Final Report

Central Coast Vineyard Team Pesticide Reduction and Identification of Source Mitigation (PRISM) Project

Central Coast, California

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2.0 Grant Summary Page

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4.0 EXECUTIVE SUMMARY

The primary goals of this project were to increase awareness of the environmental impacts of pesticides, show alternative practices to high risk materials, and measure the effectiveness of the alternative practices through trials and demonstrations.

Several research and demonstration sites were selected and addressed the following issues: reduced risk management strategies for the control of mealybug populations, weed management strategies to reduce the reliance on high risk herbicides, best management practices to mitigate the movement of soil and water, and qualifying the movement of certain high risk material in surface water runoff.

Staff developed 13 sites for this project addressing reduced risk mealybug/ant control (organophosphate mitigation); alternative weed control (simazine mitigation); and erosion control practices. Plans for each project were site specific and were developed through the assistance of the University of California Berkeley, California Polytechnic University of San Luis Obispo, University of California Cooperative Extension, Department of Pesticide Regulation, local growers, and other industry representatives. Various evaluation methods were used: photo documentation, pest and beneficial insect monitoring; utilizing quadrats and transects to evaluate weed densities; and collection of natural and simulated rain runoff.

Mealybug Management Projects – Alternatives to Organophosphate

There are currently three high risk materials (in terms of chemistry and potential for water contamination) registered for use on the mealybug/argentine ant complex (Lorsban, Lannate, and Dimethoate). Currently, there are four reduced risk insecticides on the market (Admire, Venom, Applaud and Fuji Mite). CCVT project evaluated and demonstrated the use of reduced risk materials, beneficial insects, vegetative insectary plantings, and new ant bait technology, and combinations of these, each as an alternative to the organophosphate treatments.

Staff compared mealybug levels and crop damage with replicates using Applaud (active ingredient: buprofizen) and EF300 (a plant extract based insecticide) in a replicated trial. But due to the patchy and inconsistent population levels and densities throughout the trial block and the relatively low pest levels, results were not conclusive because measured crop damage at harvest was minimal for all treatments. Nevertheless, the lessons learned indicate that mealybug presence does not necessarily predict crop damage, so chemical treatments may not be necessary.

In addition to the evaluation of chemical control methods, several biological control methods were evaluated at several project sites. As a generalist predator, the green lacewing (*Chrysoperla rufilabris*) is a common biological control insect used to control a wide variety of insect pests. Staff released green lacewing eggs (20,000 eggs per acre) twice during the season at one site. Populations of mealybugs and lacewings were evaluated on a weekly basis to evaluate establishment and control of mealybugs. During initial sampling there was no indication that the green lacewings had established. After the second release, the cards upon which the eggs were attached were closely monitored to see why green lacewings were not establishing. After checking on the cards several hours after the release, staff realized that argentine ants were removing and eating the eggs on the card. This experience showed that the control of mealybugs with green lacewings released as eggs on cards is not plausible if there is an established population of argentine ants in a vineyard.

A more specialized predator known as the mealybug destroyer (*Cyptolaemus montrouzieri*) was also evaluated at two vineyards for its ability to control mealybugs. Staff established two demonstration sites to evaluate the ability of the mealybug destroyer to establish with and without the presence of argentine ants. Argentine ants were excluded from vine through the implementation of adhesive barriers around the vines. Weekly sampling indicated the mealybug destroyer had success establishing on vines with argentine ant exclusion.

Staff implemented several project sites at which ant bait stations were set up to control argentine ant populations, thereby increasing the possibility of biological control of mealybugs. The ant bait stations used in this project were designed by researchers at the University of California Berkeley and consisted of a PVC pipe container with a boron based liquid bait placed inside of the container. Project cooperators installed 205 stations at three sites consisting of 15 acres.

At Cal Poly Chorro Creek Ranch Vineyard, staff established an integrated mealybug management plan involving 40 bait stations and an insectary buffer to promote beneficial insect activity. The insectary bordered the project site and was approximately 400 square feet in area. The cooperating grower was so pleased with the activity of ants around the bait stations, that he has continued to use the practice and has moderately expanded the number of stations used. The grower at this site is an employee of a large wine producer and vineyard management company. Therefore, if the company finds this practice successful and economical, the inclination to adopt this practice over a significant amount of acreage with similar ant control problems is increased.

At Sierra Madre Vineyards, just east of Santa Maria California, in cooperation with CCVT staff, a grower constructed 150 ant bait stations and placed them over 10 acres where the mealybug argentine ant complex had become a problem. The grower at this site was satisfied at the ease of establishment and activity of the ants at the bait stations.

At the Cal Poly Student Vineyard in San Luis Obispo CCVT project staff coordinated the implementation of approximately 15 bait stations over a two acre site to evaluate the effectiveness of a new material called Vitis from Bayer. This project site was arranged at the end of this project and evaluations are currently being conducted by students at Cal Poly, San Luis Obispo. This site will be an excellent tool to teach students, who will soon be new growers, about this reduced risk method for ant control.

In addition to the three sites above, three more sites with a previous history of high risk chemical use implemented monitoring programs to evaluate mealybug populations throughout the season. The monitoring at these sites provided growers with detailed information on pest populations. This, in turn, saved them time and money and provided assurance that there was not a significant pest problem. Providing a sound understanding to the grower of the status of their pest pressure ensures that blanket approaches to their pest management strategies are avoided. This equates to economical savings for the grower and an environmental benefit through the reduction of chemical applications in the vineyard.

Weed Management – Alternatives to Simazine

Simazine, a pre-emergent herbicide linked to ground water contamination, has been found in California drinking water sources since the early 1990's. The increased focus on simazine is due to its potential threat to aquatic organisms and its increased usage in agricultural systems over the past few years.

Staff worked with three participating growers to evaluate the effectiveness of alternative methods for the control of weeds in vineyards. The weed control methods evaluated included Simazine, acting as the control; Flumioxazin (commercial name is Chateau), serving as the chemical alternative; under row cultivation; an under row cover crop; and no weed control where the weeds were allowed to grow throughout the season.

Each site varied in the number of practices evaluated as the level of participation was different for each of the growers. Each site was different in location, soil type and weed pressure. Therefore each of the different weed management strategies worked differently at each site.

Chalk Knoll Vineyards. This site evaluated the effectiveness of the two chemical herbicides and cultivation. The two herbicides worked very differently. Simazine was very effective through much of the season. It controlled a wide variety of weed species and kept the over all number of weeds to a manageable level. Flumioxazin performed poorly at this site providing a very low level of control. Flumioxazin allowed one species of weed to grow, and this weed dominated throughout the growing season. The cultivation practice worked well throughout the season, but required three passes throughout the season to keep weed populations at a manageable level.

Hog Canyon Vineyards. CCVT staff evaluated the two herbicides on their ability to control weeds at Hog Canyon Vineyards. Both simazine and flumioxazin controlled weeds well at this site. Flumioxazin controlled more weeds and more species of weeds for a longer duration than simazine.

Sunnybrook Vineyards. Sunnybrook vineyards evaluated all five of the weed control strategies. Both of the herbicides performed similarly throughout the season. However, flumioxazin preformed slightly better that simazine towards the end of the season. The cultivation treatment was operated once during the growing season and had an effect in reducing the number of weeds after the pass. Unfortunately, the one pass did not provide control for the rest of the season. Weeds re-emerged some time after the pass to place. However, it should be noted that the yields in the cultivation treatment were not impacted when compared to the herbicide treatments. The under row cover crop generated a significant amount of vegetation. This vegetation, underneath the vine row, highly suppressed the growth and the yield of the vine. The weedy plot acted as the control. Weeds were allowed to grow throughout the growing season and were not treated with any herbicide or cultural practice. The presence of weeds affected the growth of the vines the most. The growth weedy plot reduced vine yield and vine biomass the most compared to all the other treatments. In addition to evaluating the weed and vine growth at this site, arthropod activity was monitored in association with the different weed management strategies. Evaluations showed treatments with greater amounts of vegetations (the under row cover crop and the weedy plots) had the greatest amount and most diverse number of insects.

Erosion Control

Many vineyards on the Central Coast of California are planted on sloped hillside properties that are prone to erosion during the rainy winter periods. The eroded soil can decrease the quality of the water by increasing turbidity and potentially moving nutrients and agrichemicals into the waterways. Several project sites address issues surrounding erosion control.

Terrace Management. Bowker Vineyards implemented several BMPs to reinforce the terraces in his newly purchased vineyard. The vineyard manager reinforced the terraces by spreading grass seed over the slopes, then covering the newly seeded slopes with jute netting. This ensured that the seed and soil stays in place during windy and rainy periods before the seed has a chance to germinate.

These terraces have very little visible erosion due to these BMPs. The BMPs implemented here have the potential to last a significant number of years if properly maintained.

Road Management. Wolff Vineyards addressed a hillside road. The soil used to re-grade the road before the storm was extremely loose and dry. Mr. Wolff had concerns about how the newly placed soil would sustain the winter weather. It was then decided to broadcast a low cost erosion control seed mixture over the road which was then covered with rice straw provided by the Californian Conservation Corps. The BMPs implemented at this site were very effective and were able to withstand the storms that passed through during the winter. The grasses that were planted were able to establish and will continue to provide structure and erosion control for seasons to come.

Filter Strips. Hog Canyon installed filter strips, five to eight feet in width, comprised of barley and ryegrass throughout his vineyard. The filter strips were planted on roads that were on the down slope of the ranch. The roads also surround the outer edges of the vineyard that borders a habitat that surrounds a riverbed. The filter strip has two strips of grasses planted, one on either side of the road, with the middle remaining bare. The filter strip closest to the vineyard was eight feet long, and the filter strip on the outer edge of the row was approximately five feet long.

Water Runoff Studies – Simazine and Chlorpyrifos

Staff established several projects to evaluate the movement of Simazine and Chlorpyrifos in surface water runoff in Central Coast Vineyards during storm events. Staff established two sites to measure in field surface water runoff for simazine, a pre-emergent herbicide. Plastic tubs were placed on the bottom of slight slopes in plots that had been treated with simazine and in plots that had not been treated with simazine. Grab samplers were utilized to grab water samples during storm events. Water was then collected and evaluated for the amount of simazine in the water. Throughout the sampling period, the storm events were not big enough to produce sufficient amounts of runoff water consistently between plots, and between the two sites. Only one site during one storm event produced enough water to evaluate the movement of the target material during three storm events. However, the data obtained was from only one replicate, and was therefore not sufficient to make any conclusive evaluations.

Because of these obstacles, the project technical committee decided to build a rainfall simulator. The rainfall simulator allowed CCVT project staff to generate artificial storms in a controlled environment in order to obtain consistent data which in turn helped characterize the movement of the target material at a particular site.

During the months of March and April 2007, significant progress was made on the monitoring of surface water runoff for the presence of chlorpyrifos and simazine at two different sites. Both sites varied in their location, slope, percent ground cover, and soil structure. The first site was located in Edna Valley in San Luis Obispo, California. The vineyard in Edna Valley was monitored for the presence of chlorpyrifos. The second site was located on the east side of Paso Robles, California. This site was utilized to monitor the presence of simazine in the surface water runoff. Both sites indicated that the target materials were present in the surface water runoff during simulated storm events. The amounts of water running off the two sites were different due to the varying characteristics of each site.

The concentration of chlorpyrifos in the surface water runoff at each site did not reach levels of environmental concern during a one hour, 100 year simulated storm event. However, after the material was applied to the Edna Valley site, there was approximately 1.4 inches of rainfall which prohibited staff from entering the field and conducting the rain simulation. This washed away a majority of the target material that CCVT project staff would have collected during the simulated storm event. Nevertheless, there was chemical runoff and this information was an important point in outreach efforts to communicate that application timing is a critical management factor for mitigation.

During a one hour 100 year storm on a hillside vineyard on the east side of Paso Robles, the concentration of simazine in the surface water runoff reached levels of concern for aquatic insects and aquatic plants according to the Environmental Fate and Effects Division of the Environmental Protection Agency. However, there are several factors that need to be taken into account. This is a small scale study with no dilution effect taking place. This suggests that the concentration is likely to be higher than would occur in a natural storm event (Sharply and Kleinman 2003). The concentrations of simazine in the surface water runoff at this site need to be interpreted carefully. At first glance, these concentrations might appear to be high, but through careful interpretation, these levels, even under a worst case scenario, may not be a significant threat to the environment.

Outreach and Education

Central Coast Vineyard Team published fourteen articles and publications circulating to 308,000 people, hosted 65 educational events with 2,617 attendees representing 582,036 acres, conducted tailgates and workshops in San Luis Obispo, Santa Barbara and Monterey Counties, attended 40 community events with 56,715 attendees and participated in 20 winegrape industry events with 37,191 attendees. Central Coast Vineyard Team attended 14 youth events reaching 16,790 children.

5.0 PROBLEM STATEMENT - RELEVANT ISSUES

Winegrape growers apply chlorpyrifos to control argentine ant and mealybug populations in Central Coast vineyards. Controlling mealybugs is essential for the production of salable winegrapes; and controlling argentine ants is critical for the reduction of mealybug populations. Chlorpyrifos is generally applied in two ways: at post harvest to reduce over-wintering mealybugs and argentine ants, or as a dormant season application in early spring to reduce the over-wintering stage of mealybugs. The dormant season application likely poses the highest threat to water quality, as it is applied during a time of year where the possibility of a rainfall event after the application is greatest. Growers use chlorpyrifos because it is a low cost, effective material. However, chlorpyrifos is a restricted use pesticide and a biological endocrine disruptor that has been linked to adverse biological effects in animals and aquatic organisms. It is being found in several water bodies where production agriculture is located. Due to the spread of vine mealybug and the argentine ant, coupled with the expanded registration of this material for the control of these two species, the use of chlorpyrifos has increased significantly in the Central Coast over the past few years and nearly doubled in the pounds applied from 2003 to 2004.

However, there are alternative insecticides (Admire, Venom, Applaud and Fuji Mite) that are not biological disruptors and do not present a threat to water quality. But the use of these materials is limited because of their cost and need for precise application timing.

There are also several biological control agents such as green lacewings and mealybug destroyers that can either be introduced into a vineyard or naturally occur within a vineyard. As mealybugs feed on the surface of the leaf and on the fruit, honeydew is produced. This honeydew is a sucrose-based solution that is an excellent food source for argentine ants. The argentine ants feed on the honeydew from the ants, and in return, the argentine ant provides mealybugs protection by preying on potential predators and parasitoids. This symbiotic relationship between mealybugs and the argentine ant, make most biological control measures ineffective if the argentine ant is present.

The recent registration of ant bait stations provides an alternative sustainable solution to chlorpyrifos. The ant bait stations are PVC containers that protect the liquid bait solution, and provide a feeding platform for the argentine ants. Due to the infancy of this management strategy and the relatively new introduction of the material, grower adoption has been slow. The integration of several management strategies such as reduced risk chemicals, biological control, and the use of ant bait stations, may provide the best reduced risk alternative to chlorpyrifos for mealybug control. Increasing the awareness of reduced risk strategies such as those mentioned above, and measuring their impact may potentially increase the adoption of these practices.

Chlorpyrifos is not the only chemical used in Central Coast vineyards that have received heightened attention. Simazine, a pre-emergent herbicide, has been a focal point in terms of its environmental impact over the past several years. Despite grower lead efforts to promote herbicide reduction strategies and technologies, over 23,000 pounds of simazine were applied to Central Coast vineyards in 2004. There are many established weed management technologies and techniques that reduce reliance on this herbicide. Due to the potential threat that this herbicide poses to water quality, grower awareness of other management practices needs to increase. Once the effectiveness of alternative management strategies is determined, growers may adopt them in lieu of, or in rotation with simazine.

Many vineyards on the Central Coast of California are planted on sloped hillside properties that are prone to erosion during the rainy winter periods. The potential movement of the soil on these properties can be costly to the grower and to the environment. If the movement of soil stays within the properties it may be costly for the grower. There can also be a significant impact to the environment if the soil moves off site and into nearby water systems. The implementation of erosion control strategies can mitigate the cost of soil relocation to grower and mitigate the movement of soil into nearby waterways. Several of our project sites address issues surrounding erosion control.

6.0 PROJECT GOALS

The Central Coast Vineyard Team's project goals are to extend the information gained from previous projects through the implementation and measurement of the reduced risk management practices at project sites and monitoring of water quality through June 2007.

Project goals include:

- Collect and record data regarding population dynamics of pests and weeds for projects sites. The effectiveness of certain management strategies can be evaluated through data collection at specific project sites.
- Assisting growers in implementing new practices using a collaborative problem solving process. The project will employ a collaborative problem solving loop involving project coordinator, University of California Farm Advisors, University of California Entomologists. California State University Weed Ecologist, Pest Control Advisors, and growers.
- Collect surface water runoff samples during storm events to analyze samples for target pesticides.
- Extend information to winegrape growers within and beyond the Central Coast. CCVT will use its current mechanisms for outreach and education: newsletters, website, industry presentations, educational meetings, on-farm tailgates and industry publications.
- Analyze the pesticide use information for the California and the Central Coast region.

