

2007 Research Report

Systemic insecticides for selective and targeted insect control in Michigan vineyards

Rufus Isaacs, Steve Van Timmeren and John C. Wise

Dept. of Entomology, Michigan State University, East Lansing, MI 48824
Trevor Nichols Research Complex, Fennville, MI 49408

Executive Summary

The grape industry is gaining registrations of systemic insecticides that can be delivered through the vine roots after application to the soil. This project tested various systemic insecticides and showed that they can provide high levels of vine protection against potato leafhopper and Japanese beetle depending on the application timing and application method. They have the added benefit over conventional insecticides of being most effective in new shoot growth where potato leafhopper infestation is greatest. We also detected reduction in grape berry moth in one of the study years, and there was no consistent effect on soil-dwelling beneficial insects. Soil applications at commercial farms were effective only in vineyards using drip irrigation, suggesting that vines must have root systems near to the emitters for this approach to be most effective.

2007 Research Report

Systemic insecticides for selective and targeted insect control in Michigan vineyards

Rufus Isaacs, Steve Van Timmeren and John C. Wise

Dept. of Entomology, Michigan State University, East Lansing, MI 48824
Trevor Nichols Research Complex, Fennville, MI 49408

Introduction

Systemic insecticides provide unique tools for grape growers in that once the insecticide is inside the plant tissues, it should provide a long duration of protection against various grape feeding pests such as leafhoppers and Japanese beetles. The neonicotinoid class contains a range of insecticides (e.g. Provado, Venom, Assail, Actara, Clutch) that can be applied to the foliage and others that can be applied to the roots (e.g. Admire, Venom, Platinum, Belay).

To get the soluble insecticide into the plant, it can be delivered through a drip irrigation system or sprayed directly on the vine. For soil applications, once the insecticide is absorbed by the roots it moves in the transpiration stream to the foliage. Insects feeding on treated vines then receive a dose of the insecticide, causing repellency or death. Potential benefits of this approach to insect control include: 1) longer duration of residual control against foliar pests, 2) protection of insecticide from wash-off, 3) control of multiple pest types with one application 4) low worker exposure to pesticide residues, and 5) reduced toxicity to natural enemies.

Systemic insecticides are increasingly being registered for use in vineyards, and this research was conducted to evaluate the registered insecticides and those with potential for future registration. The objectives of this study were as follows:

1. Compare soil-applied insecticides under vineyard conditions for control of leaf - feeding insects.
2. Determine the optimal time of application of soil insecticides.
3. Compare uptake of systemic insecticides into foliage.
4. Evaluate effects of tested insecticides on soil arthropods.

Methods

1. Chemigation in Drip-Irrigated TNRC Vineyard Planting.

Three soil-applied insecticides were tested during 2007 in a hybrid grape vineyard at the Trevor Nichols Research Complex in Fennville, Michigan. We evaluated the following treatments, with rates selected to provide the similar amounts of active ingredient across treatments (Table 1). To compare the treatments listed in Table 1, they were applied to seven vine plots of hybrid grapes (cv. Chancellor and Aurora). This vineyard was planted in June 2005 on a site with sandy loam soil. Plots were arranged in a randomized block design with four replications of each treatment.

Table 1. Irrigation Injection treatments at TNRC in 2007.

Treatment	Rate (oz/acre)	Active ingredient
Untreated	-	-
Admire Pro	14	imidacloprid
Platinum 2SC	16	thiamethoxam
Belay 16WSG	20	clothianidin

Treatments were made on 6 June 2007 at the 8-10 inch growth stage using CO₂ pressurized canisters that were attached to the drip lines running to each of the seven-vine plots receiving an insecticide (Fig. 1). Vines were irrigated for a total of four hours before, during, and after chemical applications to ensure that the insecticide reached the root zone. A second application of chemicals was made on 6 July 2007 in order to further explore the effects treatments would have on Japanese beetles which were just emerging at the time of the second application, as well as grape berry moth.



Figure 1. Irrigation injection setup to apply insecticides to vines in 2006.

