tested, Assail, Platinum and soil applied Venom appeared to provide the most effective VMB control. Platinum and soil applied Venom treated plots hosted very similar VMB populations throughout the growing season. At harvest, nearly all of the clusters treated with these products were infested with mealybugs; however 27.5% of the clusters in Platinum treated plots had 10 or fewer mealybugs compared to 15% of the clusters in soil applied Venom treated plots.

Assail treated plots hosted slightly higher VMB populations than Platinum and Venom treated vines as indicated by two minute timed counts during the season. These plots had significantly fewer VMB than control plots only on August 3. At harvest 50% of the clusters sampled from Assail treated plots had 10 or fewer mealybugs. Specifically, this treatment had the most clusters in the lowest damage categories at harvest of all neonicotinoids evaluated.

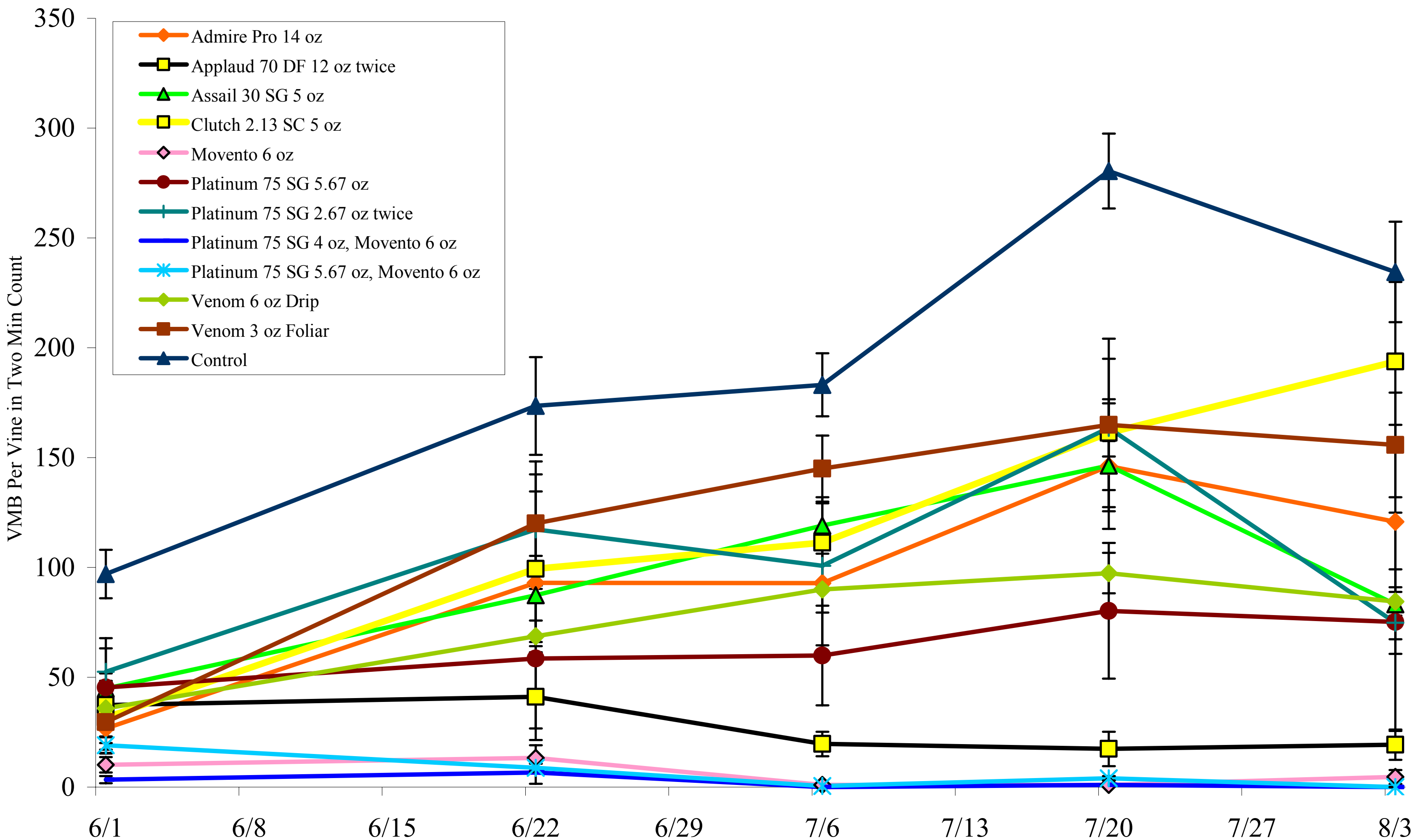

Figure 1. Average number of VMB per vine in two-minute timed counts during growing season

