**Interim progress report for CDFA Agreement number 15-0219-SA**

# EVALUATION OF COMMERCIAL ANT BAITS AS A COMPONENT OF AN INTEGRATED PEST MANAGEMENT PROGRAM FOR VINE MEALYBUG, *PLANOCOCCUS FICUS*

**Principal Investigator:**
Monica L. Cooper
University of California, Cooperative Extension
1710 Soscol Ave., Suite 4
Napa, CA 94559
mlycooper@ucanr.edu

**Co-Principal Investigator:**
Lucia G. Varela
University of California, Cooperative Extension
133 Aviation Blvd., Suite 109
Santa Rosa, CA 95403
lgvarela@ucanr.edu

**REPORTING PERIOD:** The results reported here are from work conducted July 1, 2015 to June 30, 2016.

**INTRODUCTION:** The vine mealybug (VMB), *Planococcus ficus* (Signoret), is a destructive vineyard pest that contaminates fruit, debilitates vines and vectors plant pathogens such as *grapevine leafroll-associated virus-3* (Daane et al. 2012). First reported from vines in the Coachella Valley (Gill 1994), VMB soon spread throughout California, likely on infested nursery stock (Haviland et al. 2005). It is currently found in most California grape-growing regions (Godfrey et al. 2002; Daane et al. 2004a, 2004b) and has the potential to spread throughout the western United States.

Management of VMB populations can prove challenging and often requires the use of multiple tactics, including biological control, mating disruption and insecticides (Daane et al. 2008b). Management can be particularly complicated in coastal wine grape growing regions where VMB populations are tended by Argentine ants, *Linepithema humile* [Mayr]. In the presence of tending ants, biological control of mealybugs can be significantly interrupted, resulting in large VMB populations that may be more easily spread to new areas. These populations also contaminate the fruit, causing yield losses and decreased fruit quality. In vineyards where Argentine ant is prevalent, management of ant populations is a critical part of an IPM program for VMB and necessary for containment of insect populations (Nyamukondiwa and Addison 2011; Mgochecki and Addison 2009).

Liquid ant baits adapted from the urban environment (Klotz et al. 2002) for use in vineyards (Cooper et al. 2008), significantly reduce mealybug populations in vineyards by contributing to increases in biological control (Daane et al. 2007). The costs associated with the manufacture, deployment and maintenance of bait stations have been prohibitive to widespread adoption of Argentine ant management in vineyards, despite the benefits that could result from such programs (Nelson and Daane 2007).

There is continued interest among coastal grape growers in the development of a simpler and more economical bait program that could be widely implemented. Baits formulated as granular products, or polyacrylamide gels that can be broadcast with a fertilizer spreader could be distributed more quickly and frequently over a large area, and would not require the manufacture and maintenance of bait stations. The sustained use of the granular or polyacrylamide baits could lead to longer-term containment and control of Argentine ant populations (Boser et al. 2014; Krushelnycky et al. 2004).

We are evaluating a granular ant bait and an experimental polyacrylamide bait that can be broadcast to control populations of Argentine ant. Ant control would in turn contribute to the sustainable control of VMB populations. In the absence of an economical bait program, ant suppression must be achieved with the broad-spectrum insecticide, chlorpyrifos that can affect water quality, disrupt populations of beneficial insects and pose vertebrate health risks.

**OBJECTIVE:** The broad goal of this research is to increase the efficacy and adoption of integrated pest management programs for vine mealybug, a destructive pest of grapevines in California. Our specific objective is to: Evaluate the efficacy of two bait formulations to control Argentine ant as part of an integrated pest management program for vine mealybug.

**OBJECTIVE 1. Evaluate the efficacy of two bait formulations to control Argentine ant as part of an integrated pest management program for vine mealybug.**

**ACTIVITIES:**

**2015 field season-GRANULAR BAIT TRIAL:** In 2015, our experiment was established in two vineyard blocks in Napa, California (Carneros American Viticultural Area (AVA)). Both blocks were planted in 1999 and are a mix of Chardonnay clones (17-Robert Young and 6) on SO4 rootstock (*Vitis berlandieri* x. *V. riparia*). We used a randomized complete block design, and established six, 6-row replicates of each treatment. The treatments were 3 commercial granular bait products (Table 1).

