

YEAR 1 PROGRESS REPORT

ACTIVITY AND POTENTIAL SIDE EFFECTS OF SYSTEMIC NEONICOTINOID INSECTICIDES FOR PROTECTION OF VINES FROM INSECT DAMAGE

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ORIGINAL GOALS AND OBJECTIVES

1. Compare soil-applied insecticides for control of leaf -feeding insects.
2. Determine the optimal time of application of soil insecticides.
3. Compare uptake and persistence of systemic insecticides in grape foliage.
4. Evaluate potential negative effects of tested insecticides on non-target soil arthropods.

METHODS

Insecticide Comparison. Three soil-applied insecticides were tested during 2006 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).

Table 1. Soil-applied insecticide treatments tested during 2006

Treatment	Rate (oz/acre)	Active ingredient
Untreated	-	-
Admire	16	imidacloprid
Platinum	16	thiamethoxam
Belay	20	clothianidin

Treatments were applied to seven vine plots of hybrid grapes (cv. Chancellor and Aurora) at the Trevor Nichols Research Complex. Plots were arranged in a randomized block design with four replications of each treatment. Treatments were made on June 6, 2006 at the 8-10 inch growth stage using CO₂ pressurized canisters that were attached to the drip lines running to each of the 7 vine plots receiving an insecticide. Half an inch of rain fell at this site within 24 hours of the treatment, ensuring that the insecticide reached the root zone.

To assess the effect of the treatments on potato leafhoppers (PLH), each plot was sampled every 3-4 days after the application. 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. On 5-July-2006 vines were assessed for leafhopper damage on four leaves on each of five vines in each plot, as indicated by leaf yellowing, using a scale from 1 (no leaf yellowing) to 3 (significant leaf yellowing). In order to investigate the potential for control of other insects, leaves were assessed for Japanese beetle (JB) feeding damage on 28-July-2006. The percent leaf area removed by JB was estimated on five leaves on each of five vines. At three times during the season grape clusters (three per vine) were assessed for the percentage of clusters infested with grape berry moth (GBM).

Grape leaves were sampled periodically through the trial in order to test for insecticide residues. 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 were analyzed later for insecticide residue levels using HPLC.

Soil samples were taken either directly under the vines or in an adjacent row middle at 1, 7, 14, and 30 days after chemical treatments took place. Soil samples were taken from two vines in each row and either sampled for presence of nematodes or placed into Berlese funnels for an assessment of arthropods in the soil.

Imidacloprid Timing

Testing of imidacloprid timing took place in a Concord vineyard equipped with drip irrigation. Seven vine plots were arranged in a randomized block design with four replications of each treatment. Treatments were applied on 6, 19, and 29-June-2006 at 16 oz/acre. Insect assessments were the same as the insecticide comparison trials, except that vines were not rated for leafhopper damage symptoms because of the lack of such symptoms on the Concord vines.

RESULTS

Insecticide Comparison. A comparison of the soil formulations of clothianidin, imidacloprid, and thiamethoxam showed significant differences in abundance of PLH adults and nymphs (Fig. 1). Populations of nymphs increased rapidly on untreated vines while dropping down to near zero in the three insecticide treatments. PLH nymphs on both clothianidin and thiamethoxam-treated vines dropped to near zero by the sixth day after treatment, while imidacloprid-treated vines took an additional week to drop off.

When the season totals of PLH nymphs were analyzed, all three insecticide treatments had significantly fewer nymphs than the controls (ANOVA, $F=21.69$, $P<0.01$) (Untreated: 235.0 ± 46.0 , Clothianidin: 4.3 ± 1.3 , Imidacloprid: 41.0 ± 8.7 , Thiamethoxam: 11.3 ± 2.8 PLH nymphs per plot). PLH adults were relatively scarce on all treatments for the first 15 days after treatment at which point populations on untreated vines increased as nymphs entered adulthood. Adult abundance in the three insecticide treatments stayed low but began to gradually increase until near day 30 when they increased to the levels in the untreated

treatments. Season totals of PLH adults were not significantly different from each other (ANOVA, $F=1.67$, $P>0.05$) (Untreated: 39.0 ± 16.4 , Clothianidin: 12.8 ± 3.1 , Imidacloprid: 27.8 ± 4.8 , Thiamethoxam: 17.8 ± 4.3 PLH adults per plot) because of the decrease in efficacy of the insecticide treatments later in the trial.