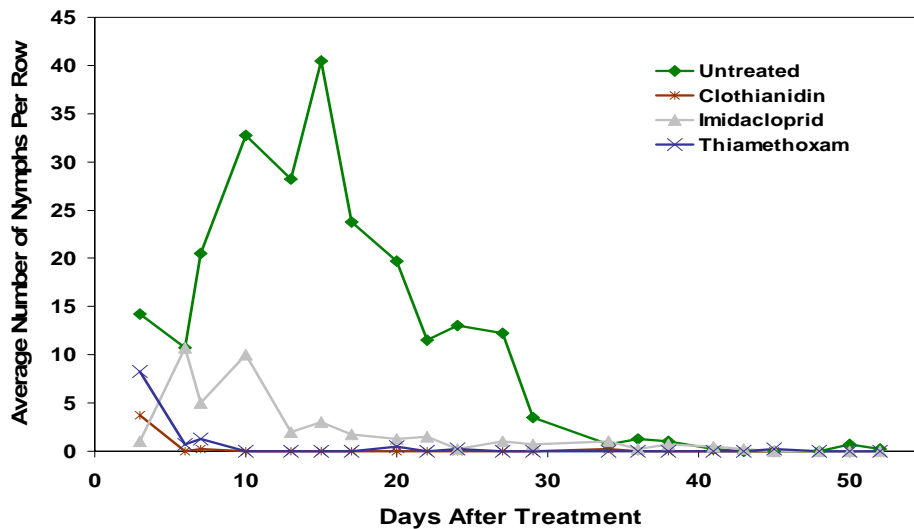


Figure 2. Average number of potato leafhopper nymphs found on grape leaves on vines treated with various chemicals via irrigation injection. Applications took place on 6 June 2006 and assessments were conducted approximately once a week for 52 days after the treatments.

Potato leafhopper. Each plot in the experiment was sampled once a week after the application for potato leafhopper (PLH). Within each plot, six leaves were assessed on each of five vines, for a total sample of 30 leaves per plot. The number of adult and nymph PLH was recorded. Initial sampling in plots in 2007 indicated PLH populations were too low to provide any useful data so clip cage experiments were conducted in order to verify the 2006 experimental results (Fig. 2). One vine per plot had two clip cages attached to leaves on one shoot. One cage was attached to a newly unfolded leaf (Fig. 3) and another was attached to a mature leaf closer to the base of the shoot. Five PLH nymphs were placed in each clip cage and attached to the vines at 1600 hours on 2 July 2007. Cages were taken off of vines at 0900 hours on 3 July 2007 and the number of dead and dying nymphs was recorded. Cages were only left on vines overnight in order to minimize stress due to high temperatures during the day.



Figure 3. PLH clip cage attached to newly unfolded grape leaf.

Japanese beetle. Assessments on the effects of the treatments on Japanese beetle (JB) presence and feeding consisted of weekly sampling of vines for the presence of healthy JB as well as JB suffering sublethal chemical effects (leg twitching, slow movement, etc.). Laboratory bioassays were conducted weekly to assess the amount of JB feeding that was occurring over time. Later in the season vines were assessed for JB damage in order to verify results from the laboratory feeding bioassays. The weekly JB assessments consisted of counting the total number of healthy and sublethal JB per plot. For the weekly laboratory bioassays, one mature grape leaf was cut from each of the middle five vines per plot and placed in a water pick which was placed in a 32 oz deli container (Fig. 4). One female JB was added to each container and was allowed to feed on the grape leaf for 48-160 hours depending on the week. At the end of the 48-160 hour period leaves were assessed for the percent of the leaf surface area fed upon by the beetles, measured in 5% increments.



Figure 4. JB leaf feeding bioassay.

On 10 August 2007 JB leaf feeding damage assessments were conducted on the vines in the irrigation injection plots. Ten mature leaves were assessed on each of the middle five vines per plot. All the leaves on each vine were located on the highest shoot on the vine that had ten leaves above the six foot high trellis wire. Individual leaves were assessed for JB feeding damage by estimating the percent of the leaf surface area fed on by JB, measured in 5% increments. Assessments started at the base of the shoot and continued until ten leaves were assessed.

Grape berry moth. At four times during the 2007 season grape clusters (approximately ten per vine) were assessed for the percentage of clusters infested with grape berry moth (GBM). Two GBM assessments were conducted in 2006.

Insecticide residues. Grape leaves and clusters were sampled periodically through the trial in order to test for insecticide residues in both 2006 and 2007. Four leaves were taken from five vines in each row at the 1, 7, 14, and 30 day point after the insecticide treatments took place. Leaves and clusters from 2007 are still in the process of being analyzed using HPLC.

Response of soil arthropods. Soil samples were taken with golf cup cutters either directly under the vines or in an adjacent row middle at 3 days before, 10 days after, and 140 days after the 6 June applications in both 2006 and 2007. Soil samples were taken from two vines in each row, with one sample analyzed for the presence of nematodes and the other sample placed into Berlese funnels for an assessment of arthropods in the soil. Nematode samples from both years are in still in the process of being assessed and Berlese funnel samples from 2007 are still being assessed.

2. Soil-Applied Insecticides at commercial vineyards.

Three commercial vineyards, two located near Traverse City, MI and one located near Fennville, MI were used to test different methods of applying systemic insecticides to the soil. The chemicals tested and rates applied are listed in Table 2. Two of the vineyards (one in Traverse City and one in Fennville) had no drip irrigation systems in place.