7.0 PROJECT DESCRIPTION

7.1 MEALYBUG MANAGEMENT ALTERNATIVES TO CHLORPYRIFOS

Past University of California and recent Regional Water Quality Control Board studies indicated the harmful impact of organophosphates (OP), such as chlorpyrifos, to Central Coast watersheds. Studies from 2003 to 2005 showed the mortality of several aquatic organisms was attributed to the non-point source pollution of chlorpyrifos from agricultural applications to control pest populations (Anderson et al 2003, Hunt et al 2003, RWQCB 2005).

Central Coast agriculture has a considerable proportion of its acreage appropriated for vineyards. Winegrape growers apply chlorpyrifos to control ant and mealybug populations. From 2001 to 2003 chlorpyrifos usage in winegrapes has increased from 4,700 lbs to over 14,000 lbs in San Luis Obispo and Monterey Counties combined. The introduction of vine mealybugs (*Planoccocus ficus*) in winegrape growing areas poses a major economical threat to the industry. There is a symbiotic relationship formed between mealybugs and argentine ants. Mealybugs produce a sweet "honeydew" like substance that the ants feed on and in return, the ants protect the mealybugs from predation and parasitism. Recent registration of chlorpyrifos to control mealybugs and ant populations has likely led to this increased usage of OPs.

Increased reliance on OP for the control of mealybug pests is not a sustainable approach to control mealybug species in Central Coast Vineyards. This type of insecticide not only causes the mortality of the target pests, but also of beneficial insects that control them. There are several reduced risk insecticides currently available on the market that have been shown to be effective on mealybug species. Reduced risk pesticides are so called because they either pose a minimal threat to the applicator or the environment.

The following sections will address several projects looking at alternative methods to control mealybug populations in Central Coast Vineyards. These alternative management strategies to OP's include the evaluation of reduced risk insecticides, biological control insects, and the value of monitoring pest populations.

7.1.1 Reduced Risk Pesticide Trial Background

Reduced-risk pesticides are those that may reasonably be expected to accomplish one or more of the following:

- Reduce the risks of pesticides to human health
- Reduce the risks of pesticides to non-target organisms
- Reduce the potential for contamination of groundwater, surface water or other valued environmental resources
- Broaden the adoption of integrated pest management strategies, or
- Make such strategies more available or more effective
- Reduced risk pesticides are either synthesized chemicals or biopesticides derived from animals, plants, fungi or bacteria. Examples of synthesized reduced risk pesticides are

plant and insect growth regulators, and chemicals that kill the pest but not the natural enemies (www.healthylawns.net).

7.1.1.1 Introduction

Phelps Vineyard, located just south of King City, California has allowed CCVT to use approximately 15 acres of its vineyard to test the efficacy of two reduced risk pesticides in controlling mealybug populations. EF300, an organic oils pesticide from US Agritech, is a new insecticide whose effectiveness on the control of mealybug species in the Central Cost is relatively unknown. This study aims to evaluate the effectiveness of this new material in comparison to buprofizen, a reduced risk material with proved effectiveness in Central Coast vineyards.

7.1.1.2 Materials and Methods

The treatments evaluated were Buprofizen, and EF300 and an untreated control. Each treatment had three replications, each replication consisted of four rows, and each row had 75 vines. Each of the replications had 16 randomly selected vines sampled per visit. Each vine is sampled for 2.5 minutes, where counts of mealybug crawlers, mealybug adults, and beneficial insects were carried out. All parts of the vine (trunk, cordons, spurs, shoots, leaves, and fruit) were sampled during the 2.5 minutes of sampling (Geiger et al. 2001). However, during the growing season, the locations of mealybug populations change with the location of nutrients in the vine. Therefore, early in the season, when there was little foliage, sampling was focused around the trunk and spurs of the vine as this was were the majority of the mealybug population was located. Later in the season, when there was more foliage, sampling was focused in the canopy and around the spurs. Sampling took place on a weekly basis starting in May going through mid-August.

Insecticide applications were timed at maximum emergence and when the most susceptible stage of the mealybug was present. Application of the materials took place on July 21st 2005. Buprofizen was applied at .0525 lbs a.i./acre. EF300 was applied at 32 oz. per acre. The insecticides were applied separately in different plots within the same vineyard.

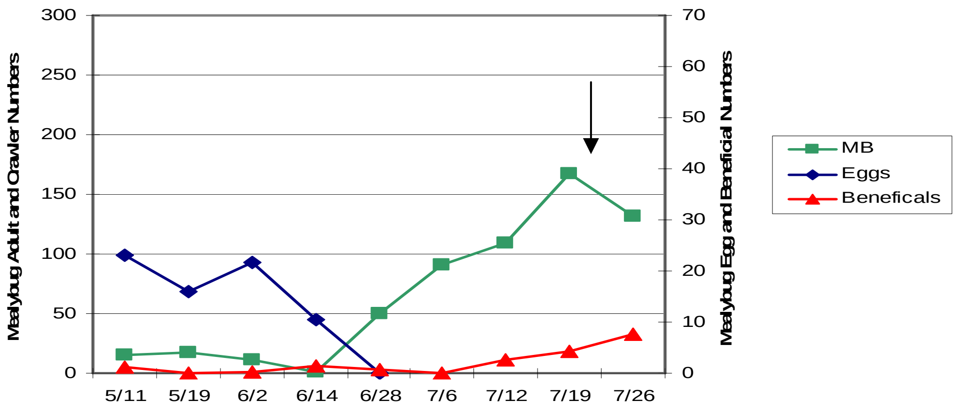
Damage levels were assessed at harvest. For the damage levels, eight vines per row were sampled by randomly selecting clusters from each vine, and rating them on a scale from zero to 3 in terms of mealy bug damage with 3 being unsalvageable and zero having no damage (Geiger et al. 2001).

7.1.1.3 Results

Graph 1 shows the population levels of mealybug eggs, mealybug juveniles and beneficial insects in the different treatments over the course of the sampling season.

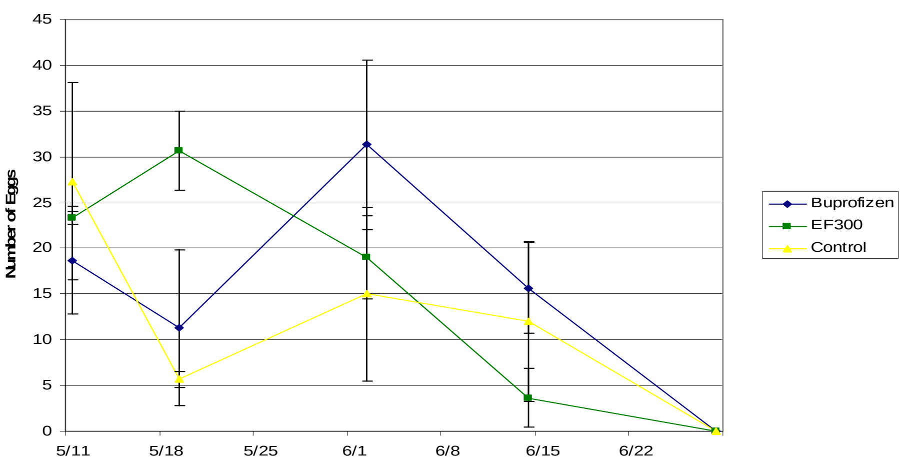
Insecticide application took place on July 21st (indicated by an arrow on the graph). After the treatment we can see a decrease in the number of mealybugs found on the vine. That decrease continues for another three weeks. When the EF300 treatment is compared to the control there is an obvious decrease after the sample date. After the third week of sampling, after the treatment was applied, it was decided to stop sampling as there was no noticeable change in pressure

Graph 1 is a representation of the mealybug egg, mealybug adult and beneficial insect population during the growing season. The blue line represents the egg masses found underneath the bark early in the season. The number of egg mass is on the right Y axis. The red line represents the beneficial insect population over the sampling season. The number of beneficial insects is on the right Y axis as well. The green line represents the number of mealybug juveniles during the sampling season. The number of juvenile crawlers can be found on the left axis.



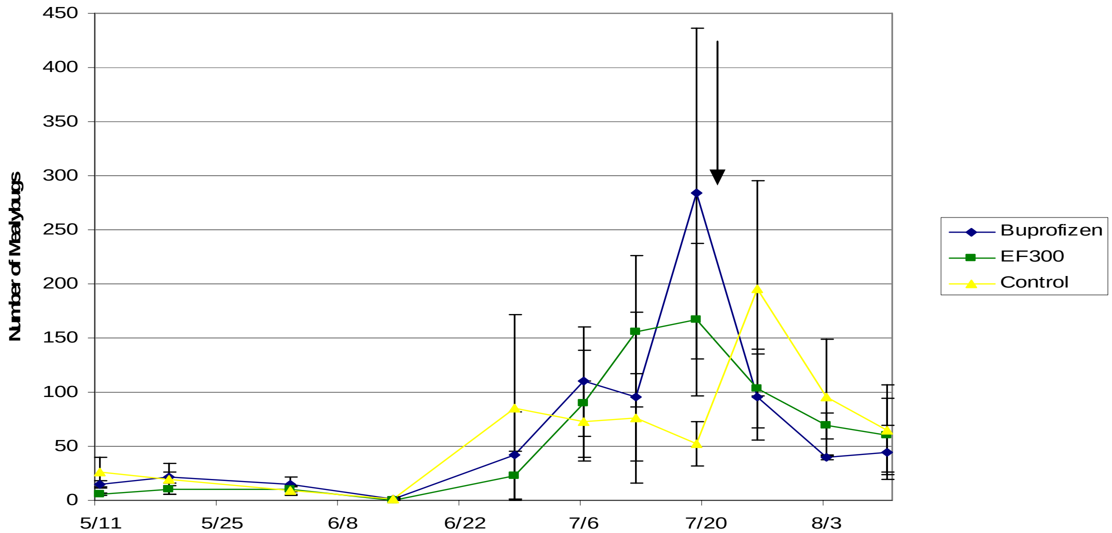
Graph 1. Population levels of mealybug egg masses, mealybug crawlers, mealybug adults and beneficial insects throughout the season at Phelps Vineyard in King City, California in 2005. An arrow indicates the period where the insecticides were applied.

Graph 2 shows the number of egg masses during the growing season. The levels of mealybug egg masses started off high at the beginning of the season. As the season progresses, the number of egg masses becomes less.



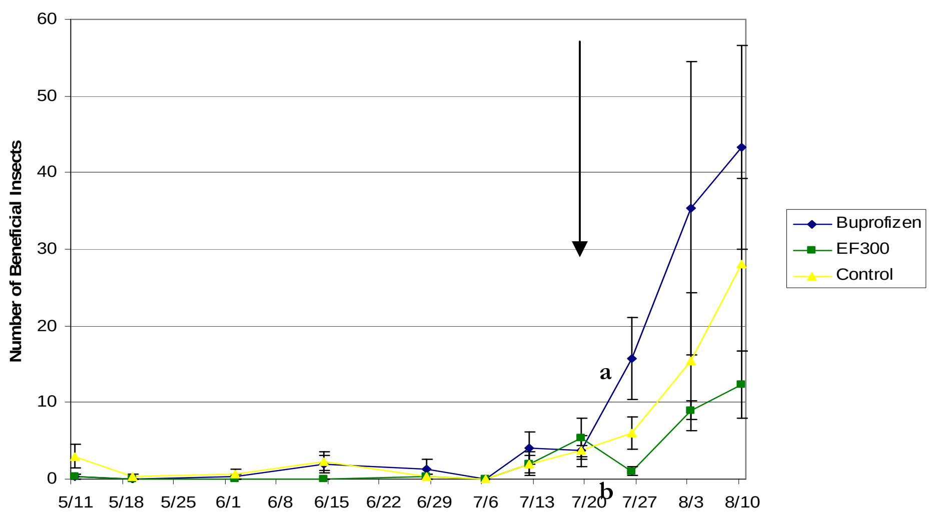
Graph 2. Number of eggs during the season at Phelps Vineyard in King City, California during in 2005. Error bars represent the Standard error of the mean (s.e.m.)

Graph 3 shows the number of mealybug adults and juveniles through the growing season. The numbers of mealybugs were low at the beginning of the season, but as the season progresses, the number of mealybugs increase in all the treatments.



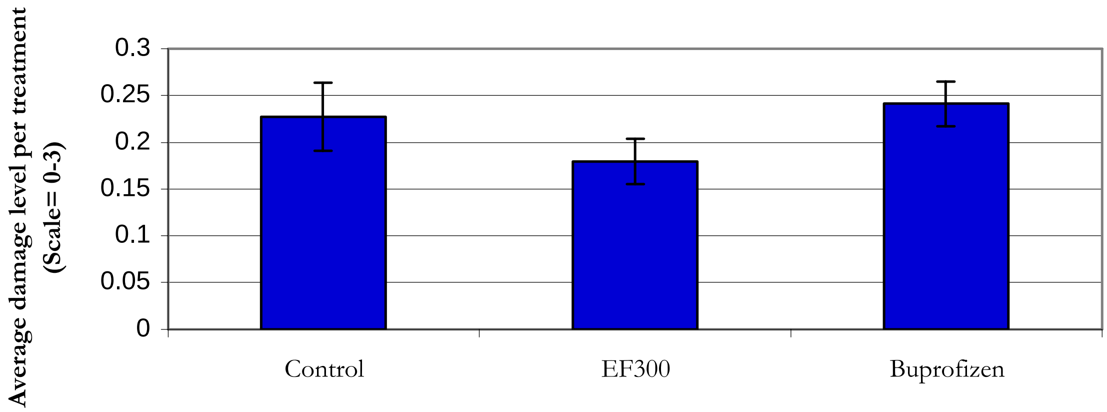
Graph 3. Number of mealybug adults and crawlers during the growing season at Phelps Vineyard in King City, California in 2005. Error bars represent the s.e.m. The arrow shows the point where the insecticide application took place.

Graph 4 shows the number of beneficial insects during the growing season. The number of beneficial insects started off at low levels. As the season progressed, the number of beneficial insects increased. The number of beneficials in the buprofizen plot is significantly higher (P=0.03) than in the control and EF300 plots.



Graph 4. Number of beneficial insects during the course of the growing season at Phelps Vineyard in King City, California in 2005. The arrow indicates when the insecticide application took place.

There was no significant difference in visible fruit damage levels at harvest between the treatments (Graph 5).



Graph 5. Damage levels at harvest caused by mealybug feeding at Phelps Vineyard in King City, California in 2005. The error bars represent the s.e.m.

7.1.1.4 Discussion

Reduced Risk Insecticide: Buprofizen

Mealybug development is directly related to temperature. At the beginning of the year, in the winter, mealybugs lay dormant underneath bark, cracks, and other crevices throughout the vine. During this time many of the mealybugs could potentially die off during very cold winters. Numbers of mealybugs during the winter are generally lower than the summer, due to the cold, and the fact that the previous generation was removed during harvest, as many of the mealybugs were likely in the harvested bunches. During the dormant period, mealybugs are laying egg masses underneath the bark. As temperatures begin to increase, and new shoots are produced on the vine, newly hatched crawlers begin to emerge on this new growth. As this brood feeds, they become adults, and eventually move back underneath the bark on the cordons and new shoots, where they lay more eggs. These eggs will produce the crawlers and adults that will cause the economic damage to the crop the following growing season. Therefore, this is the stage of the mealybug development targeted in this trial.

The mode of action on the two reduced risk insecticides is very different. Buprofizen is an insect growth regulator. This means that when an insect comes in contact with the material, the molting, or growing process is disrupted. Since the growth of the insect is disrupted, the insect dies. Because this insecticide relies on targeting the growth stage of the mealybug, the adults can not be affected. Therefore, the insecticide must be applied to the vine while the juvenile stages of the insect are present. Because this insecticide targets a particular life stage of the pest, application timing is crucial. In order to kill the maximum population, the applicator should likely wait to apply the material at peak emergence of the pest, but also before the juveniles turn into adults. As can be seen in Graph 2, the material was applied at maximum emergence of the mealybugs. After this application there was a decrease in the population of the mealybugs.