Chemigation treatments of Admire, Platinum and Venom were applied on May 13. Foliar treatments of Applaud, Assail, Clutch and Venom were applied May 18. All Movento treatments were foliar applied on May 19. A second chemigation application of 2.67 oz ac^{-1} Platinum was made on June 15 in conjunction with four hours of irrigation. A second foliar application of Applaud was made on June 26.

Table 5. VMB populations counted in two minutes on five dates and cluster damage ratings at harvest.

Treatment	June 1 Avg.	June 1 SE	June 22 Avg.	June 22 SE	July 6 Avg.	July 6 SE	July 20 Avg.	July 20 SE	August 3 Avg.	August 3 SE	Avg. Cluster Rating[‡]
Admire Pro 14 oz	26.8	9.7 ab	93.0	27.0 bcd	92.9	13.4 cd	146.1	28.6 cd	120.8	44.1 def	2.1
Applaud 70 DF 12 oz twice	37.4	11.0 abc	41.1	19.7 abc	19.6	5.6 ab	17.4	7.9 ab	19.3	6.9 abc	0.7
Assail 30 SG 5 oz	44.9	6.9 bc	87.4	17.9 bcd	119.0	10.2 cd	146.4	11.2 cd	83.3	15.9 cde	1.5
Clutch 2.13 SC 5 oz	31.6	16.1 abc	99.4	35.2 cd	111.3	20.6 cd	161.3	33.8 cd	193.8	36.2 ef	2.4
Movento 6 oz	10.1	3.5 ab	13.3	5.7 ab	1.0	0.6 a	1.0	0.5 a	4.6	3.2 ab	0.4
Platinum 75 SG 5.67 oz	45.4	22.4 abc	58.5	31.8 abcd	59.9	22.7 bc	80.3	30.9 bc	75.3	49.7 bcd	2.0
Platinum 75 SG 2.67 oz twice	52.5	10.7 bc	117.3	25.1 cd	100.8	8.8 cd	163.5	13.0 cd	74.8	14.1 cde	2.2
Platinum 75 SG, 4 oz Movento 6 oz	3.4	1.7 a	6.6	5.2 a	0.0	0.0 a	1.0	0.5 a	0.0	0.0 a	0.4
Platinum 75 SG, 5.67 oz Movento 6 oz	19.0	3.7 ab	8.8	1.9 a	0.5	0.3 a	4.0	1.0 a	0.0	0.0 a	0.5
Venom 6 oz Drip	35.9	3.0 abc	68.6	7.2 abcd	90.0	25.5 c	97.4	9.2 c	84.5	6.5 cde	2.2
Venom 3 oz Foliar	29.6	9.5 abc	120.0	28.2 cd	145.0	15.1 d	164.9	39.3 cd	155.8	23.8 def	2.6
Control	97.0	11.1 c	173.5	22.2 d	183.1	14.3 cd	280.5	17.1 d	234.5	22.9 f	2.7

†Numbers within a column followed by the same letter are not significantly different at $\alpha=0.05$ using Tukey's HSD procedure.
‡Clusters were harvested August 13-14. Average Cluster Damage rating is derived from Figure 2. Mean separation was not performed on these data, as they represent categories and are not continuous data.