Chemical applications were applied via a backpack sprayer on 1 June 2007 in Traverse City and 5 June 2007 in Fennville followed by irrigation (equivalent to 0.5-1.5 inches of rain) to water in the chemical. The other vineyard in Traverse City had a drip irrigation system in place and chemicals were applied via a backpack sprayer on 1 June 2007 and the chemicals were watered in using the drip irrigation system (equivalent to 1.5 inches of rain). Assessments of leafhopper populations (including grape leafhoppers, potato leafhoppers, Virginia creeper leafhoppers, and three-banded leafhoppers) were made on a weekly basis by counting the number of leafhopper adults and nymphs on 30 leaves per plot.

Table 2. Irrigation Injection treatments at On-Farm vineyard sites in 2007.

Treatment	Rate (per acre)	Active ingredient
Untreated	-	-
Admire Pro	7 oz	imidacloprid
Admire Pro	14 oz	imidacloprid
Venom 70SG	1.13 #	dinotefuran
Venom 70SG	1.32 #	dinotefuran

Data from all assessments were analyzed using analysis of variance (ANOVA) followed by Fisher’s Protected Least Significance test for post-hoc comparisons. Means and percentages are presented ±SE and an alpha value of 0.05 was used in procedures.

Results

Chemigation at TNRC Vineyard Planting.

Results from clip cage experiments show significant differences in PLH mortality on mature leaves but not on young leaves (Fig. 5) ($F_{\text{mature}} = 2.3$; $df_{\text{mature}} = 3, 12$; $P_{\text{mature}} = 0.13$; $F_{\text{new}} = 2.3$; $df_{\text{new}} = 3, 12$; $P_{\text{new}} < 0.003$). On mature leaves, the highest percentage of dead and dying nymphs were found in thiamethoxam (Platinum) treatments, while the lowest percentage was found in untreated vines. While newly unfolded leaves showed no significant differences, the same trend of greater percentage of dead and dying nymphs in Platinum treatments was evident.