Table 1. Ant bait products applied in trial blocks in a Napa County vineyard.

| Treatment | Active Ingredient (concentration) | Rate per acre | Bait applications (2015) |
|---|---|---|---|
| Altrevin | metaflumizone (0.063%) | 1.5 lb. | March 14 & 15; April 15 & 16; June 15 & 16 |
| Altrevin & powdered sugar | metaflumizone (0.063%) | 1.5 lb. | |
| Extinguish | hydramethylnon (0.365%) & methoprene (0.25%) | 1.5 lb. | |
| Seduce | Spinosad (0.07%) | 20 lb. | |
| Untreated | none | none | none |

In March, April and June 2015, the cooperating vineyard manager applied the bait in the vine row with a modified broadcast spreader mounted on an all-terrain vehicle (ATV) (Figure 1). Because Altrevin and Extinguish are formulated with a protein attractant specifically for control of red imported fire ant (*Solenopsis invicta*), we included one Altrevin treatment in which the bait was coated with powdered sugar before application to make it more attractive to Argentine ants. The spinosad bait, Seduce, is formulated with a carbohydrate attractant (sugar) specifically to target the Argentine ant. Additionally, Seduce has been approved for use in organic vineyards. Since there are a limited number of insecticides approved for VMB management in organic vineyards, ant bait can be an essential component of an IPM program in these vineyards.

Ant densities were determined indirectly as a measure of feeding activity, assessed as the amount of nontoxic sucrose water removed from 50-milliliter (ml) polypropylene centrifuge tubes (Corning Inc., Corning, NY) tied to the vine trunk (Klotz et al. 2002, Daane et al. 2008a) in the center two rows of each plot. The 50-ml tubes are henceforth referred to as monitoring tubes. A 2-centimeter (cm) hole was drilled in the cap, and a square of permeable plastic mesh (Weedblock, Easy Gardener Inc., Waco, TX), was placed between the cap and the filled tube, covering the hole. The mesh is fine enough to retain the liquid when the tube is inverted, but coarse enough to allow ants to remove the liquid on contact. A second lid was fixed to the original lid, and covered with a permanent mesh to discourage feeding by honeybees and wasps. Before the tubes were deployed in the vineyard, each tube was filled to 45 ml with 25% sucrose water and the weight of each tube was recorded. Tubes were inverted on a vine trunk for 4 to 7 days (depending on ant activity), at a density of 12 tubes per plot, or a total of 72 tubes per treatment. At the end of the monitoring period, the tubes were brought back to the laboratory and the new weights were recorded. One additional monitoring tube per plot was attached to an ant-excluded bamboo stake to measure the amount of water lost to evaporation; this amount was averaged across all plots and used to adjust the final weight.

A.

Figure 1. (A) modified broadcast spreader mounted on ATV; (B) Seduce bait (reddish pellets) under the vine row; (C) Argentine ants feeding on cotton ball used for monitoring ant activity.

Photo credit: (A) K. Taylor, Constellation Brands; (B) M. Cooper, UC Cooperative Extension (UCCE); (C): M. Hobbs, UCCE

B.

C.

We measured ant activity with monitoring tubes during six periods: February 24 to March 3 (pre-treatment); March 24 to 31; April 24 to 28; May 26 to June 3; July 2 to 7; and August 6 to 11. We conducted an additional monitoring September 18 to 25; however, bees foraging at the tubes removed large quantities of sugar water so the September data were discarded.

**2016 field season:**

**GRANULAR BAIT TRIAL:** Based on results of our 2015 trials (described below), we eliminated both Altrevin and Extinguish ant baits from our 2016 trials, focusing solely on Seduce (0.07% spinosad)—the product that was most efficacious in preliminary trials. We selected 5 experimental blocks (in the Oakville and Rutherford appellations of Napa Valley AVA), and established split-plot design (bait and untreated) in all blocks. In two of those blocks (designated I1 and I2), Seduce ant bait was applied at a rate of 20 lbs per ac on April 15 and 16. In the remaining three blocks (designated T1, T2, F1), Seduce ant bait was applied at a rate of 28 lbs per ac (slightly higher than the target rate due to challenges with calibration and the spreader equipment) on May 19 and 20; a second application at the rate of 20 lbs per ac was applied in blocks T1, T2 and F1 on June 25 and 27, 2016. The spreader equipment was the same as that used in the 2015 trial. The cooperating vineyard managers made all the bait applications.