However, at day 27 significantly more adults were found in untreated rows than in the clothianidin and thiamethoxam treated rows (ANOVA, $F=3.84$, $P=0.039$) (Untreated: 5.8 ± 2.5 ,

Clothianidin: 0.8 ± 0.3 , Imidacloprid: 2.3 ± 0.3 , Thiamethoxam: 0.3 ± 0.3 PLH adults per

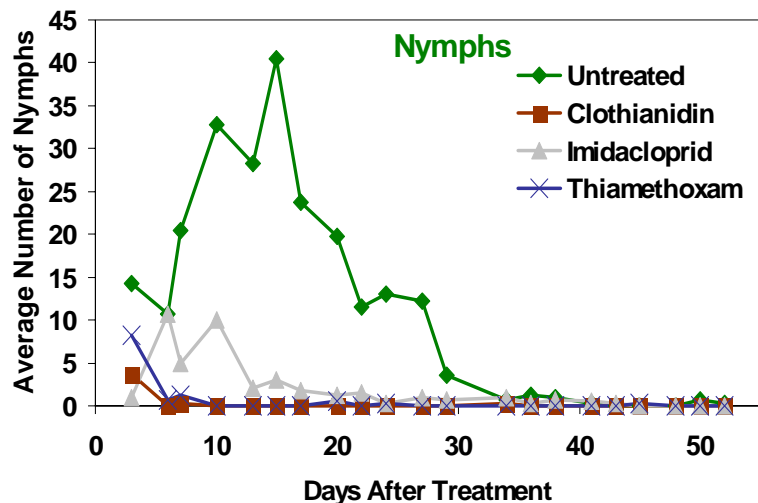


Figure 1. Number of potato leafhopper nymphs on 30 grape leaf samples after treatment with insecticides by drip irrigation.

plot). The higher number of PLH adults and nymphs in the untreated rows resulted in significantly more damage to leaves. Leaves in untreated rows showed significantly more yellowing than in any of the insecticide treatments (Fig. 2; ANOVA, $F=9.17$, $P<0.01$).

Levels of JB feeding in the insecticide comparison experiments were not significantly different (ANOVA, $F=1.20$, $P>0.05$) (Untreated: 16.1 ± 4.7 , Clothianidin: 17.3 ± 3.3 , Imidacloprid: 8.5 ± 3.7 , Thiamethoxam: 13.8 ± 2.0 percent leaf area removed).

Likewise, no difference was found in percent of clusters infested with GBM (ANOVA, $F=1.03$, $P>0.05$) (Untreated: 34.3 ± 4.4 , Clothianidin: 31.7 ± 14.9 , Imidacloprid: 11.8 ± 2.7 , Thiamethoxam: 25.3 ± 13.1 percent GBM-infested clusters).

Analysis of insecticide residues in grape leaves showed varying levels of the chemicals. Vines treated with clothianidin or thiamethoxam had low and variable residue levels, suggesting inconsistent analysis or breakdown of the active ingredient. The leaves treated with imidacloprid showed higher levels, allowing interpretation of the time course of uptake; imidacloprid increased over the first seven days then declined during the month (Fig. 3; ANOVA, $F=46.12$, $P<0.01$).

Soil samples testing for nematodes and arthropods are still being sorted so no results are available at this time.

Imidacloprid Timing

A comparison of imidacloprid timings showed significant differences in the number of PLH nymphs per plot (Fig. 4). The early imidacloprid application had only a few nymphs within the first few days and then had zero nymphs for the rest of the season. Over the course of the season PLH nymphs were significantly lower in the early imidacloprid treatment than in the untreated controls (T-test, $t=-4.73$, $P<0.01$) (Untreated: 12.5 ± 2.4 , Early Imidacloprid: 1.0 ± 0.4 PLH nymphs per plot). The average

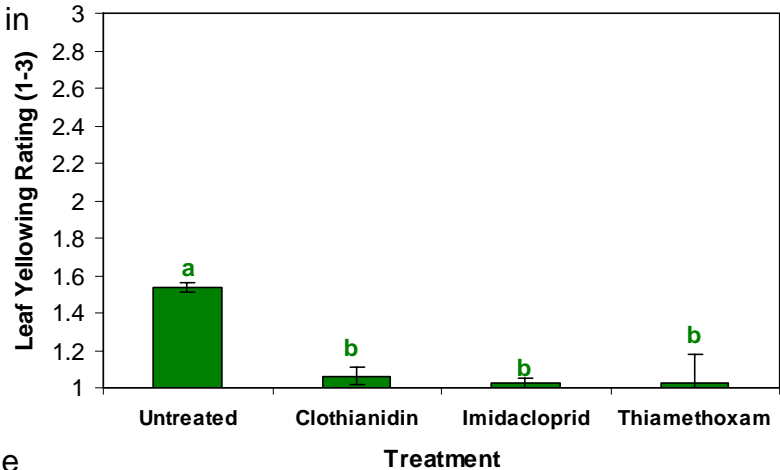


Figure 2. Damage ratings on grape leaves treated with different insecticides by irrigation injection. Means with letters that are different are significantly different from each other ($P<0.01$).