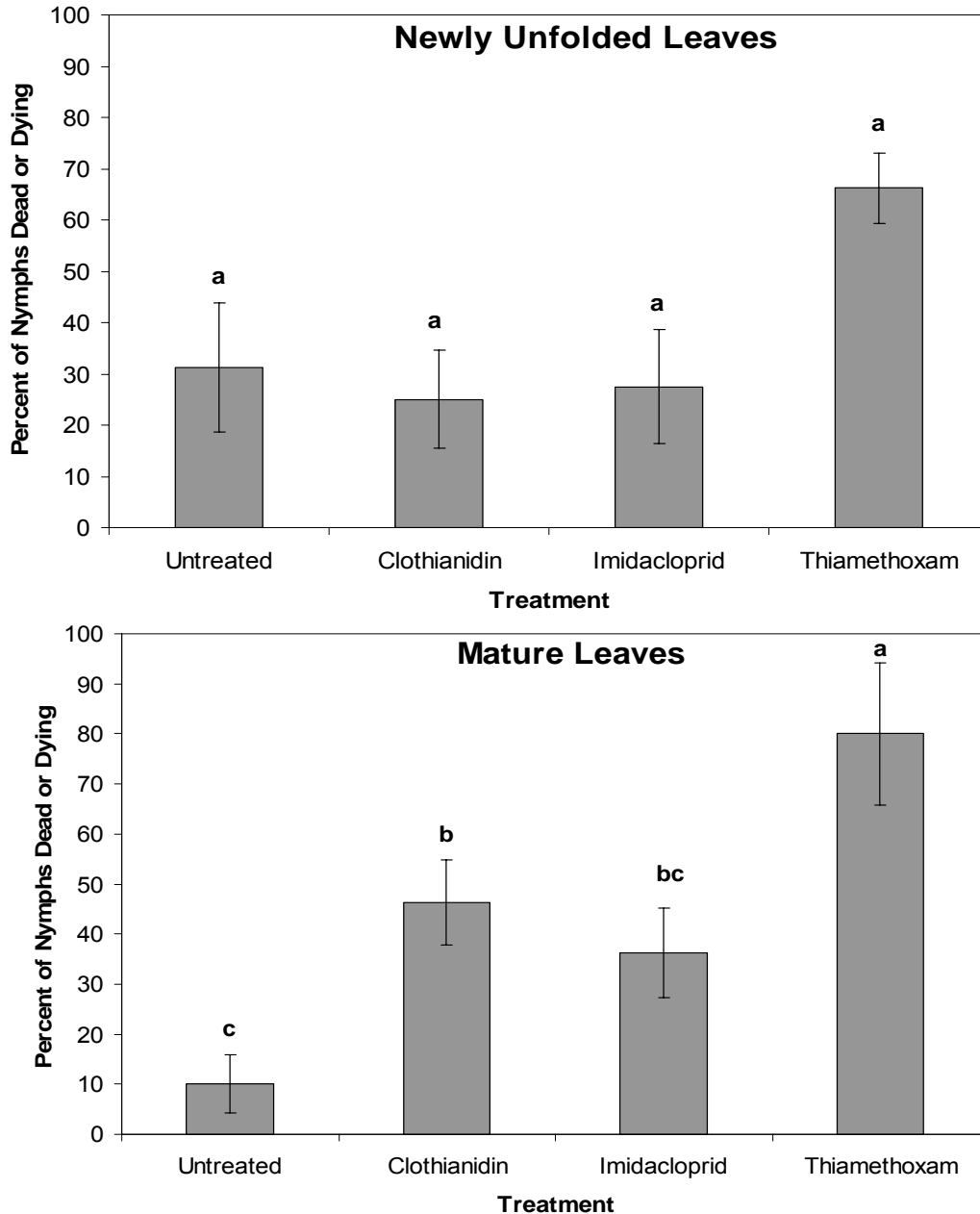


Figure 5. Percent of PLH nymphs that were dead or dying after overnight confinement on newly unfolded or mature grape leaves on vines treated with various chemicals via chemigation 25 days earlier. Percentages are presented \pm SE and averages with the same letter are not significantly different at $\alpha=0.05$.

Japanese beetle leaf-feeding bioassays showed significant reductions in leaf feeding in some of the treated plots over the course of the field season (Fig. 6) ($df=3,12$; $F_{3 \text{ DAY}}=7.0$; $P_{3 \text{ DAY}}=0.006$; $F_{11 \text{ DAY}}=4.8$; $P_{11 \text{ DAY}}<0.02$; $F_{17 \text{ DAY}}=12.9$; $P_{17 \text{ DAY}}<0.001$; $F_{24 \text{ DAY}}=29.0$; $P_{24 \text{ DAY}}<0.001$; $F_{31 \text{ DAY}}=21.3$; $P_{31 \text{ DAY}}<0.001$; $F_{38 \text{ DAY}}=16.8$; $P_{38 \text{ DAY}}<0.001$; $F_{45 \text{ DAY}}=14.5$; $P_{45 \text{ DAY}}<0.001$; $F_{52 \text{ DAY}}=7.6$; $P_{52 \text{ DAY}}=0.004$; $F_{60 \text{ DAY}}=14.9$; $P_{60 \text{ DAY}}<0.001$; $F_{66 \text{ DAY}}=3.1$; $P_{66 \text{ DAY}}=0.066$). Leaves from imidacloprid treatments had significantly lower feeding damage than each of the other treatments for all days except at 52 days after treatment where imidacloprid and thiamethoxam treatments were not significantly different, and at day 66 where there were no significant differences among any treatments. Clothianidin-treated leaves were not significantly different from untreated controls on any of the days through the season.