Reduced Risk Insecticide: EF300

Botanical insecticides are naturally occurring chemicals extracted from plants. EF300 is a botanical insecticide utilizing several different plant extracts as their active ingredients. These include:

Active Ingredient	Percent (%)of Total Solution
Cinnamon extract	3.5
Citric Acid	3.1
Garlic Extract	1.7
Malic Acid	5.1
Peppermint extract	4.5
Rosemary extract	8.1
Sesame Plant Extract	5.2
Thyme	3.7

The manufacturer claims that the combination of these materials provides an effective delivery system that targets and kills pests on the vine. There is no distinguishable mode of action for this material, which is a common problem with botanical insecticides. However, the majority of the insecticide is composed of oils and soaps form the active ingredients listed above. Therefore, it can be suggested that the material acts as an oil, blocking the respiratory system of the insect, and as a soap, degrading the cuticular structure of the pest. There is a potential for materials with unknown modes of action to kill beneficial insects that are present in the crop as well as on the pest that the grower is trying to target. This type of action could potentially be considered similar to a broad spectrum insecticide. Many other synthetic broad spectrum insecticides kill both the target pest and the beneficials in the vineyard. CCVT project staff hypothesized that this botanical insecticide will work similarly to oils. Oils tend to suffocate the target pest by clogging the airways of the pest upon contact. This is likely what happened in this project. As seen in Graph 1, there is a decrease in the population levels after the treatment of EF300 was applied. The drop in population levels is not as great when compared to the Buprofizen treatment plots. An additional note is the decrease in activity of the beneficial insects in the EF300 plots after the application of the material (Graph 1), which could potentially be due to the broad spectrum activity of this material.

Damage Levels at Harvest

The damage levels at harvest were actually minimal in all of the treatments. None of the treatments, had damage levels greater than 0.3 on a scale from 0 to 3 (Graph 5). The minimal damage levels at harvest could potentially be due to relatively low population levels throughout the plot.

Comparison of Reduced Risk Materials to the Control

Both of the plots that received an application of reduced risk insecticides saw a decline in their populations after the treatment occurred. In comparison, the control plot had a spike in the population levels after the materials were applied in the other two plots. This could be an indicator that the application of the two materials had an effect on the population levels of the mealybugs. However, what should be noted is the decrease in the population levels within the control plots after the previous spike in the population levels. This decline is likely due to the movement of the mealybugs to the interior of the clusters. This could potentially be the cause of the decline in the visible population levels in the two reduced risk material plots. Because the spike in population levels occurred sooner than the control plots, the movement into the clusters could have occurred sooner than the control plots. The counterpoint to this is that CCVT project staff saw dead mealybugs during the sampling period after the application occurred. Therefore, CCVT staff concluded that the reduced risk insecticides did have an effect on the mealybug populations. Although the reduced risk materials had an impact on the population levels at harvest, they did not minimize the damage on the grapes caused by the mealybugs. It is likely that the population levels at this project site were not large enough to produce a difference in the results for damage levels at harvest.

Beneficial Insect Activity

In Graph 1, the mealybug activity throughout the test plots is shown here. Of particular interest is the activity of the beneficial insects coinciding with the maximum emergence of the mealybug species in the vineyard. The more pests that are present during the sampling period, the more beneficials become present. What should be of interest to the grower is that the beneficial species are actively feeding on the mealybug species. Therefore, the grower should tailor their pest control program around the use of materials that would have a minimal impact on the beneficial populations.

Potential Issues With the Data

There is a significant amount of variability with the data. This makes it difficult to come to any solid conclusions. This can be explained by the variability of pest populations on the field level. It was impossible to control for pest populations in the field, so initial levels were inconsistent within the replicates.

7.1.2 Mealybug Management Demonstration Sites

Insect pest control can be defined as the application of technology, in the context of biological knowledge, to achieve a satisfactory reduction of pest numbers or effects. The technological aspect includes tools such as insecticides, biological control, cultural methods, and the equipment used to apply them. Biological knowledge allows us to identify where, when, and how to apply the technology (Pedigo 1996).

Integrated pest control attempts to use a combination of suitable control techniques (biological and chemical) in a compatible manner to maintain pest populations below defined economic injury level (Debach 1991).

Part of CCVT's PRISM Project goals is to explore new ways to control mealybug populations. Currently, there are four reduced risk insecticides on the market which are Admire and Venom, both systemic insecticides, and Applaud and Fuji Mite which are foliar insecticides. There are currently three high risk materials registered for use on mealybugs, which are Lorsban, Lanate, and Dimethoate.

Table 1. Information on the materials available for the control of mealybugs species in Central Coast Vineyards. Source: UCIPM Online Accessed June 11, 2007

Commercial Name	**Chemical Name**	**Mode of action**	**Application**	**Species Controlled**
Lorsban	Chlorpyrifos	Organophosphate	Contact	Vine Mealybug: *Planococcus ficus*
Admire Pro	Imidacloprid	neonicotinoid	Systemic	Grape mealybug: *Pseudococcus maritimus* Obscure mealybug: *Pseudococcus viburni* Longtailed mealybug: *Pseudococcus longispinus* Vine Mealybug: *Planococcus ficus*
Venom	Dinotefuran	Neonicotinoid	Systemic	Grape mealybug: *Pseudococcus maritimus*
Applaud	Buprofizen	thiadiazine	Contact	Grape mealybug: *Pseudococcus maritimus* Obscure mealybug: *Pseudococcus viburni* Longtailed mealybug: *Pseudococcus longispinus* Vine Mealybug: *Planococcus ficus*
Fuji Mite	fenpyroximate	mitochondrial electron transport inhibitor	Contact	Grape mealybug: *Pseudococcus maritimus*
Lanate (LV or 90 SP)	Methomyl	Carbamate	Contact	Grape mealybug: *Pseudococcus maritimus* Obscure mealybug: *Pseudococcus viburni* Longtailed mealybug: *Pseudococcus longispinus* Vine Mealybug: *Planococcus ficus*
Dimethoate	Dimethoate 25wp	Organophosphate	Contact	Grape mealybug: *Pseudococcus maritimus* Obscure mealybug: *Pseudococcus viburni* Longtailed mealybug: *Pseudococcus longispinus* Vine Mealybug: *Planococcus ficus*

From Table 1 it can be seen that there are several chemical options for controlling a wide variety of mealybug species in California. However, several of these insecticides pose a potential threat to water quality and other environmental factors.

Therefore, it is important for CCVT to investigate the effectiveness of different mealybug management practices. The following demonstration site focuses on the use of biological and chemical methods for the control of mealybug populations in Central Coast vineyards.

7.1.2.1 Zabala Vineyards - Green Lacewing Release

Zabala Vineyards was monitored for mealybugs during the 2005-2006 growing season in order to assist the cooperating grower in making management decisions for the control of mealybugs based on pest pressure. Throughout the season CCVT staff continually found mealybug populations.

Some sections of the vineyard had high population levels and other sections had relatively low population levels. In cooperation with the grower, it was decided that a chemical treatment was not necessary because the population levels present would not significantly effect the quality of the fruit produced. Therefore, it was decided to implement the release of a biological control agent to determine if a reduction in the population could be achieved.

In consultation with a local insectary, it was decided to release green lacewing (*Chrysoperla rufilabris*) eggs in the vineyard. Green lacewings are a generalist predator that feeds on mealybugs among other species. Green lacewing eggs were released in the vineyard at 20,000 eggs per acre. The eggs are attached to cards that contain a food supplement for the hatching larvae to feed on. The cards also act as a delivery mechanism for the eggs. The eggs were released twice during the end of the growing season based on technical recommendations and pest pressure. The second release was done to augment the first release and ensure establishment. Monitoring after the release of the green lacewing focused on the presence of this species in addition to the mealybug population. After the first release, there were no green lacewings recovered during the sampling period. After the second release, the green lacewing cards were closely monitored due to the lack of recovery at the previous monitoring trip. Upon the monitoring of the lacewing cards, it was realized that ants were feeding on the eggs and the food supplement that were on the cards (Pictures 1 through 3). After about 5 minutes, the cards were covered in argentine ants (Picture 1). After two hours the eggs and the food supplement had been completely cleaned off (Picture 3). After this realization, no further releases were conducted due to the ants feeding activity on the cards. Due to the activity of ants at this vineyard, the biological control method evaluated above will not be effective.

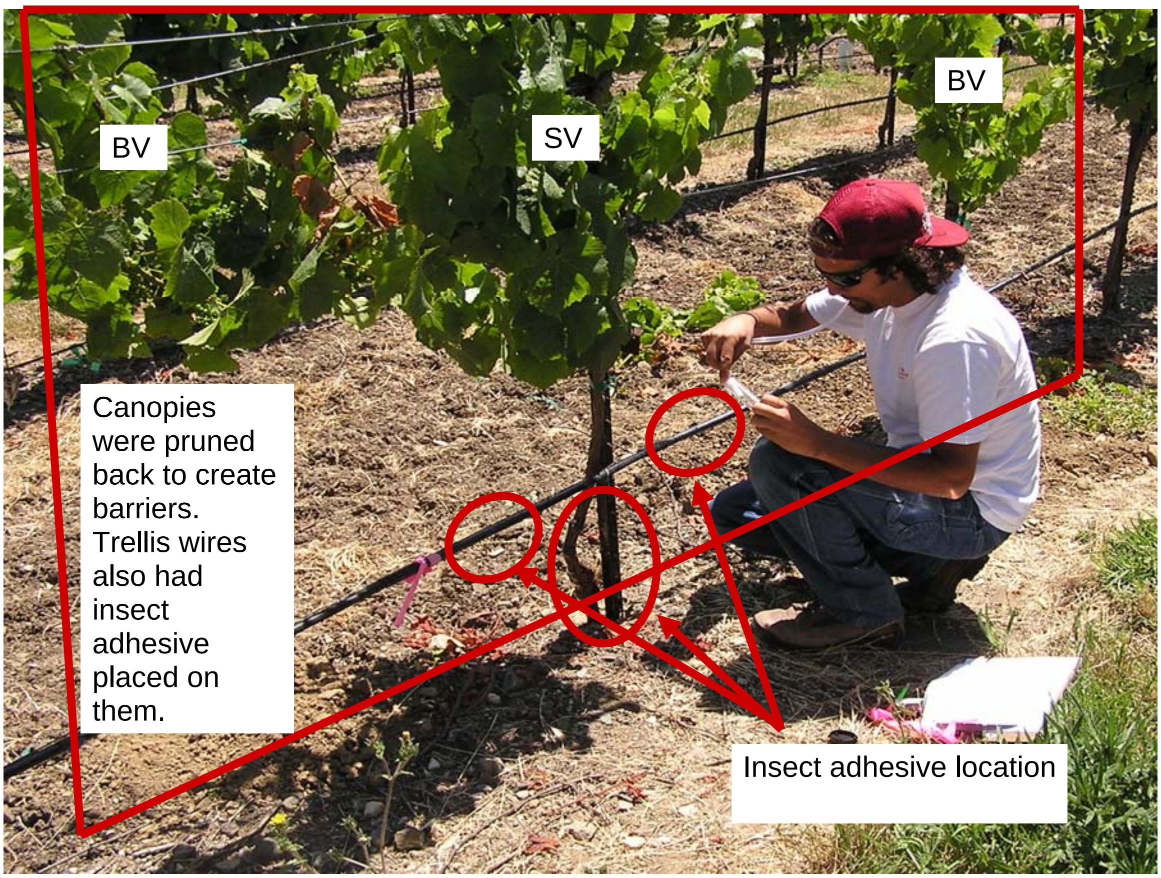
Picture 1. One minute after the green lacewing card was placed on the vine

Picture 2. Five minutes after the green lacewing card was placed on the vine

Picture 3. Two hours after the green lacewing card was placed on the vine

7.1.2.2 Cal Poly and Zabala Vineyards - Mealybug Destroyer Release

Mealybug destroyers (*Cryptolaemus montrouzieri*) (MBDs) are a very effective predator in the larval and adult stages against a variety of mealybug species. The MBD preys on both the eggs, larval and adult form of mealybug species. A characteristic of the mealybug destroyer's juvenile stage is that they look very similar to the mealybug species that it feeds on. Mealybug species produce honeydew when they feed. This honeydew is an excellent food source for argentine ants that reside in the vineyard. The excess honeydew produced by the mealybugs is consumed by argentine ants. Due to the food source produced by the mealybugs, the argentine ants protect them from predators and parasitoids. The advantage that MBDs have over other predators and parasitoids is that it's juvenile stage is ignored by the ants due to the aforementioned physical properties. CCVT project staff evaluated this theory by setting up a demonstration site where small plots either included or excluded ants from the vines. This was done by placing an insect adhesive around the trunks of the vines and the stakes that hold the vine. In addition, the insect adhesive was placed on the trellis wires and the irrigation tube surrounding the vine in order to stop the ants from moving into the plots (Picture 4). CCVT project staff then ensured that there were no ants in the plots that were supposed to have ants excluded from them. Once this was accomplished, MBDs were released in the plots at 15 MBDs per vine. Monitoring then took place over several weeks in order to determine the establishment of these species on the vine in the presence and absence of ants.



Picture 4. This is a diagram of an experimental plot that is excluding ants from the vine. In the diagram BV= a buffer vine and SV= a sample vine, where information on the establishment of the MBD and population information for mealybugs were taken

Picture 5. Mealybug Destroyers come in vials for release in vineyards.

Picture 6. Field Scout Places MBD on the different plots

Picture 7. MBD on a grapevine trunk feeding on a mealybug egg sac

The monitoring at this site continued for several weeks after the release took place. During the monitoring period, several activities would occur. First, ant exclusion sites were monitored to confirm ant absence. If the ants were able to find a path into the plot, that path was blocked with insect adhesive. The next activities included monitoring for mealybug populations and for the recovery of the MBDs.

The information gathered from the site was not conclusive. However, there were several valuable observations that occurred throughout the course of the monitoring period. MBDs were recovered at this site within the experimental plots. No MBDs were recovered from vines that had ants on them. The only recovery of MBDs occurred on the vines that had ants excluded from them.

Even though a vine was considered to be in an exclusion treatment, this did not mean that there were zero ants on the vine. The insect adhesive did a good job in preventing ants from getting on the vine, however, there were some cases where ants were able to make their way onto these plots. In some cases MBDs were recovered on ant excluded plots that had ants on them. In these cases, observations were made that ants were ignoring the larval stage of the MBDs on the vine. This supports the idea that ants ignore the larval stages of the MBDs. What could potentially be deduced from this site is that the adult stages of the MBDs will have difficulty establishing on vines that have a high infestation of ants. The adult phase of the MBD is an important life stage of the MBD, because it is the most mobile form of the insect as it is the only stage that can fly. This means that without the adult form, the spread of the MBD is going to be limited. Additionally, the adult phase is the stage where reproduction takes place. Without reproduction, the establishment of the MBD will not happen. This will result in the need to continually re-release the MBD which is un-economical. The argentine ant (*Linepithema humile*) and mealybug complex makes it very difficult for biological control systems to take effect.

7.5.2.3 Cal Poly - Integrated Mealybug Management Site

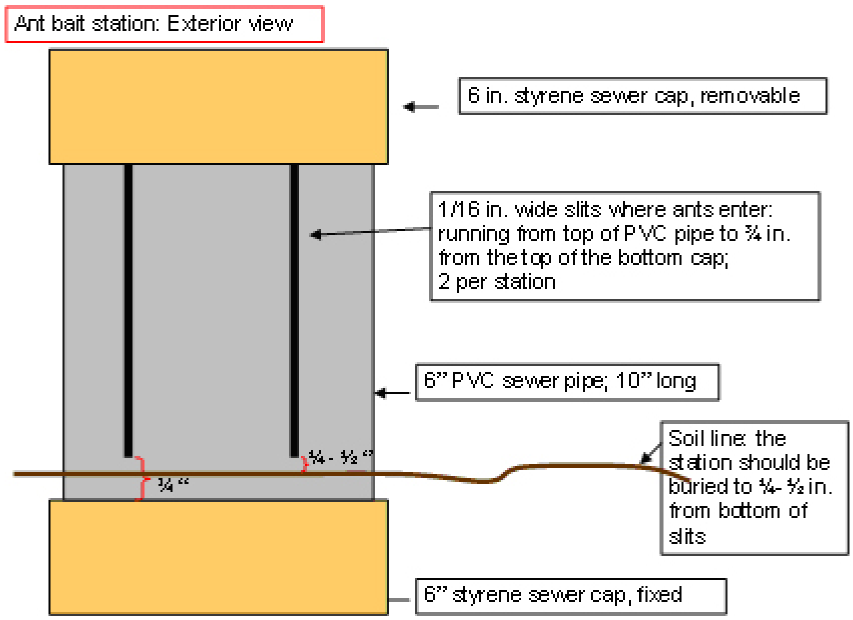
As can be seen in Table 1, there are a wide variety of chemical solutions for the control of mealybug species in Central Coast vineyards. However, even if there are reduced risk insecticides available for the effective control of these species, biological and cultural control methods also need to be practiced in order to make the reduced risk insecticide more effective. A sustainable approach to the management of any pest should not rely strictly on chemicals, even if there are a variety that can be used in rotation. In order to ensure the greatest longevity and success for the control of mealybugs, a diverse range of management strategies should be considered. The initial implementation of some of these strategies may be costly, however in the long term, these costs could balance out as the grower becomes more efficient in their use, and once these practices lessen the reliance on some of the more expensive chemical solutions.

As previously stated, the argentine ant can be extremely disruptive to integrated pest management systems. In order to effectively manage mealybugs to a point where they become less disruptive, argentine ants must be controlled. Once ants are controlled, the potential for biological control systems to be effective are greater than when the ants are present.