We monitored ant activity pre- and post-application using cotton balls (Fisher Scientific) soaked in 25% sucrose solution. Ant activity was measured once every 2 weeks. Forty-five or fifty vines per treatment per block were selected as monitoring vines. One saturated cotton ball was deployed on each monitoring vine, either on the ground (early season) or on the vine (after fruit set), depending on where the ants were predicted to be most active. After 2.5 to 3 hours, cotton balls were retrieved from each monitoring vine, and ant activity on the cotton ball was assessed using a 0 to 3 scale where '0' equals no ants, '1' equals the presence of 1 to 10 ants, a value of '2' is assigned to cotton balls with 11 to 50 ants, and a rating of '3' assigned for the presence of greater than 50 ants.

**POLYACRYLAMIDE GEL BAIT TRIAL**:
Based on a pilot study that eliminated >99% of ants from treated plots in the California Channel Islands (Boser et al. 2014), and a preliminary vineyard study conducted by the Principal Investigators in 2015, we are evaluating the efficacy of a polyacrylamide gel bait formulation in vineyards. We established three experimental blocks (split-plot design: treated and untreated treatments); two of these blocks (designated C1 and C2) are located in the Carneros appellation (Napa Valley AVA) and one (designated M1) is located in the St. Helena appellation. Blocks C1 and C2 are populated with the invasive vine mealybug; block M1 is populated with the native grape mealybug (*Pseudococcus maritimus*). In addition to the economic damage sustained by VMB populations, the spread of grapevine leafroll-associated virus 3 (GLRaV-3) is a major concern in all of these blocks.

The bait solution consists of 0.0006% thiamethoxam (Platinum insecticide, Syngenta US) in 25% sucrose solution, deployed at a rate of 10 lbs. per ac in polyacrylamide Water Storing Crystals (MiracleGro®). These crystals absorb water and water-soluble chemicals, and when hydrated present a thin layer of liquid bait solution on the surface for 24 to 72 hours following application. To allow sufficient time for the crystals to absorb the bait solution, they were added to the mixture 24 hours prior to the application. The hydrated crystals were deployed using an 85 lb tow spreader (Agri-Fab, model #45-0315) pulled with an all-terrain vehicle (ATV). Bait applications were initiated once foraging ants were detected at sugar-soaked cotton balls. The cooperating vineyard manager made the bait applications on March 16 and April 14 in blocks C1 and C2, and on April 15 and May 26 in block M1. Because block M1 is in a more northerly location within Napa County, ants did not become active until later in the season (ant foraging is reduced below 60 F (15 C)). Ant monitoring pre- and post-application followed the method described previously, using cotton ball soaked with a 25% sucrose solution.

**RESULTS:**
**2015 COMMERCIAL BAIT TRIAL**: Ant feeding activity is reported as grams (g) of sugar water removed from monitoring tubes per day (Figure 2). During the February and March monitoring periods (pre-treatment and 10 days after the first treatment, respectively) ant feeding activity was not significantly different across all treatments. This is not surprising since we blocked for consistent ant populations prior to treatment; also, and most importantly, baits have delayed toxicity and would not be expected to control populations so quickly (10 days) after application. During the April 24 to 28 monitoring period, feeding activity was significantly reduced in the Seduce bait treatment (Tukey's pairwise comparison, $p=0.0099$); this is roughly 6 weeks after the first bait application and 1 week after the second. From May 26 to June 3, feeding activity in the Seduce treatment (-0.007 +/-0.12 g per day) was reduced compared to other treatments (0.52 to 0.92 +/- 0.35 to 0.55 g per day), although the difference was not statistically significant due to the high variability in ant feeding—particularly in the Altrevin and untreated blocks. During the July and August monitoring periods, ant feeding was low to none in all treatments. In other ant bait trials, we have detected similar feeding lulls at our monitoring tubes during the summer (Daane et al. 2006, 2008a). We did not see any differences in population suppression between the powdered sugar-coated bait and those protein-based baits without powdered sugar. Since the sugar is not an inert ingredient of the bait, it may not adhere well to the bait. It could have been removed during the application process or not durable in the field. At this point, there does not appear to be a measurable

improvement in bait performance through the addition of the powdered sugar under these conditions. And adverse effects were noticed as the sugar heated (and melted) in the spreader, thereby clogging the mechanisms of the spreader that impacted application efficiency and necessitated additional disassembly/cleaning time. Overall, the collaborating vineyard manager concluded that the Seduce bait was the easiest to apply; we attributed this to weight and consistency of the bait as well as application rates (higher rates made the applied bait more visible, and therefore easier to calibrate the spreader and adjust drive speeds).