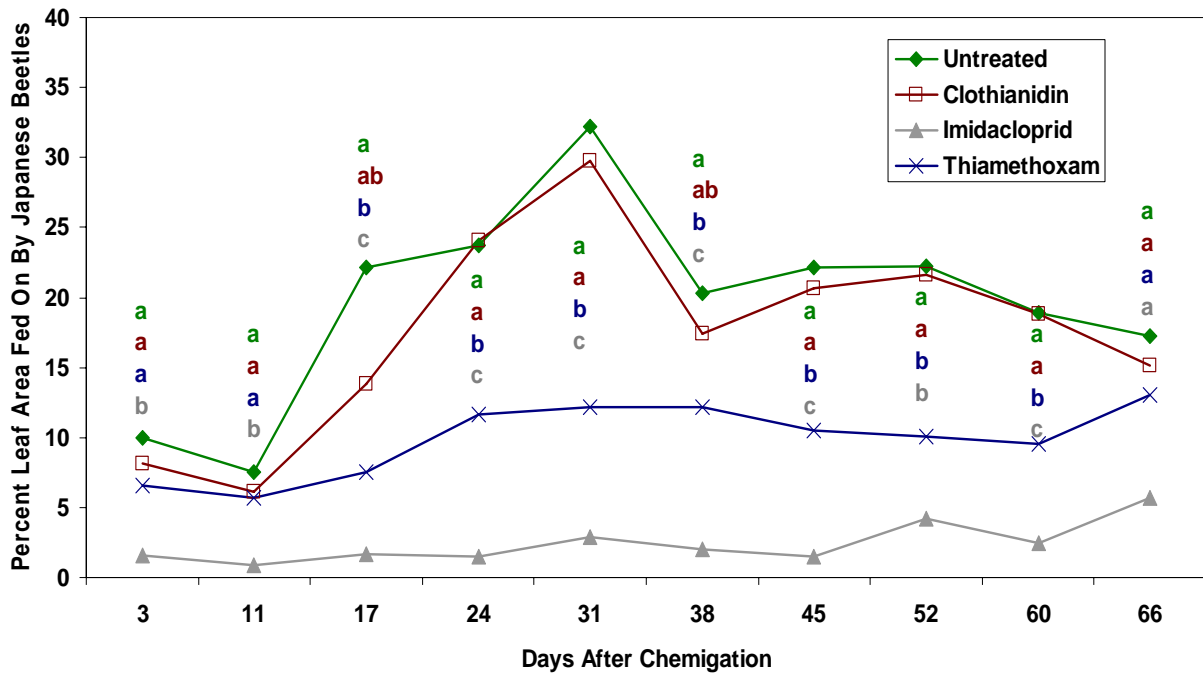


Figure 6. Percent of mature grape leaf surface area fed on by Japanese beetles in laboratory bioassays. Grape vines received various chemical treatments delivered by irrigation injection on 6 July 2007 and bioassays were conducted on a weekly basis for 66 days after application. Letter that are the same within each sampling date are not significantly different at $\alpha=0.05$.

Assessments of Japanese beetle feeding damage on grape leaves within the treated vineyard plots showed significant differences among the treatments that reflect the differences found in the laboratory bioassays (Fig. 7). Imidacloprid-treated vines had the lowest levels of feeding damage while clothianidin-treated vines were not significantly different from controls ($F=21.3$; $df=3, 12$; $P<0.001$).

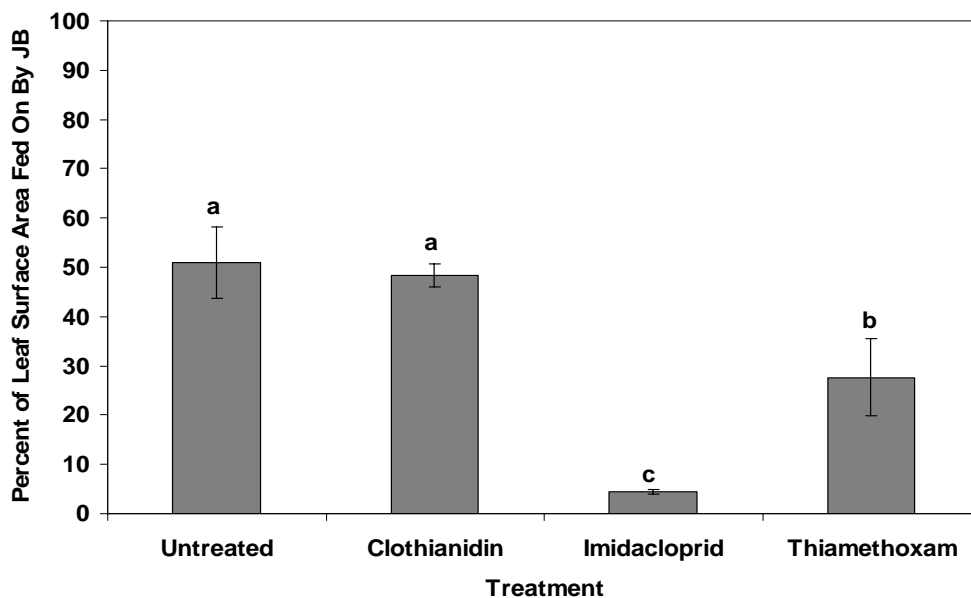


Figure 7. Percent of grape leaf surface area fed on by Japanese beetles on vines with roots treated with systemic insecticides. Chemical applications took place on 6 July and damage assessments took place on 10 August 2007. Percentages are presented \pm SE and averages with the same letter are not significantly different at $\alpha=0.05$.

Grape cluster assessments later in the growing season showed no significant differences in 2006 and some significant differences in 2007 (Fig. 8) ($F_{2006}=1.03$; $df_{2006}=3, 12$; $P_{2006}=0.42$; $F_{2007}=9.4$; $df_{2007}=3, 12$; $P_{2007}<0.002$). Clusters on imidacloprid-treated vines had significantly lower levels of GBM infestation than in untreated controls. None of the other treatments were significantly different from the controls.

