# Developing IPM Strategies for Vine Mealybug

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Vine mealybug has quickly become a serious pest of table, wine, and raisin grapes in California. It was first introduced into California's Coachella Valley in the early 1990s. It quickly spread to distant California grape-growing regions, with new infestations found in the San Joaquin Valley (1998), Central Coast (1999), North Coast (2001), Sacramento Valley (2002), Sierra Foothill (2002), and Monterey (2002) regions. Long-distance spread of this pest has likely been the result of contaminated nursery stock, whereas localized spread is primarily a result of mealybugs "hitchhiking" on equipment and personnel working in vineyards.

Vine mealybug infestations can have significant impacts on the quality and yields of grapes. Prior to harvest, mealybugs have a great affinity for feeding in the cluster. This feeding results in clusters contaminated with mealybugs, honeydew and sooty mold. Wounds caused by mealybug feeding also allow for the entry of fruit-rotting pathogens into the rachis and fruit, causing individual berries or the entire cluster to become rotten.

Control of vine mealybug with insecticides is expensive, with costs being prohibitive to many raisin and winegrape growers in the San Joaquin Valley. Many of these insecticides, particularly the organophosphates and carbamates, are disruptive to IPM programs for several different pests. For these and other reasons, significant research is under way to develop management options for vine mealybug that can prevent spread to new locations, and can control this pest with softer pesticide chemistries, biological control, and other IPM friendly-strategies.

## Preventing the contamination of nursery stock with IPM

The most effective way to control vine mealybug is to never have it in the first place. While this might sound a little cliché, it is the basis for all management decisions in the production of nursery stock. Preventing contamination is the only method to ensure that pest populations do not exceed the level of zero tolerance.

For decades, hot-water treatments have been available, although inconsistently used, for the decontamination of dormant grape nursery stock from pests such as phylloxera and root-knot nematode. More recently, research has documented the effectiveness of these treatments against vine mealybug. Laboratory experiments have shown that 99.9% of vine mealybugs can be killed by immersing dormant cuttings or vines in hot water at 127°F for five minutes. Field experiments in Kern County validated the effectiveness of hot-water treatments on a commercial scale, resulting in 99.8, 100, and 100% mortality to vine mealybug in three different experiments, respectively.

Commercial hot-water treatments involve a three-step process. First, dormant cuttings or benchgrafts are immersed for five minutes in a warming tank at around 90°F for five minutes to warm up the wood. Second, the wood is immersed for five minutes in the hot-water treatment tank at 127°F, followed by five minutes in a cooling tank at around 70°F. The last of these tanks is to cool the wood as quickly as possible to prevent losses in quality. Wood can be treated once, as is the case with cuttings used for potted vines, or twice as occurs to benchgrafts that are treated once in the cutting stage prior to grafting and a second time one year later just prior to shipping.

Despite their effectiveness, hot-water treatments should not be considered a cure-all for all vine mealybug issues at nurseries. They should only be used as a preventive control strategy and not as a method to disinfest nursery stock known to be contaminated. Treatments should always be accompanied by preventive and aggressive sanitation and monitoring programs. This includes the use of pheromone traps to identify potential vine mealybug contamination in mother blocks used to take cuttings, and sanitation practices to ensure that vine mealybug do not enter nursery operations on equipment and or personnel.

**Transitioning to more IPM-friendly insecticides in vineyards**

Insecticides have always played a pivotal role in the control of vine mealybug in commercial vineyards. Since this pest first entered the state, organophosphate and carbamate insecticides such as chlorpyrifos, methomyl, dimethoate and diazinon have been the backbone of control efforts. More recently, research has documented the effectiveness of reduced-risk insecticides such as the neonicotinoid imidacloprid, and the insect growth regulator buprofezin. These new chemistries are not only safer for humans and the environment, but may be used with minimal disruption to some biological control organisms of vine mealybug and other grape pests. However, care should be taken when applying buprofezin since it might be disruptive to mealybug destroyers (*Cryptolaemus* sp.). The mealybug destroyer is an important natural enemy in the coastal regions of California.