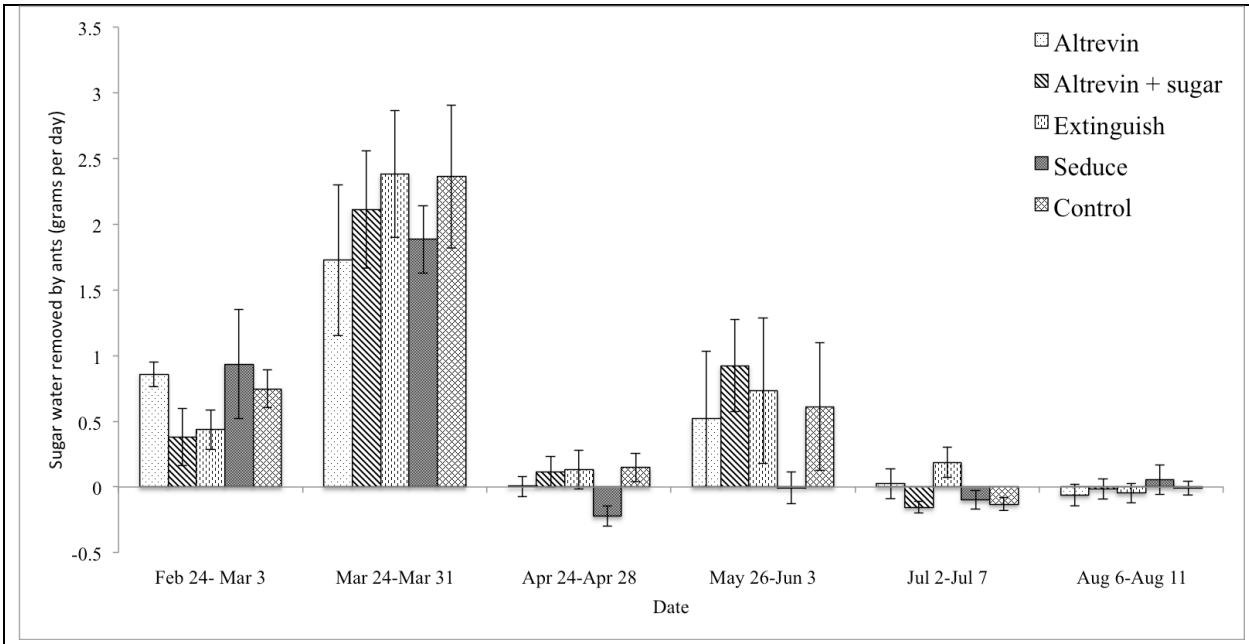


Figure 2. Average sucrose water removed (grams per day) from monitoring tubes by Argentine ants, during six monitoring periods in a Chardonnay vineyard (Carneros AVA) in 2015. Results are reported for each bait treatment and the untreated control. During the April 24 to 28 monitoring period, feeding activity was significantly reduced in the Seduce bait treatment (Tukey's pairwise comparison, p=0.0099). On all other dates, there were no significant differences among treatments.

**2016 GRANULAR BAIT TRIAL:**

Due to some challenges with site selection, the first bait applications in blocks T1, T2 and F1 occurred later (May 19 and May 20) than would be desired to optimize results. In blocks I1 and I2, bait applications were initiated early in the growing season (April 15 and 16), and within 14 days of the time when ants were reliably detected and temperatures were adequate for foraging to occur. On May 6, we detected reduced foraging activity in blocks I1 and I2, in the bait treatment (Figure 3). However, by June 3 (7 weeks after application), there was no difference in ant activity between treatments in these blocks. In block T1, ant activity was reduced immediately after bait application, however ants were detected in the baited treatment on June 10 (22 days post-application), although populations remained lower than in the untreated control. In T2, ants were detected in the treated plot on May 27 (7 days post-treatment) and had rebounded to levels no different from the control plot by June 10 (22 days post-treatment). These results suggest that multiple applications of Seduce may be necessary to obtain adequate control of Argentine ant populations. Alternately, it is possible that a higher product rate may be more efficacious over a longer period. Both options should be explored in future studies.