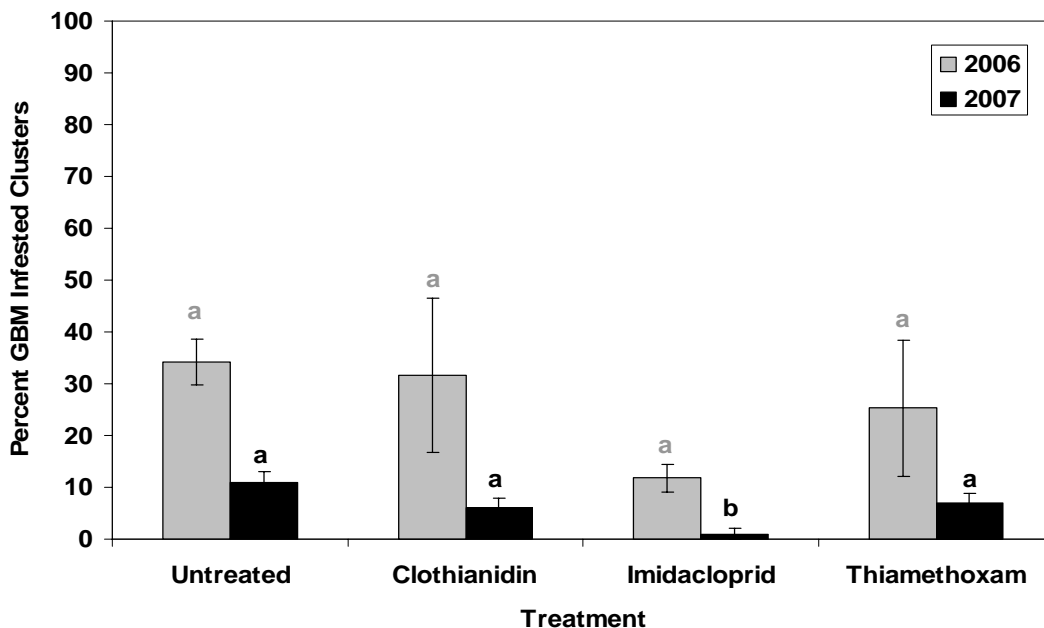


Figure 8. Percent of grape clusters infested with grape berry moth on vines treated with various chemicals via chemigation in 2006 and 2007. Assessments took place on 28 July 2006 and 24 August 2007. Values within each year with the same letter are not significantly different.

Berlese funnel samples taken from underneath treated vines and in adjacent row middles indicate no significant differences in arthropod abundance among treatments. Most arthropod groups were present at low levels with no clear differences between treatments. Collembolans were the most abundant soil arthropods at this site and no significant differences were found among treatments on any of the dates for either the under the vine samples (Fig. 9) ($df=3, 12; F_{-3 \text{ DAT}}=1.7; P_{-3 \text{ DAT}}=0.21; F_{14 \text{ DAT}}=1.4; P_{14 \text{ DAT}}=0.28; F_{140 \text{ DAT}}=1.04; P_{140 \text{ DAT}}=0.41$) or the row middle samples (Fig. 9) ($df=3, 12; F_{-3 \text{ DAT}}=1.1; P_{-3 \text{ DAT}}=0.38; F_{14 \text{ DAT}}=1.4; P_{14 \text{ DAT}}=0.29; F_{140 \text{ DAT}}=1.7; P_{140 \text{ DAT}}=0.23$).