Experiments on imidacloprid (Admire, Bayer Corp.) and buprofezin (Applaud, Nichino America) have proven that both insecticides can protect the grape crop. Imidacloprid, when applied in textured light soils through a drip-irrigation system in April or May, provided the greatest reduction in cluster damage. Foliar applications of buprofezin performed best during the early part of the season when this growth regulator could inhibit molting of actively-developing nymphs. Buprofezin is also valuable on flood-irrigated vineyards and in those on heavy textured soils where imidacloprid performs poorly.

The adoption of reduced-risk insecticides has been an important first step toward advancing IPM in the grape crop. Predator and parasite populations, which were commonly reduced by applications of organophosphate and carbamate insecticides, can now be maintained within a vineyard. This opens up a window of opportunity for biological control through augmentative releases of parasitoids.

**Augmentative releases of a vine mealybug parasitoid**

The most important biological control organism for vine mealybug is the parasitoid, *Anagyrus pseudococci*. This parasite attacks third-instar mealybug nymphs and prevents them from completing their development. In regions where it is established, it is not uncommon for more than 80% of vine mealybug to be parasitized by the end of the season. Unfortunately, natural parasite activity is often too late to adequately control this pest prior to harvest in the San Joaquin Valley. *Anagyrus* also overwinter poorly as they are not very good at parasitizing mealybugs in protected locations.

Augmentative releases of *Anagyrus* are currently being investigated as a way to jumpstart parasitoid activity in the spring. Increased spring populations should enhance vine mealybug control throughout the rest of the season, and hopefully in time to control mealybugs prior to harvest.

Thus far, data on augmentative releases are encouraging. Researchers have been able to mass-produce the parasitoids, release them, and document decreases in the numbers of vine mealybugs and damage to the clusters at harvest. However, they have not been able to document definitively that the parasitoid releases were solely responsible for the differences due to the many factors that influence these insects and the crop in the field.

Ongoing research will continue to develop information on augmentative releases of *Anagyrus*. If shown to be cost-effective, this IPM practice could serve as a tool for vine mealybug control in conventional as well as organic vineyard operations. It could also be used in conjunction with other tactics such as mating disruption to aid in both control and eradication programs.

**Mating disruption**

Mating disruption works by inhibiting the ability of male vine mealybugs to find the females. If the males and females cannot mate, there will be no offspring. Alternatively, the ability of females to produce eggs decreases with age, meaning that delays in the time it takes for a female to mate will result in decreased offspring per female.

For vine mealybug, mating disruption is based on the use of pheromones. These pheromones are currently available on standard rubber septa for use in pheromone traps, and are now being tested as a microencapsulated formulation and in dispensers. An advantage of the microencapsulated formulation is that it can be sprayed with commercially available pesticide equipment. This results in millions of tiny microcapsules that are spread out evenly on vines throughout the acreage. The primary disadvantage is that the pheromone is rather short-lived and repeat applications are necessary for season-long control. The advantages of pheromones in hand-applied dispensers are that they have the potential for longer activity and might be registered for use on crops that are certified as organic. Disadvantages are that hanging the dispensers can be labor-intensive.

Initial experiments on mating disruption are under way to determine how this strategy influences mealybug populations in the field. Male vine mealybugs were not able to find pheromone traps in vineyards that were sprayed with the microencapsulated formulation of the pheromone, as well as those where hand-applied pheromone dispensers were hung. This “shut down” of traps may indicate that both dispensing systems are delivering sufficient pheromone to disrupt mating. As a result, experimental plots where mating disruption was used had significant reductions in damage to clusters at harvest. Decreases in damage are likely due to the combined effects of disruption of mating as well as direct mortality from parasitism by *Anagyrus*.

Ongoing research will continue to develop and document protocols for mating disruption. This includes details such as the refinement of application rates, numbers of applications needed per season, and more details of how and when to use mating disruption. For example, situations where vine mealybug densities are high may have little use for mating disruption (since males need only walk short distances to mate), whereas disruption might be optimal where densities are low and flight is required by males to seek out the females. Ultimately, the adoptability of mating disruption, as well as other IPM approaches, will depend on their efficacy and cost effectiveness compared to more conventional strategies.