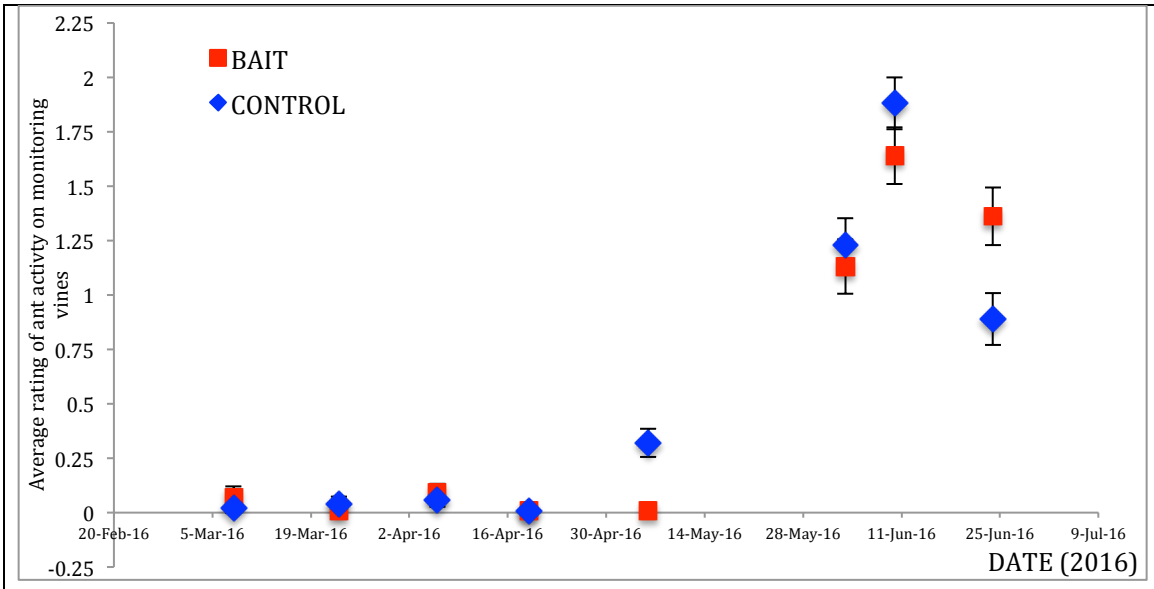


Figure 3. Ant activity at monitoring vines for blocks I1 and I2. Monitoring activity was rated on a 0 to 3 scale, at a total of 90 vines per treatment. Data are presented as the average of the ratings for all vines, by treatment. Seduce (0.07% spinosad) was applied on April 15 and 16, 2016 at a rate of 20 pounds per acre. Ant activity had rebounded by 7 weeks after treatment.

**2016 POLYACRYLAMIDE BAIT TRIAL**: In blocks C1 and C2, ants were present in pre-treatment monitoring conducted on February 26 and March 8, so the first bait applications were made on March 16. By March 23, ant activity in the baited blocks was lower than the untreated blocks. Ant activity has remained low in the baited blocks. On 3 monitoring dates (April 15, April 28, May 11) we detected no ants in the baited areas. By May 30, ants had begun to reinvade the treated blocks, although populations remain much smaller than in the untreated areas. Given the invasion biology of the Argentine ant, and that each untreated area is a large, proximal source of ants, it is not surprising that they have begun re-colonizing the baited areas. Large-scale, area-wide treatments (such as those conducted in the California Channel Islands (Boser et al. 2014) could be expected to be more successful as they would leave fewer population pockets from which ants could re-invade. Future studies should concentrate in this area.