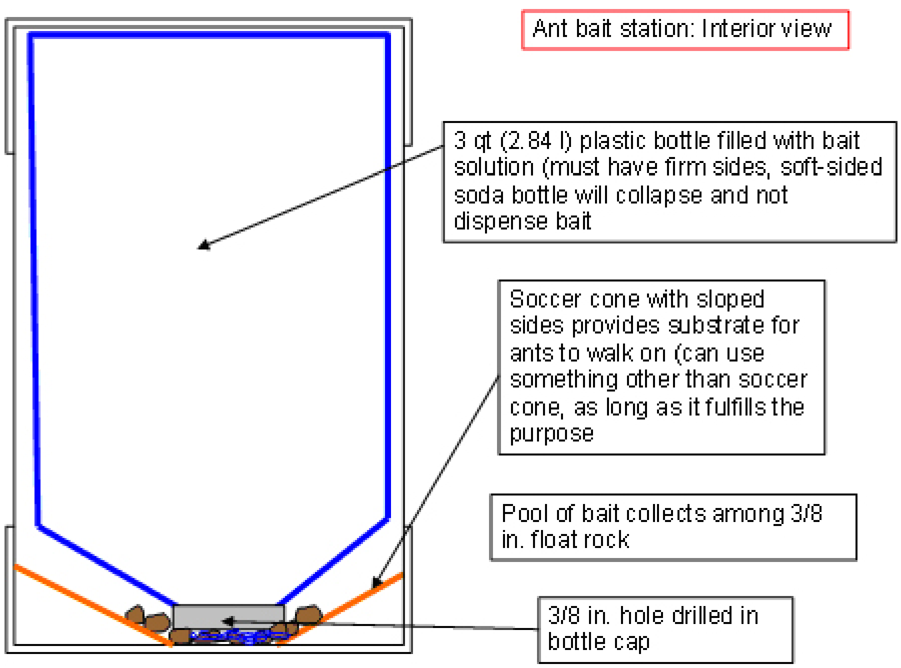
This demonstration site addressed the issues faced in the sustainable management of mealybugs. The cooperating grower at this site designated approximately 3 acres of a vineyard that has a relatively high population of mealybugs and argentine ants. In early February 2007, CCVT staff and the cooperating grower planted two insectary islands (a native flower and grass habitat) along the portion of the vineyard that was allotted for the demonstrations site. One of the insectaries was planted on the portion of the vineyard to help facilitate the movement of beneficial insects from the insectary to the vineyard based on prevailing wind patterns. Another insectary was planted on another section of the block. While the specific placement of this island may not be the optimal position for the insectary, it still provides a habitat for beneficial insects to reside (Picture 8).

CCVT project staff and the cooperating grower built 40 PVC ant bait stations (Picture 9) and placed them at a density of 13 bait stations per acre. In each of the ant bait stations, a 2.84L bottle filled with 50% Gourmet Liquid Ant Bait (GLAB) and 50% water was placed inverted on a bed of rocks placed in an inverted soccer cone-type container to act as a feeding platform for the ants (Picture 10). The GLAB solution is a boric acid solution that is used in the control of argentine ants. The low toxicity of this material ensures that the material is taken by the worker ants back to the nest and fed to the brood (newly hatched ant larvae). The material targets the newly hatched brood ensuring that the next population will be reduced through the reduction in the reproductive generation. Because the reproductive stages are targeted, and there is one reproductive cycle per year, it takes several years before there is a noticeable decrease in the population of ants in the vineyard (Pictures 11-13).

Once the ant bait stations have been in the ground for several years, the population of ants should decrease in the vineyard. The insectary should be reseeding itself each year, and any plants that are currently there should be ensuring its establishment and growing in size. Once these management strategies are in place for several years, their effectiveness should increase and will likely have a noticeable effect. The insectary will become better established making it a better habitat for beneficial insects, and the ant bait stations should continue to have an effect on the ant population present.



Picture 9. Exterior Diagram of the ant bait stations used in the control of argentine ants in Central Coast Vineyards. Design is based on the work from Danne Battany and Cooper 2006.



Picture 10. Interior diagram of the ant bait stations used in Central Coast Vineyards for the control of argentine ant. Design is based on the work from Danne Battany and Cooper 2006.

Picture 11. Ant bait stations placed in the vineyard during March to target the newly hatched larvae.

Picture 12. Bait Station in the field after 2 months of being in place.

Picture 13. A close-up of ant bait station activity after two months of being in the ground.

Picture 8 Insectary Planting at the Cal Poly Chorro Creek Ranch Integrated Mealybug Management Site

Month of 2007	Insectary Island 1- Upwind Planting	Insectary Island 2- Downwind Planting	Close-ups of the Insectary Islands
February			
March			
April			
May			

7.1.2.4 Sierra Madre Vineyards – Ant Bait Stations

Sierra Madre Vineyards east of Santa Maria, had a recent outbreak of vine mealybug in several of their blocks. The population of the mealybugs at this site has been exacerbated by the population of argentine ants. The cooperating grower at this site approached CCVT with a desire to implement a management practice to control the argentine ants. The information the CCVT provided the cooperating grower was the strategy using the ant bait stations. CCVT provided the grower with instructions on how to build the PVC bait station (Picture 8 and 9) and also provided a bait station as a template to work from. This project grower built approximately 150 bait stations to cover roughly 10 acres of grapes that have a high infestation of ants and mealybugs. This grower used GLAM as the material in the bait station.

The grower's opinion on this management strategy was that the bait stations were relatively easy to build and put out in the field. The initial costs of his stations were high because the end caps that he was able to source out were high. This grower's irrigation distributor charged more than CCVT project staff had experienced in the past as a common price for the PVC products needed for the stations. However, his opinion is that the bait stations are relatively indestructible, so he should be able to use them for some time. The cooperating grower liked the activity of ants around the station; however, this is the first year the management strategy is in place. Therefore, judging the impact of this practice on the population of ants is going to be difficult.

7.1.2.5 Cal Poly Student Vineyards – Bait Stations and Insectary Refuge

Cal Poly Student Vineyards coordinated with CCVT and Bayer to test the effectiveness of Bayer's new insecticide, Vitis, for the control of argentine ants with the use of the PVC bait station. CCVT project staff coordinated the vineyard and the materials needed for this experiment. Currently, Cal Poly students are monitoring the progress of the trial. Since the initial setup of these bait stations in the vineyard, the relationship between Bayer and the Cal Poly Student Vineyard has grown. Bayer has now provided Cal Poly with additional bait stations and the liquid bait to control ants in other commodities, like the lemons and some citrus.

Picture 13. An ant bait trial was set up at the Cal Poly Student Vineyard. Bayer science provided the bait stations and their new insecticide, Vitis, for the control of argentine ants. They have also provided some funding for a grad student to monitor the ant populations over the course of the season.

7.1.3 Monitoring and Treatment of Project Sites

Several of our project sites were monitored throughout the project period. The following section discusses the different sites, what occurred during this time, and how it impacted the pest management decisions at the site.

7.1.3.1 Stonewall Vineyards

Stonewall Vineyards is located in Northern Monterey County. The cooperating grower has a population of an obscure mealybug (*Pseudococcus viburni*) in his vineyard. The year prior to our cooperation, he treated his vineyard with a dormant season spray of Lorsban for the control of this pest. Our monitoring efforts were focused on determining the pressure and when the pest emerges from the trunk bark. Determining these two factors helped CCVT project staff and the cooperating grower in determining the best time to apply an in-season application of a reduced risk insecticide, if needed at all. Throughout several weeks of monitoring at this site, it was determined that the density and abundance of the pest was not great enough to warrant an in-season spray. It was also discussed with the grower that he not apply a post harvest or dormant application of Lorsban. Through this cooperation and monitoring the grower was able to avoid an in-season spray of a soft insecticide and a post harvest or dormant spray of Lorsban, a high risk insecticide.

7.1.3.2 Phelps Vineyard

The first season of mealybug monitoring at this vineyard was devoted to a spray trial looking at the effectiveness of reduced risk materials for the control of mealybugs. In the season following this spray trial, the focused shifted from high intensity monitoring for scientific data to less intense monitoring for determining the need for treatment. This site used Lorsban as a post season spray two seasons prior to the second season of monitoring. The monitoring took place at two blocks that had the highest infestations of mealybugs in the past. During the monitoring of the 2006 season, population levels were at a moderate level. In some instances, vines had high population levels but in most cases they were moderate to low. It was decided in cooperation with the grower, that both an in-season treatment of a reduced risk insecticide and a post harvest treatment of Lorsban was not needed, as the population levels did not present a major threat to the crop. Through this cooperation and monitoring, the grower was able to avoid an in-season spray of a soft insecticide and a post harvest or dormant spray of Lorsban.

7.1.3.3 Zabala Vineyards

Zabala Vineyards was used through the 2005 and 2006 monitoring period. During the 2004 growing season, the cooperating grower applied Lorsban to knock back the mealybug and ant population present at his vineyard. Throughout the monitoring period, the population levels were relatively low with a few hot spots of high populations. The levels never reached a point in which the cooperating grower or CCVT project staff became concerned that extensive damage might be caused. There was some consideration of an in-season Admire treatment. However, the cost to apply the Admire is expensive and was not likely to equate to savings in the quality of fruit produced. Therefore, CCVT staff and the project grower thought that this would be an appropriate opportunity to see if biological control agents would have an effect on the population levels. The narrative for this release was already previously discussed. Through this cooperation and monitoring the grower was able to avoid an in-season application of Admire.

7.1.3.4 Importance of Monitoring

All of the previously mentioned vineyards had a history of Lorsban use for the control of mealybug species in their vineyard. The mealybug pressure during the 2005 and 2006 growing seasons at these three sites never reached a level of high concern for the potential to cause significant damage to the fruit. The low population levels at this site could be due to the prior application of Lorsban, which is very effective in knocking back mealybug population levels. The low levels could also be attributed to a variety of environmental or biological factors which are very difficult to determine. Even though project staff and cooperating growers did not have to apply any in-season treatments of reduced risk materials in lieu of a high risk application of Lorsban in the dormant season, there is a high value to the scouting conducted by CCVT project staff. The support that CCVT project staff provided allowed the growers to have more detailed information on the status of the pest. This in turn saved them time and money and provided assurance that there was not a significant pest problem, conversely to previous years in which a treatment of high risk chemicals as a curative approach was warranted. Providing a sound understanding to the grower of the status of their pest pressure ensures that blanket approaches to their pest management strategies are avoided. This equates to economical savings for the grower and an environmental benefit through the reduction of inputs into the vineyard.

7.2 WEED MANAGEMENT ALTERNATIVES TO SIMAZINE

7.2.1 Background

Weed management in Central Coast vineyards generally relies on chemical and mechanical methods for control. Several applications of herbicides, or multiple passes with a mechanized weeder are often needed throughout the season to adequately control weeds. Some of the chemicals used in the control of weeds are very effective in controlling a wide variety of species for a prolonged period of time. However, some of these weed management approaches can reduce water quality in the Central Coast. The strategies include the timing of herbicides to maximize their effectiveness and to operate cultivation equipment when the weeds are most susceptible for maximum control.

Alternative herbicides, such as flumioxazin (commercial name Chateau) are available and have longer residual control, are less mobile in the soil, and have a lower persistence in the environment. Recent agricultural technology such as the Sunflower, by Pelenc, is increasing the efficiency of under row cultivation practices. The Pelenc is a cultivation tool that utilizes blades underneath a cover that facilitates the moment of the blades around the vines without causing injury to the vine. Furthermore, cultural practices such as the planting of an under row cover crop, could lead to the suppression of common weeds through competition for light and nutrients without impacting the growth of the vine. These strategies and alternative herbicides could potentially lead to a reduction in the use of herbicides and cultivation equipment, ultimately saving the grower money and minimizing the agricultural inputs on the environment. There are a wide variety of herbicides, mechanical tools, and cultural practices that can be used to control weeds. However, the appropriateness of a tool depends on the characteristics of the vineyard. Therefore, characterizing the effectiveness of different weed control strategies can assist growers in making effective management decisions.

Simazine, a pre-emergent herbicide linked to ground water contamination, has been found in California drinking water sources since the early 1990's (Lam et al. 1994). The increased focus on simazine is due to its potential threat to aquatic organisms and its increased usage in agricultural systems over the past few years. Simazine is not the only pre-emergent herbicide that can leach to ground water, but this chemical is being used in significant quantities in California's winegrape industry.

Due to the potential toxicity of this material, CCVT project staff worked with three participating growers to evaluate the effectiveness of alternative methods for the control of weeds in vineyards. The following report addresses the results and discuses their potential impacts on management practices in Central Coast vineyards.

It should be noted that the Sunnybrook study involved significant cooperation with the Horticultural and Crop Science Department, California Polytechnic State University.

7.2.2 Materials and Methods

The studies were conducted in Sunnybrook Ranch, located in East Side Paso Robles California, Hog Canyon located in Eastern San Miguel California, and Chalk Knoll Vineyards located in San Ardo California. Each vineyard is varied in its location, weed pressure and its current management style. Because of this, each site had different methods evaluated for the control of weeds.

7.2.2.1 Chalk Knoll Vineyards

In 2005-2006, CCVT staff evaluated the effectiveness of two pre-emergent herbicide treatments and a cultivation method. The two pre-emergent herbicides used in this trial were simazine and flumioxazin. Simazine was applied at 2.7 lbs. a.i./acre in a tank mixture with glyphosate at 1.3 qts. a.i./acre. Flumioxazin, an alternative herbicide to simazine, was applied alone at 6 oz. a.i./acre. The pre-emergent herbicides were applied in late February, and the first cultivation treatment was conducted at the same time. The two pre-emergent herbicide plots also had an additional in-season spray with glufosinate, a contact herbicide, which was applied at .45 qts. a.i./acre. The equipment used to conduct the cultivation treatment is called a Bezzeretti. This equipment was run along the row at approximately 6 miles per hour in order to cultivate under the vine row. It was run two more times throughout the season, once in early April, and another time in mid June. The timing of operation was determined by a combination of the weed size (approximately 6 to 18 inches tall) and availability of equipment and labor.

Weed populations were measured every two weeks. Populations were evaluated using a quadrat method and a linear transect method. The quadrat method consisted of a $0.25m^2$ quadrat thrown randomly underneath the vine row where the chemical treatments were applied. The number of species and the number of weeds within the quadrat were then recorded. For the linear transect method a 50 ft. measuring tape was laid directly underneath the vine row. The evaluator then walked along the transect, and recorded the number of weeds and the species at each of the foot marks along the 50 ft. transect.

The experimental site involved three treatments with three replicates per treatment. Each replicate consisted of four rows. The inner two rows were the sample rows and the outer two rows acted as buffer rows. The two sample rows within the two treatments were sampled twice, for a total of four samples per experimental unit using the quadrat method. For the linear transect method two sample rows were sampled, each sampled one time, for a total of two samples per experimental unit.

After data collection, the population density and species number throughout the season was then evaluated.

Weed biomass was sampled twice throughout the growing season. Samples were taken during the normal sampling period. Using the aforementioned quadrat, the species were identified, counted, recorded, then cut at the base of the shoot and placed in paper bags. These bags were then put into an oven at 200°F and dried for 48 hours. The dry mass was then weighed and recorded.

Leaf Area Index (LAI) measurements were taken using a AccuPar LiCor. light interception device. Eight samples were taken per experimental unit. Vines were chosen at random and sampled accordingly.

Harvest data was collected to evaluate the effect of the treatments on fruit production and quality. Four vines per experimental unit were sampled for number of fruit clusters and average weight of the clusters per vine. This was accomplished by counting the clusters on the vine, cutting them off and weighing the mass of the fruit as a whole, thus getting an average cluster weight. Fruit quality evaluations were taken by using a random sub-sample from the harvested fruit. The fruits were crushed and the collected juice was then analyzed for titrateable acidity, pH and brix (grape sugar content) at Baker Wine and Grape Analysis.

7.2.2.2 Hog Canyon Vineyards

Hog Canyon Vineyards evaluated two pre-emergent herbicides on the control of weeds. The pre-emergent herbicides used for comparison are simazine and flumioxazin. Simazine was applied at 2.7 lbs. a.i./acre in a tank mixture with glyphosate at 1.3 qts. a.i./acre. Flumioxazin was applied at 6 oz. a.i./acre in a tank mixture with glyphosate at 1.3 qts. a.i./acre. The treatments were applied on the 20th of March. Weed population measurements were taken every two weeks. Populations were evaluated using the same methods as the CKV trial.

The site used a completely randomized design. There were two treatments with three replications per treatment. Each replication consisted of four rows. The inner two rows were the sample rows and the outer two rows acted as buffer rows. The two sample rows within the two treatments were sampled twice, for a total of four samples per experimental unit using the quadrat method. For the linear transect method two sample rows were sampled, each sampled one time, for a total of two samples.