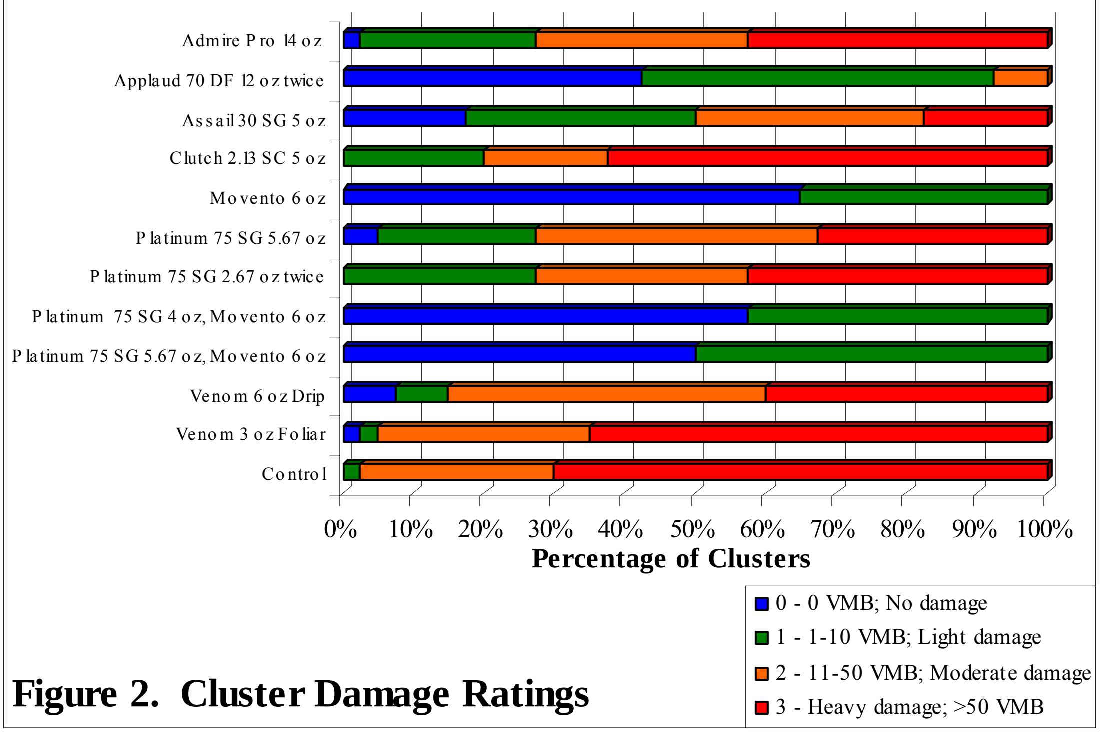

Figure 2. Cluster Damage Ratings

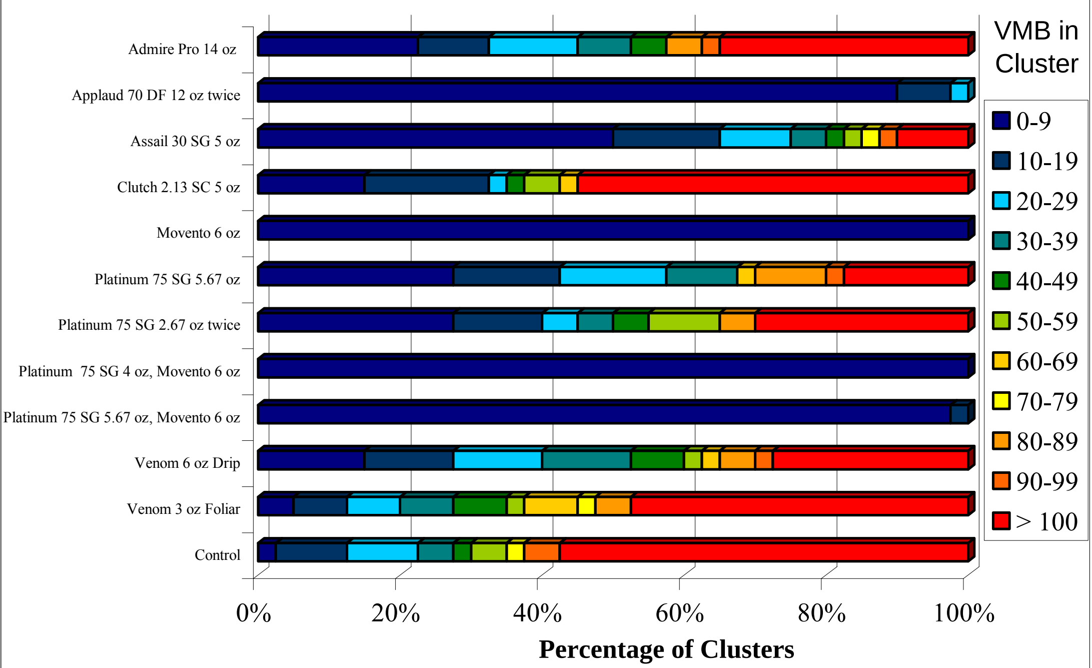

Figure 3. VMB Populations in clusters at harvest