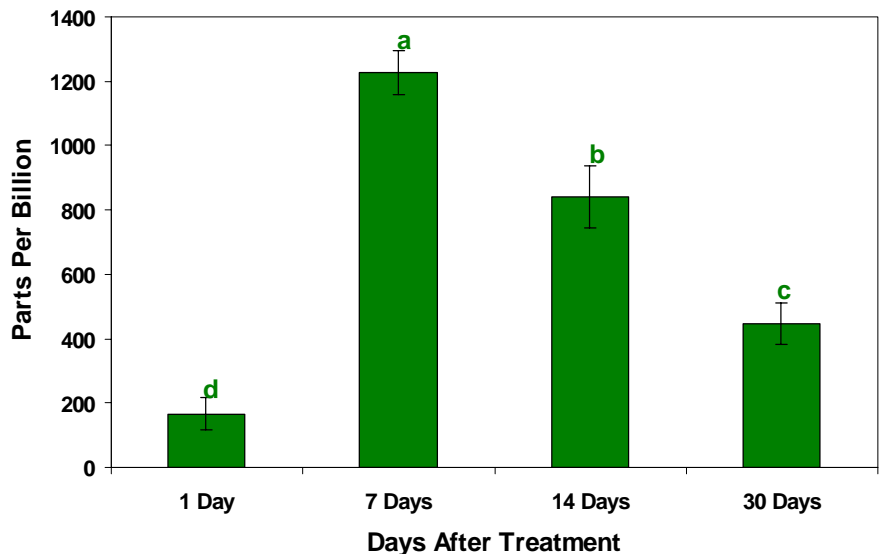


Figure 3. Concentration of imidacloprid in grape leaves after the soil beneath the vine was treated with imidacloprid. Bars with the same letters are not significantly different ($P<0.01$).

number of nymphs per plot in the mid imidacloprid treatment began at a higher level than the early imidacloprid treatment and gradually decreased to near zero within a couple of weeks. This decline was not as quick as in the early imidacloprid treatment because the treatment was applied when more nymphs were present on the vines. The

number of nymphs in the mid imidacloprid treatment was significantly lower than the untreated controls during the same time period (T-test, $t=-3.06$, $P=0.02$) (Untreated: 7.5 ± 1.3 , Mid Imidacloprid: 2.5 ± 1.0 PLH nymphs per plot). The average number of nymphs per plot in the late imidacloprid treatment started with higher numbers of nymphs as well, but declined to near zero over the course of a

couple of weeks. This decline coincided with a natural population decline in the untreated treatments resulting in no significant differences between the late imidacloprid and untreated treatments over the same time period (T-test, $t=0.49$, $P>0.05$; Untreated: 2.8 ± 1.3 , Late Imidacloprid: 3.5 ± 0.9).

The percent of leaf area removed by JB was significantly lower in all of the imidacloprid treatments than in the untreated controls (Fig. 5; ANOVA, $F=7.94$, $P<0.05$).

None of the imidacloprid treatments were significantly different from each other. Since JB did not begin to emerge until 26 days after the early imidacloprid treatment was applied, this

indicates that even a month after treatment the imidacloprid was providing at least some level of control. However, since JB populations were lower in this experiment than in the insecticide comparison experiment, it's difficult to tell how effective the imidacloprid treatments would be with heavy JB populations. The percent of clusters infested with GBM in the imidacloprid timing experiment was quite low overall, resulting in no

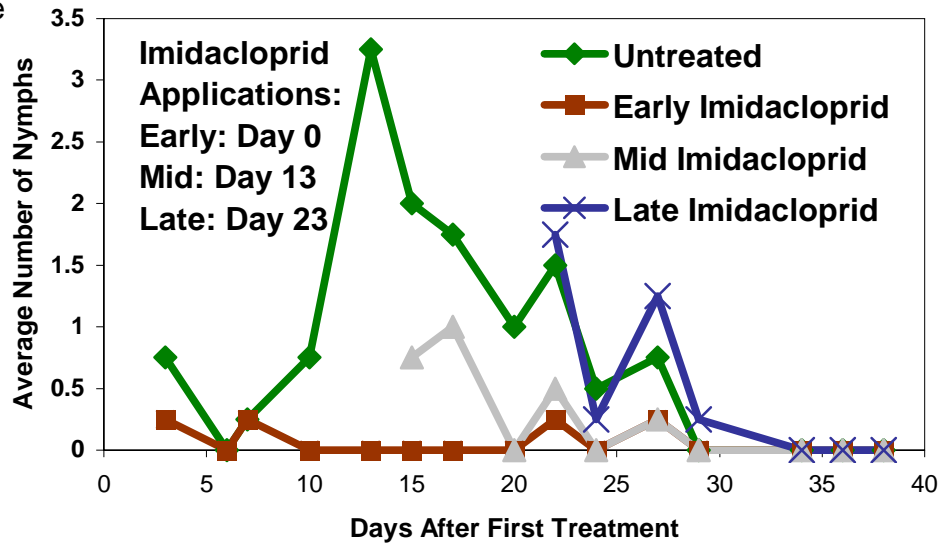


Figure 4. PLH nymph numbers on grape leaves treated with imidacloprid at three different times in the season.