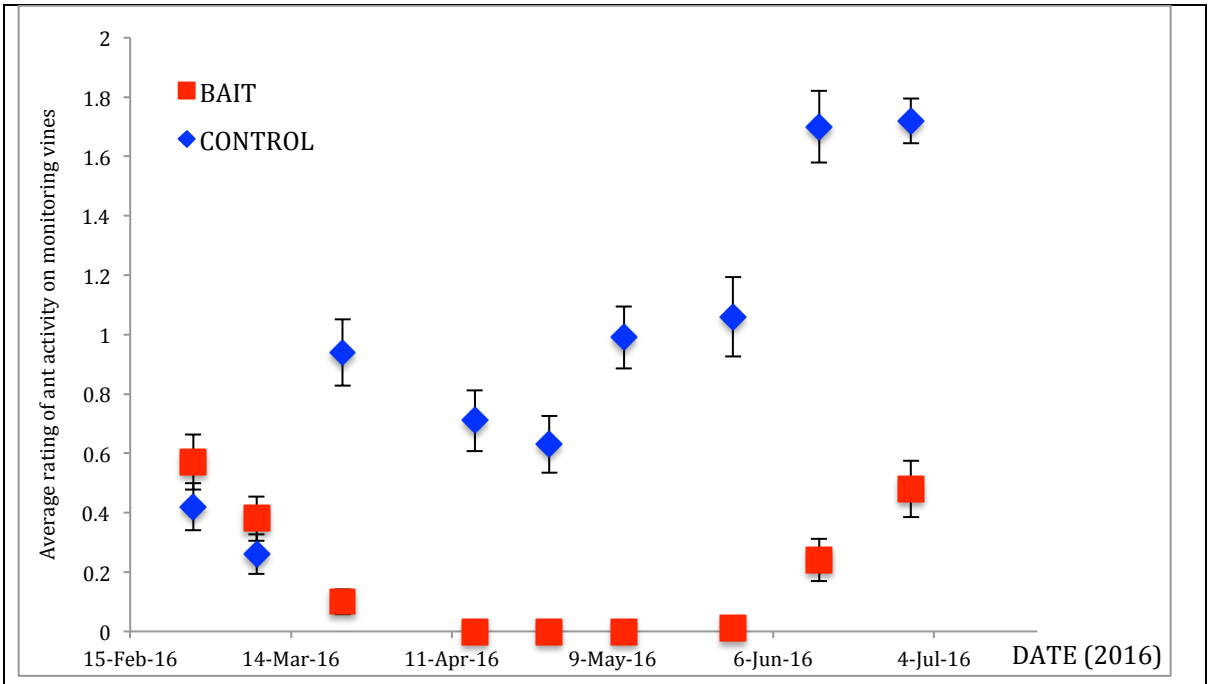


Figure 4. Ant activity at monitoring vines for blocks C1 and C2. Monitoring activity was rated on a 0 to 3 scale, at a total of 90 vines per treatment. Data are presented as the average rating for all vines, by treatment. Thiamethoxam (0.0006%) in polyacrylamide crystals was applied on March 16 and April 14, at a rate of 10 pounds of bait per acre.

**PUBLICATIONS & PRESENTATIONS**: We have not produced any publications because we aim to collect at least 2 years of data prior to publication. We presented results from the 2015 growing season trials, on November 3, 2015 during the **Continuing Education Seminar Series** organized by Napa County Farm Bureau, Napa County Agricultural Commissioner, and UC Cooperative Extension. The session was held in Yountville, CA and attended by 130 grape growers, vineyard managers and pest control advisers. We are also scheduled to present our results at a March 17, 2016 regular meeting of the **Sonoma County Vineyard Technical Group**.

**RESEARCH RELEVANCE STATEMENT:** We are evaluating a granular bait product and an experimental polyacrylamide gel product for control of Argentine ant populations in coastal California vineyards. Because Argentine ants disrupt biological control of VMB by interfering with the activity of predators and parasitoids, control of Argentine ants can be an essential component of IPM programs for VMB. Baits that can be broadcast with an ATV-mounted spreader are a more manageable alternative to the current stations with liquid bait used in vineyards. Handling and distribution of these baits is simpler and than liquid baits that must be contained within bait stations. Additionally, Argentine ant nests are typically multiple and widely dispersed throughout agricultural ecosystems in the spring, summer and fall (Markin 1970) so multiple point-sources make bait more accessible to all nests within an infested area (Boser et al. 2014). Our results suggest that one of theses baits have the potential to control populations of Argentine ant, particularly early in the growing season (April and May). This is also a critical period to control VMB because early-season population control—while the fruit is developing—can reduce pest pressure later in the season. Later-season VMB populations are more likely to cause economic damage by infesting and soiling the fruit, thus subjecting it to potential rejection by the processor.

**LAYPERSON SUMMARY:** Vine mealybug is a destructive pest in California vineyards; it contaminates fruit and reduces vine health and productivity. Grape growers may use multiple tactics (IPM) including insecticides, mating disruption and biological control, to achieve control of VMB populations. Argentine ants are invasive insects common in coastal California vineyards. Ants disrupt IPM programs for VMB because they interfere with the activity of a parasitic wasp that attacks VMB. Ant baits are an effective approach to manage ant populations while minimizing impacts on non-target organisms. We are investigating the potential of commercial and experimental bait products to control Argentine ants in vineyards. Baits were either broadcast (experimental bait) or applied under the vine with a modified broadcast spreader in spring 2016. Ant populations were monitored every 2 weeks from February through July. Both baits are demonstrating some potential to reduce ant populations. The experimental bait appears to be more effective, over a longer period of time than the granular bait.

**STATUS OF FUNDS:** We have expended funds primarily as Salary/Benefits for two research assistants working on this project. We support .20 FTE for each assistant from these funds. We have also expended funds to buy sugar and other supplies to monitor ant activity.

**INTELLECTUAL PROPERTY**: There are no intellectual property issues associated with this project. We are evaluating commercially available ant bait products.

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