UNDERSTANDING THE DYNAMICS OF NEONICOTINOID INSECTICIDAL ACTIVITY AGAINST THE GLASSY-WINGED SHARPSHOOTER: DEVELOPMENT OF TARGET THRESHOLDS IN GRAPEVINES

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ABSTRACT
The impact of systemic treatments of dinotefuran on the adult and egg stages of the glassy-winged sharpshooter (GWSS; *Homalodisca vitripennis*) is being evaluated using greenhouse and laboratory scale bioassays. One reason for the use of systemic treatments is that they exploit the xylophagous feeding behavior of the GWSS adult and immature stages. Our current data show that these treatments have an additional contact activity on emerging first instars before they begin feeding. Preliminary data indicate that dinotefuran is inherently more toxic than imidacloprid to first instar GWSS. In bioassays with adults exposed to treated grapevines, we quantify dinotefuran concentrations within the xylem and related mortality. From these bioassays, we expect to generate a value that represents the effective concentration of dinotefuran needed to kill a GWSS adult feeding on a vine. This target threshold can then be used to guide growers in the selection of treatment rates, and as an indicator of the efficacy of treatments and the level of protection their vines are receiving.

INTRODUCTION
Our research program focuses on the use of chemical insecticides for the management of the glassy-winged sharpshooter (GWSS; *Homalodisca vitripennis*). We are dedicated to formulating safe and effective treatment programs for California growers, given the almost complete reliance by the grape industry on this method of control. We have conducted extensive trials in Coachella, Napa and Temecula valley vineyards to evaluate the uptake and persistence of three neonicotinoids – imidacloprid, thiamethoxam, and dinotefuran – under the diverse range of climatic, soil, and agronomic conditions associated with these regions. We have an understanding about how the different chemical properties, particularly water solubility, of these neonicotinoids can be exploited to achieve optimum uptake into vines, and we have developed sensitive techniques that allow us to monitor the levels of insecticide present within the vines. To exploit this knowledge further for the benefit of California grape production, we need to ensure that the concentrations of insecticide present within the vines are reaching levels that are effective at rapidly killing GWSS before they can infect vines with Pierce's disease (PD). We also need to understand whether there is a sub-lethal impact of these insecticides on GWSS, since anti-feedant activity may not necessarily eliminate the threat that an infective sharpshooter poses to a vine. Our past and current research projects have established the threshold levels of imidacloprid needed to kill a GWSS at 10 ng/ml xylem fluid, and optimized treatment regimes for growers that will ensure these thresholds are attained following applications via different irrigation methods (drip, sprinkler). In 2007, a new systemic neonicotinoid, Venom (active ingredient dinotefuran), received full registration for use on grapes. An additional systemic neonicotinoid, Platinum (active ingredient thiamethoxam), is scheduled for registration in 2008 (it will soon go through the 30 day posting process according to a personal communication from David Belles, Syngenta). Our work in this area has demonstrated the excellent uptake of these new insecticides following systemic application to vines (Toscano et al., 2007). This is good news for vineyard operators who have experienced problems with imidacloprid. Imidacloprid has been the predominant neonicotinoid in use in vineyards, but our research has shown that its uptake and persistence within vines varies dramatically between regions (Coachella Valley, Napa Valley, Temecula Valley). Despite its apparent poor uptake, growers continue to rely on imidacloprid in many areas. The perception is that the insecticide will work well in all areas given its successful implementation in Temecula vineyards (Byrne and Toscano, 2006). Thiamethoxam and dinotefuran offer a potential solution to overcoming the problems encountered with imidacloprid use – their rates of uptake are faster and they reach higher concentrations at peak uptake than imidacloprid under the more challenging situations. They also exhibit favorable persistence. Having established that the uptake and persistence of these systemic insecticides is superior to imidacloprid in terms of insecticidal titers reached in the xylem, it is important to determine the threshold levels of these insecticides to ensure that the levels attained in the xylem are active against sharpshooters. Comparative data on the efficacies of systemic thiamethoxam and dinotefuran against GWSS are not available.

OBJECTIVES
1. Determine target thresholds for systemic neonicotinoids against glassy-winged sharpshooters in grapevines.

RESULTS
We are currently running two sets of experiments. Potted grapevines have been treated with Venom (active ingredient dinotefuran) at recommended field rates (6 oz/acre), and dilutions of this rate. The efficacy of dinotefuran at these treatment rates is being assessed by confining adult sharpshooters on the vines and determining the levels of mortality after one day of

exposure. The concentrations of dinotefuran in the vines are measured after the mortality has been scored so that we can derive a lethal concentration for the insecticide. Xylem fluid is extracted using a pressure bomb and the dinotefuran in the extract is then quantified by ELISA. In the first tests, the use of the field rate resulted in 100% mortality. This is not surprising since the concentrations of dinotefuran in the xylem fluid exceeded 100 ppb, the upper limit we set for the ELISA. We are continuing with the evaluation of lower treatment rates, and will present the results at the annual symposium.

In the second set of experiments, we are evaluating the effect of dinotefuran against the eggs of the GWSS. Adult GWSS are confined in cages with cotton, which is an excellent host for GWSS oviposition. Leaves with egg masses (not older than 24 hours) are cut from the plants and the petioles inserted into vials containing a range of insecticide solutions. The uptake of insecticide into each leaf is allowed to proceed for 24 hours and the leaves are then transferred to leaf boxes. The leaf boxes are maintained under lights until the normal period of embryonic development is completed. Mortality is assessed at the time of emergence of the first instar. In our first set of experiments, we tested 0.1 ppm dinotefuran (prepared from Venom 70SG). After 24 hours, the average concentration of dinotefuran present in the leaves was 7.3 ng/cm^2 leaf. At this concentration, we observed 100% mortality of emerging nymphs. As with imidacloprid, the nymphs developed fully within the egg mass and only succumbed to the effects of contact with dinotefuran during emergence. The high mortality at this concentration is in contrast to our previous data for imidacloprid, where we observed an LC_{50} of 39 ng/cm^2 leaf. Our results show that dinotefuran is more toxic to the 1st instar than imidacloprid.

CONCLUSION

In previous work, we showed that the rate of uptake of dinotefuran into grapevines was faster than imidacloprid. Also, concentrations of dinotefuran at peak uptake were higher. The results we are generating from this project are encouraging from two standpoints. First, we have shown that dinotefuran is highly toxic to GWSS adults, indicating that it will be an effective product for the control of the insect in vineyards. The use of dinotefuran will provide growers with a product that acts effectively against sharpshooters, particularly in situations where growers must respond quickly to an infestation to prevent the potential transmission of PD. When we conclude our bioassays, we will generate a threshold level of dinotefuran necessary to kill a sharpshooter quickly once it feeds from the xylem. We will then be able to determine the level of persistence that a treatment will provide. And second, dinotefuran is highly toxic to emerging 1st instars. Systemic treatments exploit the xylophagous feeding behavior of the GWSS adult and immature stages. We now know that these treatments have an additional impact on emerging 1st instars before they begin feeding.

The systemic neonicotinoids imidacloprid and dinotefuran are effective insecticides that growers can use for long-term management of GWSS populations. Because of the contrasting chemical properties of these insecticides, growers can now choose the most suitable product to meet their pest management needs.

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