Population density, species numbers, weed biomass, leaf area index and harvest data were all collected using the same methods as the CKV trial.

Weed biomass, leaf area index and harvest data were all collected using the same methods as the CKV herbicide trial.

The same treatments were assigned to the same plots and the same methods were used during the 2007 growing season.

7.2.2.3 Sunnybrook Vineyards

This experiment consisted of five treatments and was arranged as a randomized complete block design with three replications. Each experimental unit consisted of four vine rows, with two additional adjacent vine rows as buffers. The 1.3 m wide strips under the vines in each experimental unit received one of the following weed control treatments: 1) pre-emergent herbicide simazine, 2) pre-emergent herbicide flumioxazin, 3) cultivation with a Sunflower from Pelenc (Picture 14), 4) 'low growing mixture' vineyard cover crop seeds, and 5) no treatment control.

Picture 14. The Sunflower under vinerow cultivator is attached on the back of the John Deer Tractor.

Simazine was applied at 2.7 lbs. a.i./acre in combination with glyphosate at 1.3 qts. a.i./acre and oxyfluren at 0.5 lbs. a.i./acre. Flumioxazin was applied at 6 oz. a.i./acre. in combination with glyphosate at 1.3 qts. a.i./acre and oxyfluren at 0.5lbs a.i./acre in February. The cultivation treatment was applied once in April. The cultivation equipment was also used in the preparation of the soil for cover crop treatment. The cover crop seeds were mixed with sand (50:50 ratio) and applied by hand at approximately 22 $kgha^{-1}$ prior to a significant rain event in February. Table 2 shows the list of the species within the cover crop and their relative percent content within the mixture:

Table 2. List of species used in the under row cover crop cover crop treatment in Paso Robles, California in 2007

Species	Percent of Mixture
Centaurea cyanus	4.6%
Eschscholzia californica	4.8%
Festuca rubra commutata	32.8%
Layia platyglossa	1.5%
Lotus corniculatus	7.6%
Nemophila menziesii	3.0%
Trifolium incarnatum	7.0%
Trifolium repens	13.9%
Trifolium subterraneum	18.2%
Vulpia microstachys	6.6%

Weed density and number of species were sampled each month during the growing season using the 0.25 m^2 quadrant method. Four samples were taken from each experimental unit per month. Weed shoot biomass for each species was also taken using the 0.25 m^2 quadrant method. Two samples per experimental unit were collected in April, June, July, and October. Weed shoot samples were oven dried for 48 hours at 200°F, and weighed.

Ground dwelling arthropod activity, density, and diversity were sampled each month between February and October using pitfall traps. Each trap consisted of a 50 ml clear plastic cup, filled half-full with 10% ethylene-glycol solution, sunken into the ground with the lid leveled with soil surface. Two pitfall traps were placed in the vine row, and one in the row middle. The traps were located at least 25 m away from the head row, and were spaced 10 m from each other in a transect. The traps were opened for 48 hours each month, after which the traps were collected and brought to the lab. Each species of epigeal arthropods were counted and taxonomically identified.

Grapevine Leaf Area Index (LAI) was measured using the AccuPAR light interception device (LiCor). LAI samples were taken each month between July and October at four vines per block. Grapevine yield, number of cluster per vine, and berry count per cluster were also sampled from the same vines. At harvest, a 50 ml sample of fresh grape juice from each experimental unit was sent to a Baker Wine and Grape Analysis.

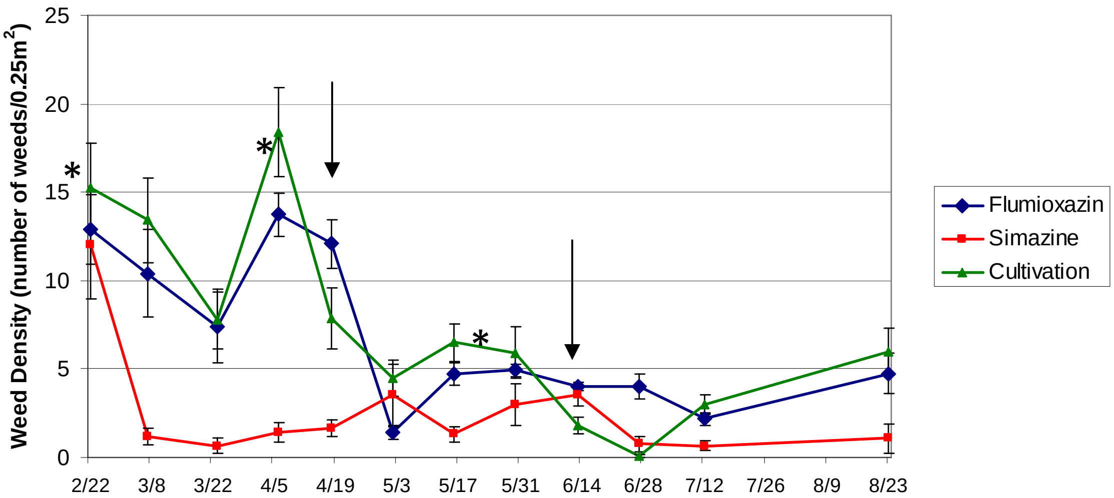
7.2.3 Results

7.2.3.1 Chalk Knoll Vineyards

The effects of the different treatments at CKV can be seen in Graphs 6 through 10. Graph 6 represents the number of weeds sampled over a period of 6 months. The application of herbicides took place several days after the first sampling. A drop in the population of weeds (Graph 6) can be seen after the initial application of herbicides. Simazine maintains adequate control throughout the season. A second application of herbicides was applied after the 6/14/2006 sampling date. There is a visible drop in the number of weeds in the simazine plot after this date (Graph 6).

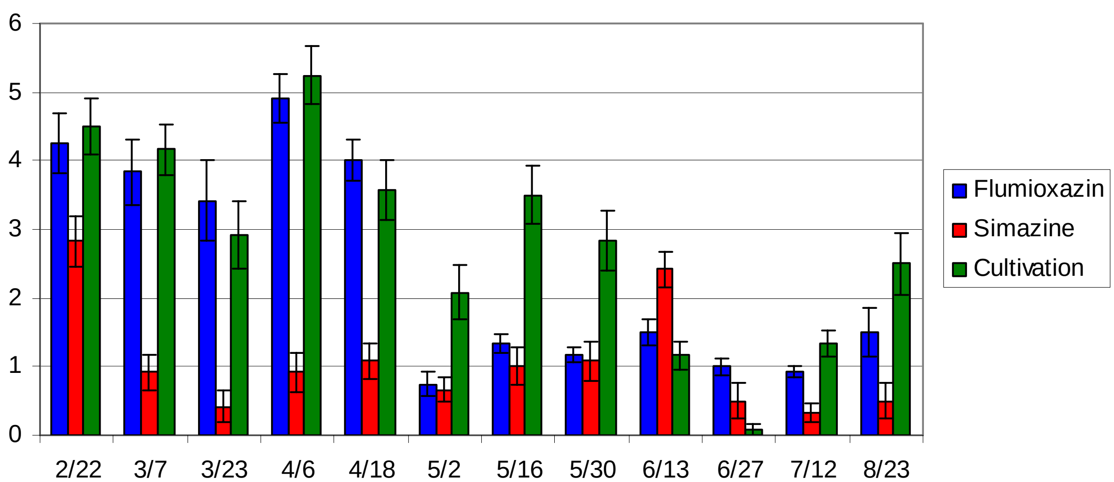
Flumioxazin had a slight drop in density at the beginning of the season after the application of the materials took place, but then there was a slight increase in the number of weeds until May 3, 2006, when the number of weeds per sample decreased dramatically (Graph 6). This is because the weeds that were being sampled were extremely large weeds of one species. Therefore, one weed was taking up a lot of space is the sample area causing the sample number to be low. Flumioxazin treatment received another herbicide application on the same date as the simazine treatment. There was not a significant drop in the number of weed species here. The quadrat sampling method did not accurately show the drop in the number of weeds after this second application of herbicides because of the size of the weeds present.

The cultivation treatment had a pass performed in the first few days after the first sampling date. The next cultivation pass took place before the 4/19/2006 sample date. A drop in the average number of weeds per treatment sample can be seen here. The next cultivation pass took place before the 6/14/2006 sample date. There was a visible drop in the number of weeds per sample after this cultivation pass took place (Graph 6).



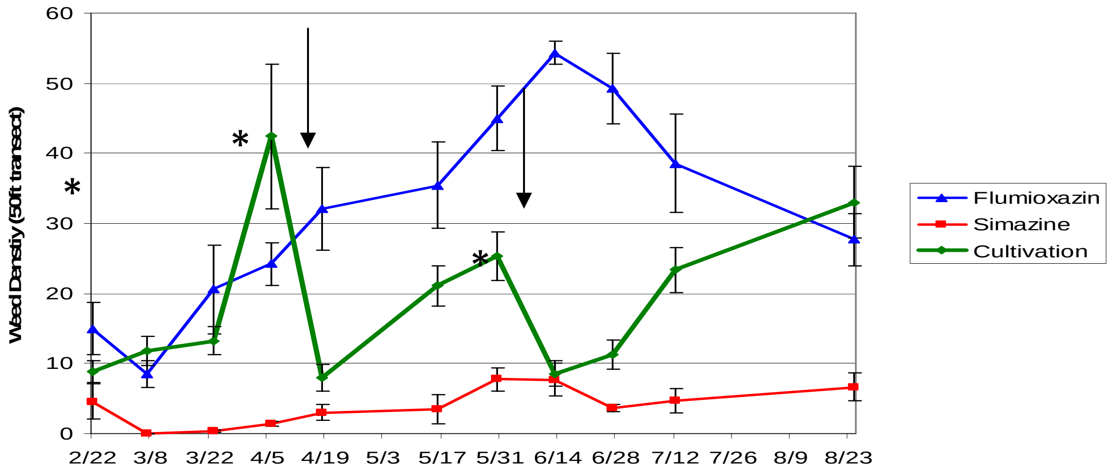
Graph 6. Number of weeds determined using the quadrat method. Arrows indicate a herbicide application and a star indicates the a cultivation event at Chalk Knoll Vineyards in San Ardo, California in 2006. Error bars represent the standard error of the mean (s.e.m.)

The different treatments at CKV had a varying effectiveness on the control of weed species. In Graph 7, it can be seen that the simazine treatment generally had fewer species throughout the growing season. Comparatively, simazine did a better job of controlling more species of weeds early on. Flumioxazin showed poor control early on and a large number of species were present. The steep drop shown on the May 3, 2006 date is due to the dominance of one weed species, knotweed, establishing and ultimately overtaking all of the other weed species there.



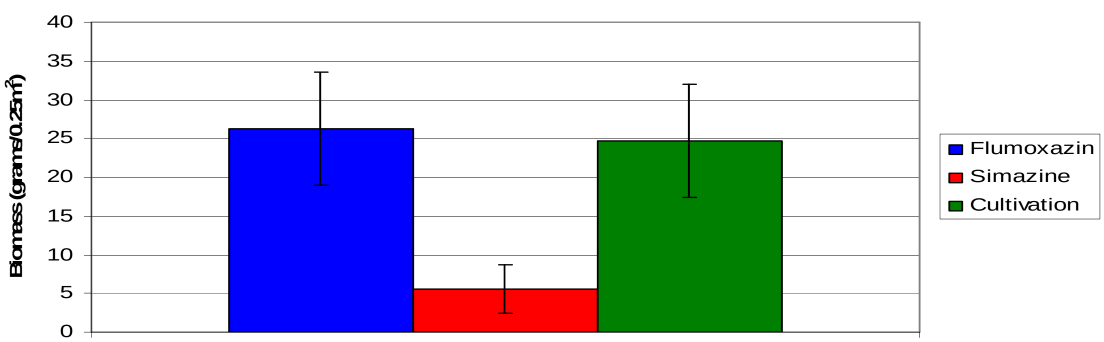
Graph 7. Number of weeds species determined using the quadrat method. at Chalk Knoll Vineyards in San Ardo, California in 2006. Error bars represent the s.e.m.

The transect method used to track the number of weeds at Chalk Knoll (Graph 8) was able to capture what occurred throughout the season. At the beginning of the season, weed populations, in most cases, declined in numbers after the first application of herbicides, and after the first pass of the cultivator. The effectiveness of simazine can be seen throughout the season. The ineffectiveness of the flumioxazin treatment can be seen clearly here as the number of weeds climbs rapidly until the application of glufosinate takes place. After the glufonsinate application, there is a drop in population levels, but the levels were still high in comparison to the simazine treatment at the end of the season. The effectiveness of the cultivation passes can clearly be seen in Graph 8. A clear drop in the population levels can be seen after the cultivator was used each time (Graph 8)



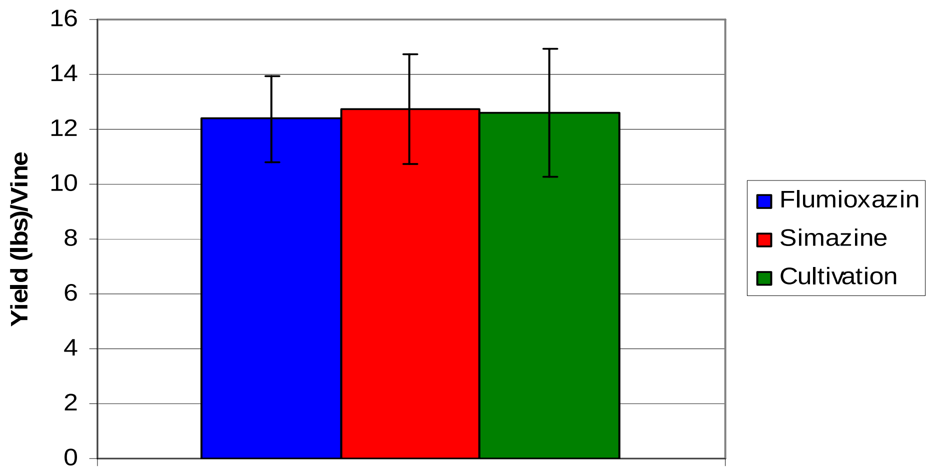
Graph 8. Weed density determined using the transect method. Arrows indicate a herbicide application and a star indicates the a cultivation event at Chalk Knoll Vineyards in San Ardo, California in 2006. Error bars represent the standard error of the mean (s.e.m.)

Weed biomass was measured as dry weight of weeds per square meter. The above ground weed biomass for each treatment was affected by each of the treatments. Both the flumioxazin and cultivation treatments had five times more weeds than the simazine treatment (Graph 9).



Graph 9. Dry weight of above ground weed biomass (grams/0.25m^2) at Chalk Knoll Vineyards in San Ardo, California in 2007. Error bars represent the s.e.m.

The harvest weights for each treatment did not differ among the treatments (Graph 10).



Graph 10. Yield (lbs) per vine at Chalk Knoll Vineyards in San Ardo, California in 2007. Error bars represent the s.e.m.

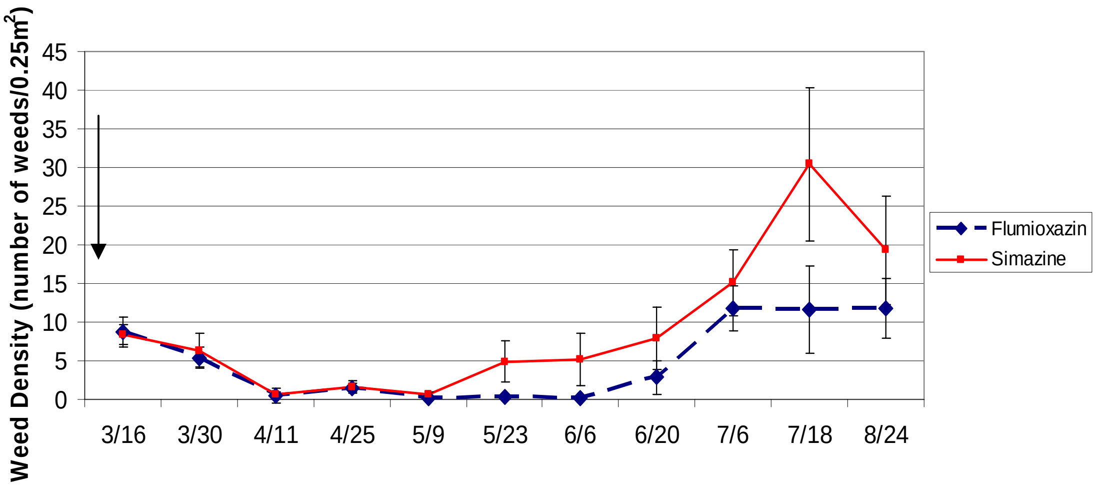
Table 3 shows standard indicators for grape quality at harvest. The Brix, Titrateble Acidity and pH were not significantly different between the different treatments, suggesting that the lower risk alternatives were acceptable in terms of grape quality.