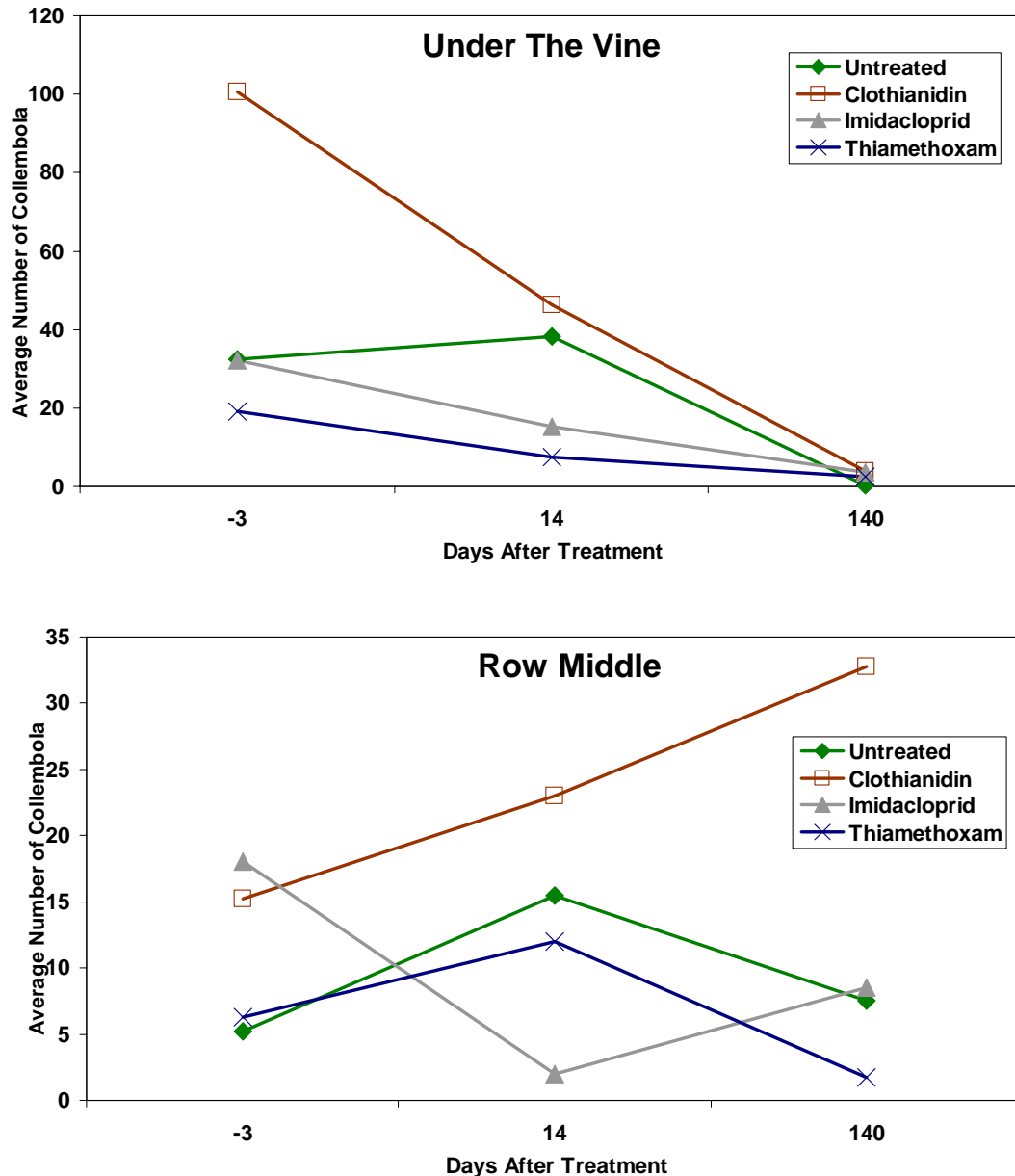


Figure 9. Average number of Collembolans found in Berlese funnel samples taken from either underneath vines that received chemigation treatments or from row middles adjacent to those treatments. Samples were taken 3 days before (precount), 14 days after, and 140 days after the chemical application on 6 June 2006. No significant differences were found among treatments on any of the dates at $\alpha=0.05$.

Soil-Applied Insecticides at On-Farm Sites.

Insecticides applied through the drip irrigation system in a young irrigated vineyard during 2006 provided excellent control of potato leafhopper nymphs (Fig. 10A) ($F=21.7$; $df=3, 12$; $P<0.001$). While there is some trend toward lower PLH abundance in some of the treated plots, when insecticides were banded under the vines and then irrigated with drip irrigation in more mature vineyards, no significant control of potato leafhopper nymphs was observed (Fig. 10B) ($F=1.6$; $df=4, 15$; $P=0.23$). Chemicals banded under the vines and then irrigated in via rainfall also did not show any significant control by the applied insecticides (Fig. 10C) ($F=2.1$; $df=4, 15$; $P=0.13$).