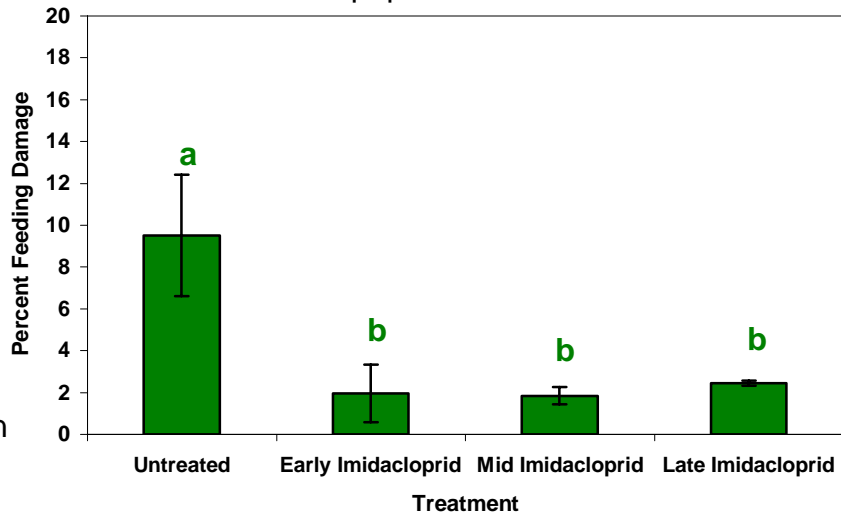


Figure 5. Percent feeding damage by Japanese beetles on grape vines treated with imidacloprid at three different times during the season by irrigation injection. Percentages with different letters are significantly different from each other ($P<0.05$).

significant differences among any of the treatments (ANOVA, $F=0.13$, $P>0.05$) (Untreated: 3.9 ± 2.2 , Early Imidacloprid: 1.7 ± 1.7 , Mid Imidacloprid: 3.3 ± 3.3 , Late Imidacloprid: 3.6 ± 3.6 percent GBM-infested clusters).

At the time of writing we have not yet completed the sorting and analysis of the soil arthropods, but will report that at the next reporting opportunity.

Summary

Results from this study indicate that three weeks of protection against adult and nymph stages of PLH can be achieved with the three neonicotinoids tested here. This activity has the potential to provide vineyard managers with a crop protection approach that will reduce the need for repeated applications of insecticides during the spring, when new foliage is growing and requiring protection against PLH. Residue analysis indicated that imidacloprid was transported rapidly to leaves on these young vines, so this treatment could be applied in response to scouting information that indicated early leafhopper presence. It will be important to determine the dynamics of insecticide uptake on more established vines and on vines not grown on drip irrigation, to determine whether these findings hold.

Control of other insect pests later in the season would improve the economics of soil-applied insecticides. Protection of the vines against JB observed one month after soil applications for control of PLH suggests that the imidacloprid residues are long-lived in the vine and will have additional benefits for foliage protection. We also expect that rosechafers will be controlled by early June treatments of neonicotinoids, but the cluster pest, grape berry moth, was unaffected in this trial. Further studies are planned to test irrigation injected neonicotinoids in commercial vineyards as a means for control of the main insect pests in grape production. This will provide information on how these insecticides can best fit into commercial growing systems.

Appendix

Impact Statement. Soil-applied neonicotinoid insecticides provide control against pests in grapes, including leafhoppers and Japanese beetles. The systemic nature of these insecticides offers another tool that grape growers can incorporate into their pest management plans for targeted control of leaf and shoot feeding insects. This project will provide information on how these insecticides will best fit into commercial growing systems, and will provide information that will help support EPA registrations for products not yet available to grape growers.

Publications. Research results were presented at the summer field days at both the Trevor Nichols Research Complex in Fennville, MI and the Southwest Michigan Research and Extension Center in Benton Harbor, MI during the summer 2006. Results were also presented at the national Entomological Society of America meetings in Indianapolis, IN in December 2006 as well as the Great Lakes Expo in Grand Rapids, MI in December 2006. A manuscript from our results to date is being prepared for submission during 2007 and we are planning an article for submission to Wine East later this year.