Table 3. Brix, Titrateable Acidity (TA), and pH and the standard error of the harvested grapes from Chalk Knoll Vineyards in San Ardo, California in 2006.

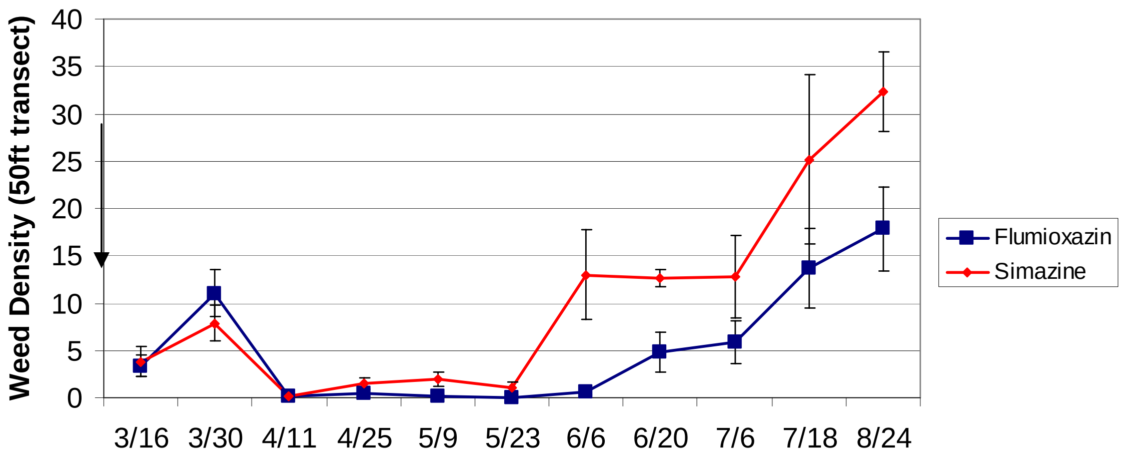
Treatment	brix°	TA	pH
Cultivation	25.30±0.25	0.58±0.02	3.36±0.01
Simazine	25.30±0.60	0.59±0.03	3.42±0.02
Flumioxazin	25.87±0.32	0.58±0.03	3.40±0.01

7.2.3.2 Hog Canyon Vineyards

CCVT project staff tested the effectiveness of two pre-emergent herbicides for weed control at HCV. Graphs 11 and 12 show the number of weeds found in each treatment. Graph 11 shows the weed density using the quadrat method and Graph 12 shows the number of weeds per sample using the transect method. Application of the pre-emergent herbicides took place several days after the first sampling date. Both of these graphs show the same trend in data. Initially, there was a stand of weeds early on during the growing season, but as the herbicides have a chance to take effect, the population levels decline. As the herbicides lose their persistence in the soil, their retention and residual effect became less throughout the season. This can be seen by the increasing number of weeds throughout the growing season. Flumioxazin treatment controls more weeds for a greater period of time when compared to the simazine treatment (Graph 11 and 12).

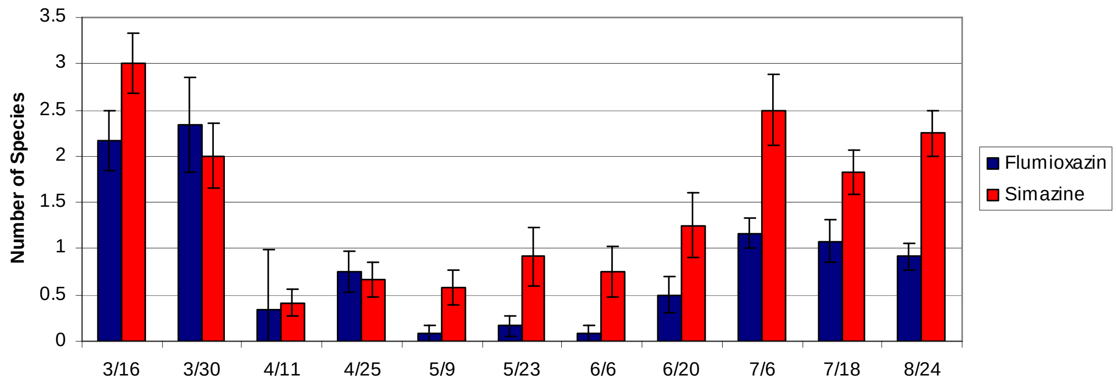


Graph 11. Density of weeds determined using the quadrat method. Arrows indicate a herbicide application at Hog Canyon Vineyards in San Miguel, California in 2006. Error bars represent the s.e.m.



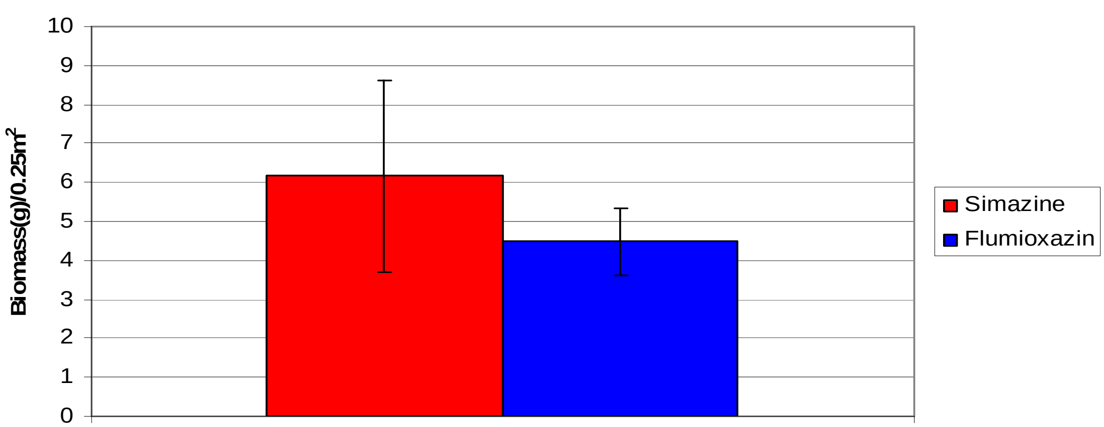
Graph 12. Number of weeds determined using the transect method. Arrows indicate a herbicide application at Hog Canyon Vineyards in San Miguel, California in 2006. Error bars represent the s.e.m.

The number of species controlled varies among the different treatments. Graph 13 shows the numbers of species present per treatment. Flumioxazin treatment had fewer weeds surviving throughout the season, suggesting that it is successful in controlling a broad range of species.



Graph 13. Number of weed species determined using the transect method at Hog Canyon Vineyards in San Miguel, California in 2006. Error bars represent the s.e.m.

Weed biomass (Graph 14) was greater in the simazine treatment than the flumioxazin treatment. Although fewer species were present in the flumioxazin plots compared to the simazine plots, no differences in weed biomass were observed between treatments (Graph 14).



Graph 14. . Weed Biomass determined using the quadrat method at Hog Canyon Vineyards in San Miguel, California in 2006. Error bars represent the s.e.m.

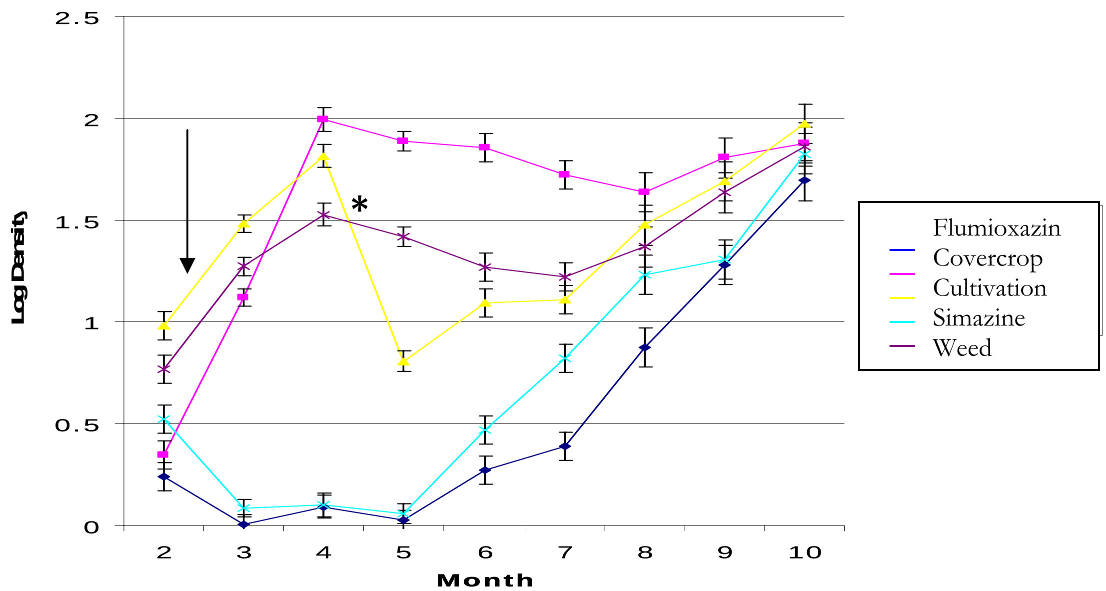
Table 4 shows standard indicators for grape quality at harvest. The Brix, Titrateble Acidity and pH are not different between the different treatments, suggesting that the reduced risk alternatives are acceptable in terms of final grape quality.

Table 4. Average Brix, Titrateable Acidity (TA), and pH and the standard error (stderror) of the harvested grapes from the different treatments.

Material	Brix	TA(g/100ml)	pH
Simazine	25.07±0.50	0.66±0.01	3.28±0.02
Flumioxazin	24.73±0.48	0.68±0	3.26±0.01

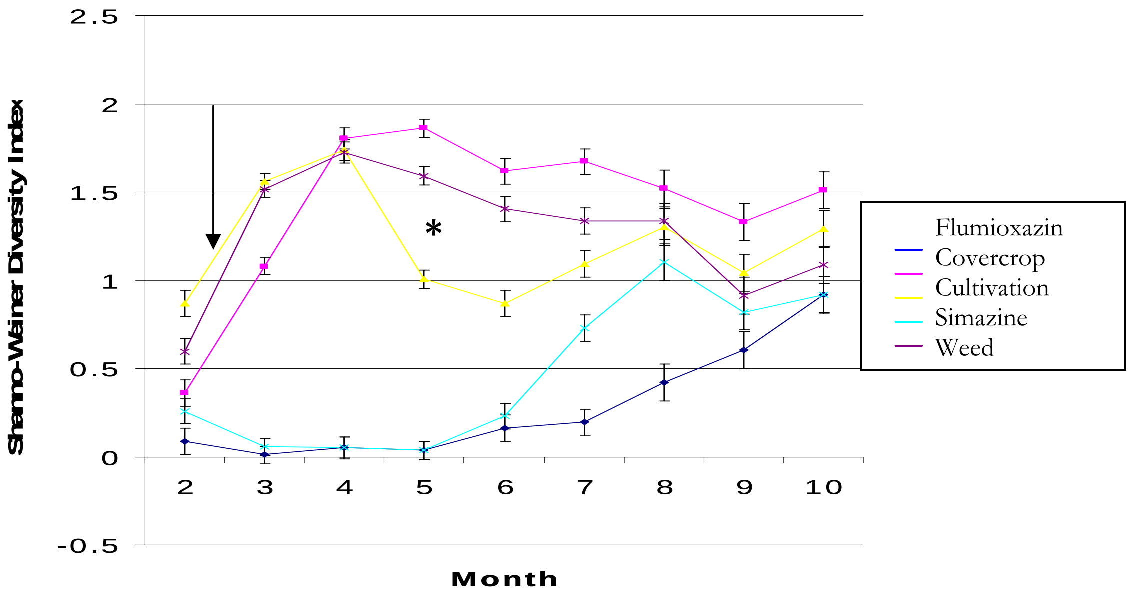
7.2.3.3 Sunnybrook Vineyards

Sunnybrook Vineyards evaluated four different weed control strategies and compared them to a weed control where the weeds were allowed to grow throughout the season. The data presented in Graph 15 represents the weed density for simazine, flumioxazin, under row cover crop, and a cultivation treatment. The two pre-emergent herbicides controlled weeds early in the season. They started to lose their effectiveness around June (Month 6) because their residual effect in the soil has become less. Flumioxazin controlled more weeds than simazine for the 4 months after May, then simazine and flumioxazin exhibited the same levels of control in September and October. The Cultivation treatment took place in the month of May (Month 5). This can be seen in the decline in weed density in the cultivation treatment during this month. The vegetative biomass of cover crop treatment accelerated significantly in the first few months of the growing season and leveled out during the rest of the season. At the end of the season, all of the treatments had very similar weed vegetation densities.



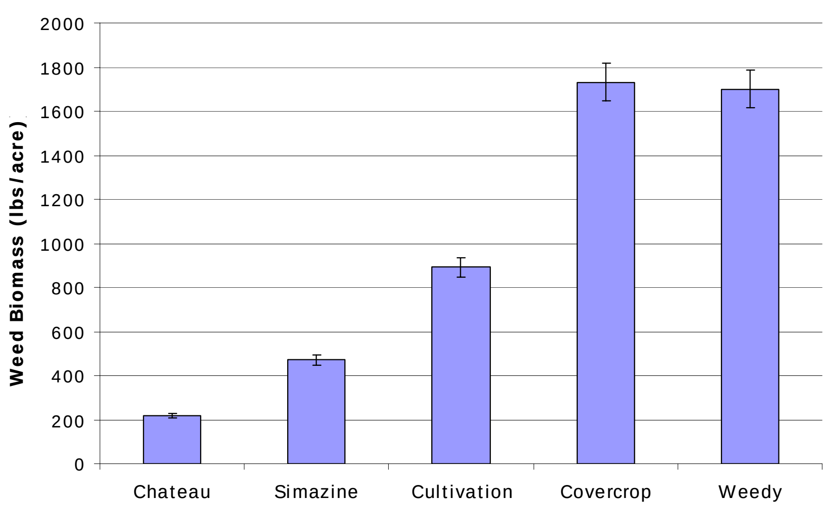
Graph 15. Weed density determined using the transect method. Arrows indicate a herbicide application and a star indicates the a cultivation event at Sunnybrook Vineyards in Paso Robles, California in 2006. Error bars represent s.e.m.

The number of species in the different treatments can be seen in Graph 16. The pre-emergent herbicides effectively controlled more species of weeds throughout the season compared to the rest of the season. Simazine and flumioxazin both controlled weed species at a similar level until May. After June, flumioxazin controlled more weeds than the simazine treatment throughout most of the sampling season until the last sampling date. At this time the number of species controlled was relatively similar. The cover crop treatment had the most number of plant species throughout most of the sampling season. The weedy treatment had the second greatest amount of weed species throughout the sampling season.



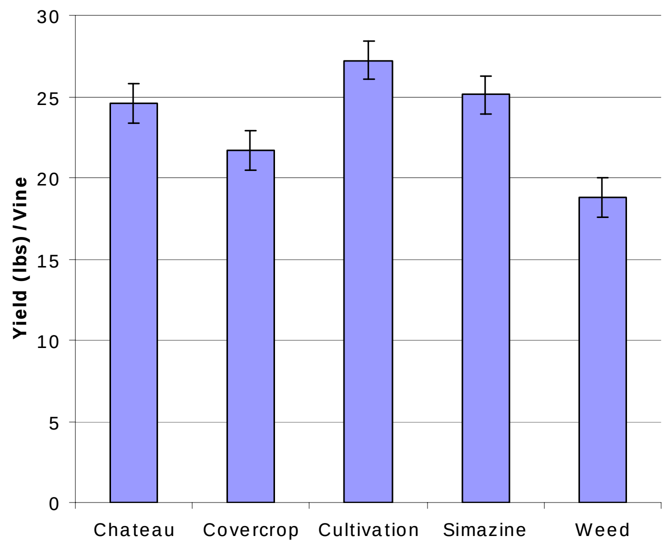
Graph 16. Weed species number determined using the transect method. Arrows indicate an herbicide application and a star indicates the a cultivation event at Sunnybrook Vineyards in Paso Robles, California in 2006. Error bars represent s.e.m.

Weed biomass was measured as dry weight of weeds above ground per square meter and then was converted to pounds per acre (Graph 17). Weed biomass from the weed control methods tested at Sunnybrook Vineyards (Graph 17) was greatest in the cover crop and the weedy control treatment. The cultivation treatment was intermediate. The simazine and flumioxazin treatment had the least amount of weed biomass. The cultivation treatment was 2-4 times greater in biomass in comparison to the pre-emergent herbicide treatments. The weed control and the cover crop had 4-8 times greater weed biomass than the weed control treatments.



Graph 17. Weed Biomass determined using the quadrat method at Sunnybrook Vineyards in Paso Robles, California in 2006. Error bars represent the s.e.m.

The different treatments showed effects on winegrape yield that did not agree with weed biomass data. The two pre-emergent treatments and the cultivation treatment did not differ in yield. The cover crop weed control treatments were reduced by a 12% yield reduction in comparison with the two pre-emergent treatments and the cultivation treatment based on the weeds competing with vines.