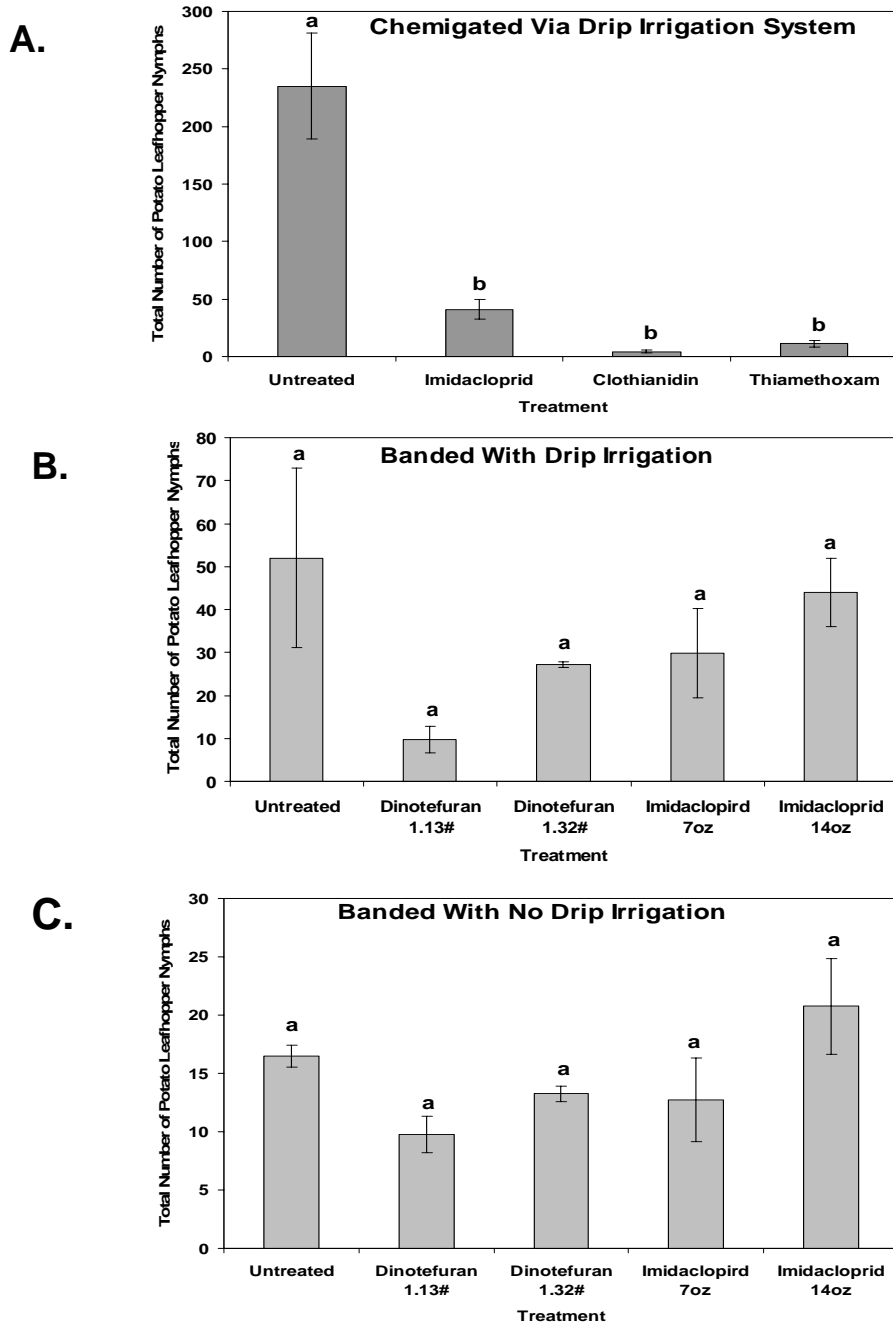


Figure 10. Total number of PLH nymphs found on grape leaves during 2007. Chemicals were applied by (A) chemigating through a drip irrigation system, (B) banding on the soil of drip-irrigated vines, or (C) banding on the soil of vines with no drip-irrigation. Means are presented + SE and means with the same

Summary

Results from this study indicate that potato leafhoppers can be controlled effectively by insecticides applied via chemigation. Vineyard assessments in 2006 and clip cage experiments in 2007 indicate the chemigated systemic insecticides can provide up to a month of control against leafhoppers. This will be of particular use to Michigan winegrape growers who are susceptible to potato leafhopper over a long period of activity during the period of rapid shoot expansion in the spring.

Insecticide treatments were also able to provide protection against Japanese beetle feeding. Imidacloprid provided the most effective control of any of the neonicotinoids tested. Beetles ate a significantly lower percentage of grape leaves in laboratory bioassays and significantly lower amounts of feeding damage was found in vineyard assessments of vines treated in early July when they were assessed in early August. Thiamethoxam also provided some level of control, while clothianidin showed no significant differences from untreated controls.

Our data also suggest imidacloprid treatments provided some control of grape berry moth. The percent of clusters infested with GBM in the imidacloprid treatments in 2007 was significantly lower than any of the other treatments. A similar trend was evident in 2006 but was not significant. Whether this is caused by direct toxicity of residues in berries to larvae or on leaves to adult moths is not clear and requires further investigation. The results of the residue analysis will be useful to interpret these data.

While insecticides applied via chemigation in our TNRC research vineyard provided excellent control of leafhoppers, other methods tested at commercial vineyards were not as effective. Banding insecticides on the soil under vines followed by either drip irrigation or rain provided no significant control against leafhoppers. This may reflect the difficulty getting the chemical into the root system on vines that have a well developed root system in which the majority of the roots are deep in the soil.

Acknowledgements

We thank the Viticulture Consortium (East), The Michigan Agricultural Experiment Station, and the Michigan Grape and Wine Industry Council for their support of this research. Thanks also to Jay Prescott, Marie Prescott, Mark VanderMeer, Adam Young, and Robert Young for their technical assistance with this project. We also thank Jeremy Hooper, Larry Mawby, and Doug Welsch for the use of their vineyards for this project, as well as Nikki Rothwell and Karen Powers from the Northwest Michigan Horticulture Research Station for assistance with data collection.

For more information on this report, please contact Dr. Rufus Isaacs at isaacsr@msu.edu