Graph 18. Yield per vine (lbs) in each treatment at Sunnybrook Vineyards in Paso Robles, CA in 2006.Error bars represent the s.e.m.

As stated earlier, weed and insect population and diversity were evaluated. The data showed that an increase in vegetation underneath the vine row increased the number of individual insects and number of species occurring within the experimental unit. Therefore, the under row cover crop and the weed control plot had the greatest number of insect and insect species in comparison to the pre-emergent herbicides.

Table 5 shows the percent of light penetrating the canopy as a result of the different treatments. The greater the percentage, the more light there is reaching the interior of the canopy. The greatest amount of light penetrating the canopy was the covercrop treatment, followed by cultivation, weed, simazine and then finally Flumioxazin.

Table 5. Percentage vine leaf light interception for each management tactic at Sunnybrook vineyards in Paso Robles, California in 2006.

Treatment	**Light Interception**
Flumioxazin	68%
Simazine	69%
Weed	52%
Cultivation	59%
Covercrop	57%

The data from Table 5 and Graph 17 and 18 shows that an increased weed biomass had an impact on the growth of the vine and yield.

7.2.4 Discussion

7.2.4.1 Chalk Knoll Vineyards Discussion

Weed density and population diversity were all highly affected by the different weed management practices. The simazine treatment worked well through most of the season. Once the residual effect of the simazine treatment became less, the additional herbicide application of glufosinate mid season, helped keep the weed populations low. The cooperating grower has stated that the tank mix of simazine and glyphosate is a common practice at CKV and has been very effective in the control of weeds in the past. This is backed up by the data presented in this paper.

Flumioxazin was previously tested by the cooperating grower at a nearby vineyard and had very little success with it. The goal of this trial was to re-test this product to see if it would be effective at CKV. Even though an herbicide may be ineffective at one site, it does not mean that it will be ineffective at another.

Flumioxazin is a pre-emergent herbicide with some contact action. What this means is that it will prevent weeds from germinating but will also have a burn down effect on any weeds that are currently present. Most pre-emergent herbicides are applied in combination with another burn down material. However, in this trial, flumioxazin was applied alone. From Graph 6 and Graph 8, the limited activity of flumioxazin can be seen. There was a slight decrease in the population density in the flumioxazin treatment, which could be attributed to the burn down property of the material. This initial drop in weed population did not likely have an effect on the growth of the vine, as the competition between the vine and weeds is minimal due to the significant amount of water available in the soil profile during this time of year.

After the initial drop in weed population density, there was a large increase in the flumioxazin treatment after continued sampling (Graphs 6 and 8). The density of knotweed (*Polygonum* spp.) was very high in the flumioxazin treatment. The coverage of this species underneath the vinerow was very evident, presumably limiting the establishment of other species. By May 3rd, there is approximately only one species that dominates experimental area (Graph 7). *Polygonum* spp. was one of the species that is not on controlled by flumioxazin. This is likely why the burn down of any seedlings of this species did not occur. It is also likely that it did not prevent seedlings from establishing. This is likely why a population of knotweed was able to establish. However, the midseason application of glufosinate killed off the majority of the weeds and, therefore, yield was not affected.

The cultivator was run twice during the sampling season and was able to kill many of the weeds present (Graph 6 and 8). Although the weed populations within the cultivation plots reached high levels throughout the season, the yield produced by the vine was not significantly compromised (Graph 10). The weeds also did not seem to highly affect the fruit quality (Table 3). CKV has been characterized as having relatively sandy soils. Flumioxazin does not bind well to sandy soils due to the lack of binding sites on a sand particle (Pers. Comm. Leon 2007). This could be an additional explanation of why this material did not work well at this site.

What could potentially be deduced from the information at hand is that when weeds are controlled at the right time during the season, the potential for them to be highly competitive with the vine is not likely to occur. This information is extremely important for growers to understand, therefore communicating an effective alternative to simazine and making the adoption of alternative practices and materials more likely. The increased adoption and understanding of alternatives to simazine is an important factor in reducing the use of simazine and reducing the potential impacts on water quality.

7.2.4.2 Hog Canyon Discussion

Weed population densities at HCV were controlled by both pre-emergent herbicides. What may have been the determining factor for the success of flumioxazin in comparison to CKV was that it was applied in combination with glyphosate, which likely facilitated the burn down of any weeds present at the time. At this site, flumioxazin was able to control a larger number of weeds and weed species for a longer period of time when compared to simazine. Because both of the herbicides were able to adequately control weeds throughout the season, there were no differences in the yield of grapes produced in the different treatments. What the grower needs to take into account for future weed management systems is what tool to use. Since both of these methods work effectively, the grower has an option of materials to use depending on the weed control budget. Because both materials were effective throughout the season, the grower now has two options available for a herbicide rotation program. An herbicide rotation program will prevent or slow the buildup of resistance of weeds to the herbicides.

The main limitation to a grower adopting a new technology or chemical, such as flumioxazin, is it will likely cost more than conventional commonly used systems. These new technologies and chemicals usually pose a reduced threat to the environment. It is this characteristic, along with its effectiveness, that would likely cause a grower to adopt a new practice. A grower needs to evaluate a situation from season to season to see if adopting a new technology is economically viable.

Research and demonstration projects like this are important to help gather and disseminate information about the factors influencing the success of reduced risk alternatives to simazine. By understanding the management factors and keys to success, growers can reduce their economic risk in adopting a relatively expensive practice and increase their likelihood for success. Again, understanding these factors is critical for influencing the increased adoption of non-simazine based materials, therefore reducing the risks to water quality.

7.2.4.3 Sunnybrook Discussion

Sunnybrook had some very interesting results. The pre-emergent herbicides at this site performed similar to the HCV experiment. They both provided adequate control throughout the season. Additionally, their persistence and effectiveness in the soil became less and, therefore, their control of newly germinating weeds became less effective towards the end of the season. Flumioxazin plots had fewer weed numbers and individual species in comparison to simazine throughout the season.

One of the more interesting results came from the cultivation treatment. A cultivation pass accurately timed controlled weed populations (Graph 15) enough to the point that yield was not affected. The cultivation pass that took place removed a majority of the winter annuals that were there, while preventing the establishment and proper vegetative growth of germinating summer annuals. Therefore, accurately timing the control of weeds with a cultivation pass or potentially an in-season application of herbicides is critical. It should be done at a time when the winter annuals are dying off and the summer annuals are emerging. This could be an effective and economical way to suppress weeds and not impact the yield of the vine.

The cover crop and weedy treatments maintained relatively high population and diversity levels throughout the season. These two treatments had a significant effect on grapevine yield at the end of the season (Graph 18). The stand of the weeds and the cover crop were likely competing with the vine for both water and nutrient during the demanding periods of the season. This ultimately led to the reduction in yield.

Although the cover crop treatment significantly affected the yield, it had a significant impact on the insect and vegetative diversity within the experimental plots. The cover crop under the vine row had the greatest association in terms of abundance and diversity of ground dwelling insects, which is desirable. Also, because of the variety of seeds in the cover crop, the vegetative diversity is also relatively high.

Many of the vines in the Central Coast are planted on hillside vineyards. Therefore, the potential for erosion is greater in these vineyards that would normally be planted on flat lands. An under row cover crop or winter weeds under the vinerow during the winter season may provide vegetative coverage that could potentially offer some level of erosion control during the rainy season.

Various value systems come into play when biodiversity is concerned. One grower may place a higher value on biodiversity than on producing a large crop. If this is the case, than an under row cover crop might be considered a highly desirable practice. However, having vegetation under the vine row makes it difficult to accurately deliver water and nutrients to the vine, which is essential in developing the flavor qualities needed for wine production. Another potential use for the under row cover crop could be to de-vigorate highly vigorous vines. Highly vigorous vines tend to produce wine grapes with vegetative characteristics, which tend to be undesirable flavors in wine. Furthermore, the under row cover crop provided an increased amount of light penetration into the canopy. Increased light penetration is an important characteristic in the development of desirable flavor compounds within the grape (Smart 2001). The use of an under row cover crop might then be considered as a practice to increase the light penetration to the vine. This could potentially replace high cost labor crews who are used to shoot and leaf thin during the season.

There are many areas of weed management technically studied that could potentially lead to a reduction of chemical and mechanical inputs. The area underneath the vinerow sprayed with herbicides, the bandwidth, is generally determined by the width of the seeder used to grow a cover crop and by the width of the mower to mow the cover crop. If the bandwidth can be reduced without affecting the growth of the vine, the grower can reduce the herbicides applied, thus reducing inputs. If the width of the seeder can be expanded, the width of the cover crop is expanded. Therefore, the area of the vineyard floor covered by the cover crop is increased, which reduces the amount of space available for weeds to grow uninhibited. Additionally, since the cover crop is covering more of the vineyard floor area, there is less area needed to cover with pre-emergent herbicides to inhibit weed growth. Furthermore, this practice could potentially reduce the risk of erosion on hillside vineyards. If the vegetative area is increased then the potential for erosion could be reduced.

Much of the lessons learned at this site are valuable for growers to understand. This increased understanding can lead to an increased likelihood of their adopting alternative practices and increasing the likelihood of their success in adopting these new practices to reduce the negative effects on water quality.

7.3 EROSION CONTROL PRACTICES

Many vineyards on the Central Coast of California are planted on sloped hillside properties that are prone to erosion during the rainy winter periods. The potential movement of the soil on these properties can be costly to the grower and to the environment. If the movement of the soil stays within the properties it be costly for the grower. For example, if the soil moves from the top of a road to the bottom of the road, the grower may need to relocate the soil back to the top of the road. The grower may also need to purchase more soil if the capacity to relocate the eroded soil is not there. The time and money lost to these operations can be quite substantial. In addition to the cost to the grower, there can be a significant impact to the environment if the soil moves off site and into nearby water systems. The eroded soil can decrease the quality of the water by increasing turbidity and potentially moving nutrients and agrichemicals into the waterways. The implementation of erosion control strategies can mitigate the cost of soil relocation to grower and mitigate the movement of soil into nearby waterways. These strategies include establishing cover crops, planting grass on roads that are prone to erosion, establishing jute netting on terraces and steep hillsides, and placing straw bales in sensitive areas to divert and slow fast moving water. Several of our project sites address issues surrounding erosion control. There were three project sites at which several best management practices (BMPs) were implemented.

7.3.1 Background

Everyone expects a little rain in the early parts of the new year, but the storm event during January of 2006 was more than most people expected. San Luis Obispo received more than 4 inches of rain during a few days. Vineyards on the east side of Paso Robles received up to 7 inches of rain. With a relatively dry period leading up to those few days of rain, there were bound to be winners and losers in terms of erosion and sediment loss. Even the best laid plans to prevent erosion aren't always enough in the face of such heavy storms. However, having some erosion control plans or best management practices (BMP) in place is likely to help mitigate any negative impact that a storm may cause.

7.3.2 Terraces

It is widely debated whether terraces can reduce the occurrence of erosion. The theory is that terraces reduce the speed that water travels down a slope, reducing the flow of water, which equates to erosion mitigation. This may be the case if the terraces are implemented correctly. However, if the terraces are neglected or improperly planned, the chance for erosion occurring increases.

Picture 15. Terraces at Bowker Vineyards covered with grass and jute netting

Picture 16. A Central Coast vineyard terrace where a large rill formed during the early winter rain.

Carl Bowker of Bowker Vineyards is currently replanting a vineyard in the Westside Paso Robles area. There are several terraces in this area that were in place before he took over the property. Mr. Bowker reinforced the terraces by spreading grass seed over the slopes, then covering the newly seeded slopes with jute netting. This helps to ensure that the seed and soil stays in place during windy and rainy periods before the seed has a chance to germinate. These terraces have very little visible erosion due to these BMPs. These BMPs at this vineyard have been in place for approximately one year. The BMPs implemented here have the potential to last a significant number of years if properly maintained.

One of the most likely points on a terrace where erosion could occur is the place where two slopes of a terrace meet. Water will flow to this location, collect, and then run down to the next terrace. Likewise, water will collect at the next level and flow to the next terrace. If the rainfall is heavy enough, a rill can form and potentially produce erosion issues. This is what occurred in the during the recent New Year's winter storm (Picture 16). The erosion on this terrace (a non project site) took place where two very slight slopes meet. You can see from this photo that water gathered and flowed down to the next terrace until a large rill was produced. It appears that some minor erosion control measures were put in place at the top terrace; however, they were not sufficient to cope with the rainfall produced from early new year's storms.

While the initial cost for the jute netting and seed was more costly than the less intensive and common grading operations to level the land at a favorable slope, the long-term benefits of reduced soil loss, and decreases in possible sediment runoff into nearby streams combined with the increased cost to repair the less protected terraces, outweigh the initial cost of prevention. In the long term it is better to spend the money upfront and receive the benefits of the erosion control than to pay later in soil loss and increased labor and repair costs. Additionally, there is a potential for poorly maintained terraces to erode away, thus washing away productive vines.

7.3.3 Roads

Jean-Pierre Wolff, of Wolff Vineyards re-graded a hillside road in his vineyard. The soil used to re-grade the road before the storm was extremely loose and dry. Mr. Wolff had concerns about how the newly placed soil would sustain the winter weather. After some discussion between him and the CCVT project staff, it was decided to broadcast a low cost erosion control seed mixture over the road which was then covered with rice straw provided by the Californian Conservation Corps.

Pictures 17 and 18. The vegetative and straw cover on the road has effectively kept the soil in place after new years storm.

Pictures 19 and 20. The newly placed regraded soil before the Best Management Practice (BMPs) was implemented.

The erosion control mixture was 75% dwarf fescue and 25 % wild oat at $0.95/lb. The erosion control measures were implemented during early December 2005, before the winter rain arrived. He also took several measures to ensure the success of the erosion control practice. First, there was no driving allowed on the road until the cover was well established. Second, after the cover was established, only the Gator all-terrain vehicle and a tractor with float tires (reduces compaction during wet weather) were allowed to drive on it.

CCVT staff visited the site just after the reconstruction of the road took place. A second visitation took place after most of the winter rains to evaluate the establishment and effectiveness of the BMP. As seen in the photos above, the structure of the road held up well. The amount of grass in the middle of the road was not as dense as the growth on the outer edges of the road. However, the few bunches in the middle and the two strips on the edges of the road held the soil in place, thereby reducing erosion. The rice straw added protection to the seeds in order to assist in their germination, and also minimized the energy of the raindrop on the new soil during the storm event. Jean-Pierre was very impressed by the way the road held especially for the low cost of materials used for the cover. This grower was able to overcome common obstacles with implementation of these practices and these lessons were shared with other growers. Highlighting success stories of implementation of practices that protect water quality is an important aspect of this project and CCVT programs.

7.3.4 Filter Strips

Paul Kenny at Hog Canyon in Paso Robles, California, planted filter strips five to eight feet in width, comprised of barley and ryegrass, throughout his vineyard. The filter strips were planted on roads that were on the down slope of the ranch and, therefore, most capable of trapping sediments. The roads also surround the outer edges of the vineyard that borders a habitat that surrounds a riverbed. The filter strip has two strips of grasses planted, one on either side of the road, with the middle remaining bare. The filter strip closest to the vineyard was eight feet long, and the filter strip on the outer edge of the row was approximately five feet long. The main purpose of a filter strip is to trap the chemical, nutritive and other sediment-bound particles from moving into nearby water systems. The filter strip provides a pathway where the flow of water is uniform through the vegetation, instead of conditions were the flow is concentrated into rills or gullies, increasing the rate of flow. This means that the time for sediments to settle out of the water within a filter strip is increased.

Picture 21. Filter strips in place at Hog Canyon

Consequently, the likelihood of sediment bound particles to move off-site into nearby watersheds is decreased. Not only is the possibility of non-point source pollution reduced with this filter strip, but the uniformity and integrity of the road is likely to be maintained due to the uniform flow of the water through the filter strip to the road. If rills or gullies are allowed to form, the smoothness of the road is decreased which can cause increased maintenance cost for machinery and augment exhaustion levels in employees due to the continued jostling in vehicles or tractors.

The BMPs mentioned above are only some of several solutions that can be used to prevent erosion. These methods are not always infallible; they do, nevertheless, provide valuable protection where there was none in the first place. Each of them provide some sort of soil stabilization and cover, thereby reducing erosion and protecting water quality resources.

7.4 PESTICIDE EVALUATION IN SURFACE WATER RUNOFF

7.4.1 Stormwater Runoff Evaluation

7.4.1.1 Introduction

Water quality monitoring is an important component of CCVT's PRISM grant. During the winter of 2005-2006 CCVT project staff set up two sites to measure in field surface water runoff for simazine, a pre-emergent herbicide.

Simazine has been linked to ground water contamination (Turner 2003), and has been found in California drinking water sources since the early 1990's (Lam et al. 1994). The increased focus on simazine usage is due to its potential threat to aquatic organisms and its increased usage in agricultural systems over the past few years.

Central Coast winegrape growers have led the way in promoting herbicide reduction strategies and technologies. However in 2003, over 19,000 lbs of simazine were applied to wine grapes on the Central Coast (DPR 2003). As the winegrape industry is in a time of oversupply and lower prices for grapes, it is likely that growers will continue to use highly effective, high risk, and affordable materials. Nevertheless, CCVT works closely with growers to educate them of the issues with high risk materials and demonstrate alternatives to these materials that potentially threaten water quality.

This experiment aims to characterize the movement of simazine within field surface water runoff in Central Coast Vineyards. This report will discuss the methodology and the findings.

7.4.1.2 Materials and Methods

Surface water runoff monitoring took place at Chalk Knoll Vineyards in San Ardo, California and Sunnybrook Vineyards in Paso Robles, California during the 2005-2006 rainy season. Three plots were treated with simazine and three plots were treated with Flumioxazin, a reduced risk herbicide, which acted as the control on February 22nd 2006. Experimental plots consisted of four treated rows. The inner two rows have a collection bucket placed at the lower portion of the vineyard. The bucket was dug into the ground so that the top of the bucket was flush with the surface of the ground.

Picture 22. View of the interior of the collection bucket. This bucket is used for field duplicates.

Picture 23. Top view of the collection bucket in the ground

Picture 24. The automatic grab sampler used in the trial.

The collection bucket had a plastic mesh guard surrounding the bucket to keep out any debris and then had lids placed over them to keep out any natural rainfall that might occur (Pictures 22 and 23). Water was gathered from the collection buckets using an automatic storm water sampler from Global Water model SS201 (Picture 24). Hoses from the Automatic Storm Water Sampler were placed flush against the bottom of the collection tub (Picture 22). An electric sensor triggered the pump within the automatic storm water sampler to start collection. This was accomplished by water completing the circuit between the two electrodes of the electric sensor. The electrode was placed at the bottom of the bucket to get the first flush from the storm.

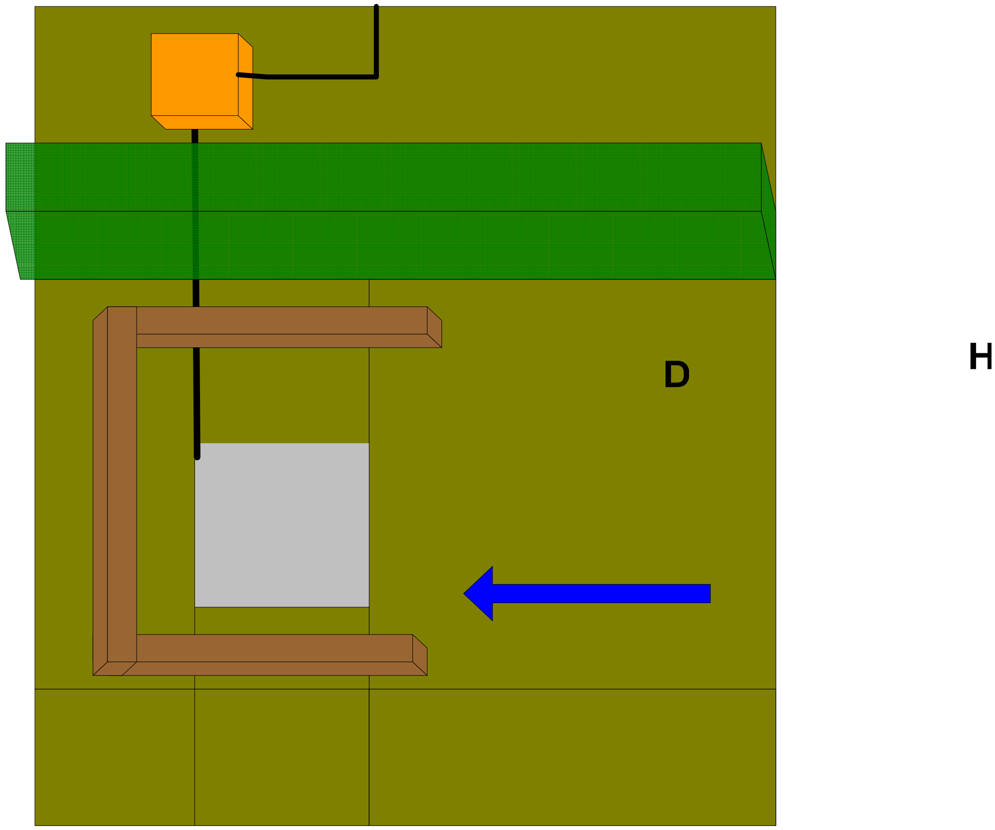


Figure 1. Schematic diagram of the field set up with equipment for the trial. All parts of the diagram are labeled and listed above. A: 7 Gallon rectangular (12 x 12 x 12") Nalgene Tub- Used to collect surface water runoff during storm events. Consists of rectangular plastic bottom and a rectangular fitted top. Fitted top is raised ¾" from the base by four wooden dowels glued to the undersurface of the lid. Tub is anchored into the ground by metal steaks.

B: Plastic Mesh Filtration Device- Used to cover the lid and opening of the collection device to prevent large pieces of debris from traveling into it. Held in the pyramid shape by a 3 ft. metal garden steak. Mesh is made of fiberglass with 1x2 mm holes.

C: Bern- Constructed of dirt at the end of the vineyard row. There to assist in the collection of runoff during storm events.

D: Automatic Storm Water Sampler (SS201) from Global Water Instrumentation: Used to collect water samples for analysis. One liter samples collected during runoff events. Collection is triggered at a standard level by a buoyant trigger in the initial Collection device (A). One sampler is able to collect samples from two collection tubs (A).

E: Collection hose (approx 25ft in length) that runs from the initial collection device (A) to the automatic sampler (D) This tube will be protected by PVC coating.

F: Vineyard Floor

G: Vine row

H: Hose from automatic sampler to second collection tub with the same set up.

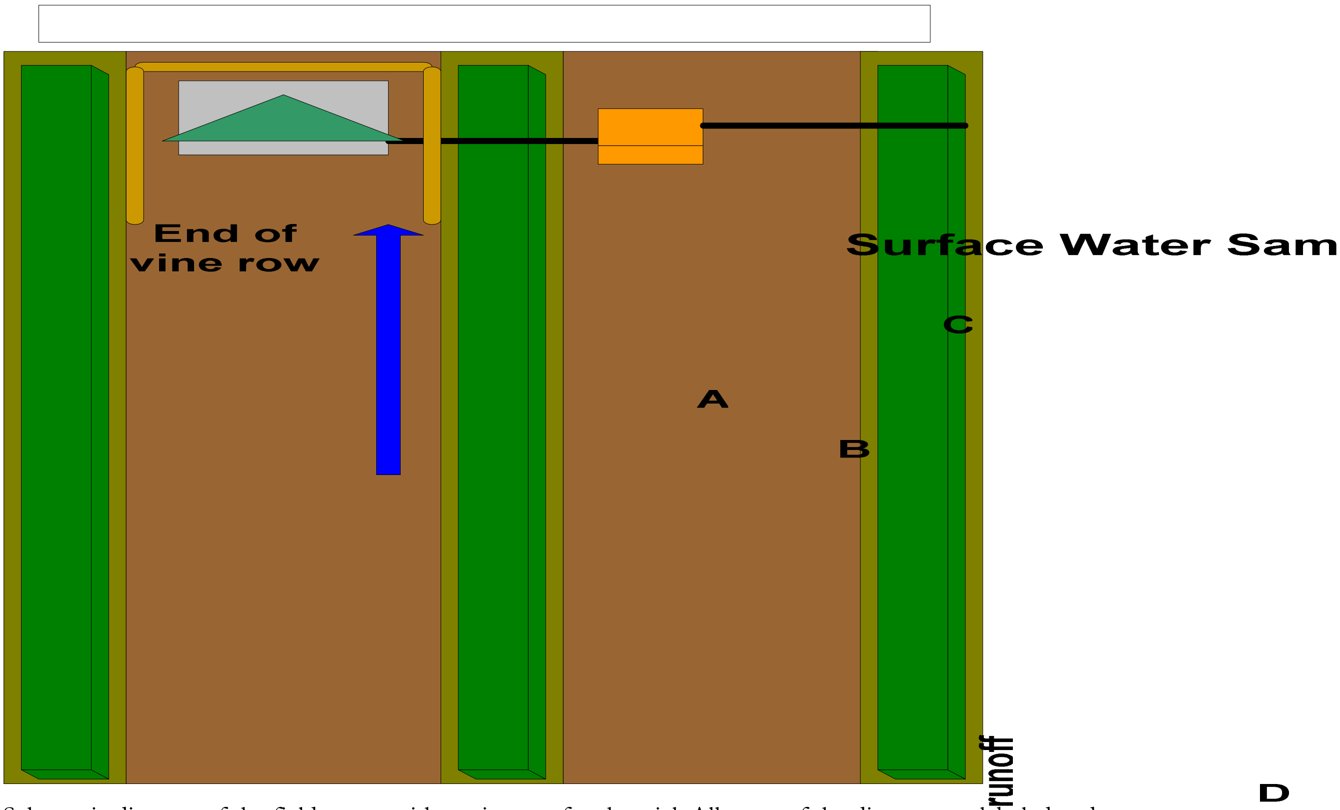


Figure 2. Schematic diagram of the field set up with equipment for the trial. All parts of the diagram are labeled and listed in Figure 1.

Sites were monitored for rainfall using a combination of weather stations at the site and web based weather sources (wunderground.com and weather.com). When a storm event produced over 0.5" of rainfall and passed over the project site, field staff visited the site to check the effectiveness of the automatic samplers. During the field visit, notes on rainfall amounts, amount of water in the tubs and the amount of water collected by samplers were noted. Site conditions and any malfunction of the equipment were also noted.

Where 1L or greater of water collected, field staff took the sample and poured it into a 1L amber bottle. The bottle was then bubble wrapped, placed in a cooler at 4ºC and shipped to Creek Labs for analysis using EPA method 619 for simazine quantification.

In between storm events, all equipment was cleaned using a triple rinse method with de-ionized water. This was to ensure that the material collected was from a particular storm event and not carry over from one storm event to the next.

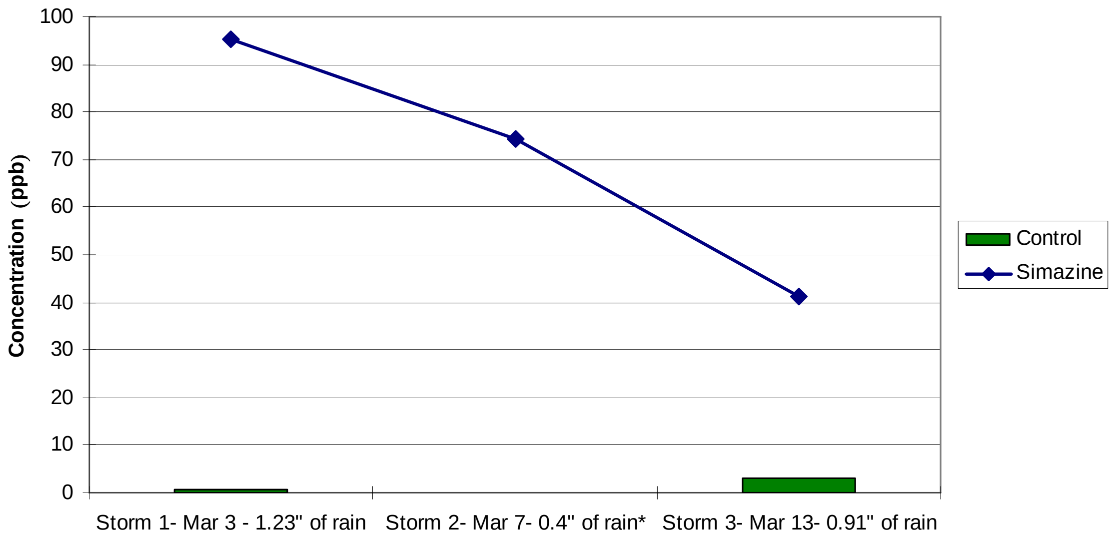
7.4.1.3 Results

<u>Chalk Knoll Vineyards</u>

Chalk Knoll Vineyards did not produce enough surface water runoff throughout several major storm events. Therefore, there was no water monitoring data collected.

Sunnybrook Vineyards

As can be seen in Graph 19, there is a decline in the concentration of simazine found in the surface water runoff from one storm event to the next at Sunnybrook Vineyards. The control plots that had simazine residues did not show a trend. During the second storm event, there was not enough water produced in the tub for a sample, therefore a trend can not be determined.



Graph 19. Concentration (ppb) of simazine within the in field surface water runoff from one treated plot and 2 control plots. The asterisk next to the information on the second storm event indicates that there was not enough surface water runoff produced in the control plot.

Table 6. Information on the tubs at the Sunnybrook Vineyard trial. SNYTub5 is the only tub in the simazine treated plots that collected enough surface water runoff from one storm event to the next for analysis. SNYTubs 1 and 4 were the only tubs from the control plots to collect enough water from one storm event to the next for analysis.

Client Sample	CCVT gathered sample	Simazine Concentration (ppb)	MRL	Units	Rainfall(in.)
SNYTub5Stm1	3-Mar	99.70	0.5	ppb	1.18
SNYTub5Stm1dup	3-Mar	90.60	0.5	ppb	1.18
SNYTub4Stm1	3-Mar	1.58	0.5	ppb	1.25
SNYTub1Stm1	3-Mar	0.00	0.5	ppb	1.3
Lab Blank		0.00	0.5	ppb	x
SNYTub5Stm2	7-Mar	74.30	0.5	ppb	0.4
Lab Blank		0.00	0.5	ppb	x
SNYTub5Stm3	13-Mar	37.60	0.5	ppb	0.9
SNYTub5Stm3Dup	13-Mar	44.50	0.5	ppb	0.9
SNYTub4Stm3	13-Mar	4.01	0.5	ppb	0.95
SNYTub1Stm3	13-Mar	2.24	0.5	ppb	0.9
SNYtripblkStm3	13-Mar	0.00	0.5	ppb	x
Lab Blank		0.00	0.5	ppb	x
SNYEqBlk	9-Mar	0.00	0.5	ppb	
Lab Blank		0.00	0.5	ppb	

7.4.1.4 Discussion

Sunnybrook

The data in Graph 19 show a trend in the concentration of simazine in the surface water runoff decreasing from one storm event to the next. This type of trend is expected to occur. As one storm event washes away the targeted material, the concentration within the environment becomes diluted, and some material has washed away. Therefore, during the next storm event, there is likely to be less of the target material in the surface water runoff.

Although the data shows a trend in the concentration of simazine leaving the research plot, no conclusive results can be made about the data. This is because only one of the three replicates for each treatment gathered enough water from each storm event to make any interpretation about the concentration of the material coming off the site.

The variability in this set up was too large to make a comparison between treatments. Even though the collection tubs were not separated by much distance, there was still a large amount of variability in the volumes of water collected by each tub. While one tub would collect a significant amount of water in one tub, the tub 5 rows over would collect no surface water runoff. This shows how large scale setups could potentially increase the variability in the data. As the area of the trial expands, it is likely that more factors that influence the movement of water come into play.

Chalk Knoll Vineyards Discussion

At Chalk Knoll Vineyards there was never enough water produced in any of the plots to evaluate the surface water runoff for the target material. One of the factors that potentially contributed to the lack of surface water runoff was some of the cultural practices implemented at the site. Prior to the winter rainy season, the vineyard manager at this site ripped and cultivated every other row. This caused the soil next to the experimental plot to act like a sponge. The soil, being highly absorbent, did not allow the accumulation and pooling of water that eventually leads to surface water runoff.

Conclusion

The size of these trials led to many of the obstacles faced throughout the sampling period. In order to accurately measure the effect of surface water runoff, the scale of the trial needed to be smaller, and a system that more closely measures the movement and volume of water collected needed to be implemented. Another component that should have been taken into account is the inherent variability that is produced by natural rainfall. It is likely that the intensity of a storm varied from one part of the system to the next. This adds to the likelihood that the data collected was variable.

In order to effectively measure this movement, future efforts will focus on the utilization of a system that is based on a smaller scale, where the volumes of water can be tracked, where the data produced has consistency and provides information from each of the replications.

7.4.2 Simulated Rainfall Runoff Evaluation

7.4.2.1 Introduction

During the winter season of 2005-2006 CCVT set up several trials to evaluate the movement of chlorpyrifos and simazine in the surface water runoff during storm events in vineyards. Throughout this period, the storm events were not big enough to produce sufficient amounts of runoff water consistently between plots, and between two sites. Only one site produced enough water to evaluate the movement of the target material during three storm events. However, the data obtained was from only one replicate, and was therefore not sufficient to make any conclusive evaluations.

Because of the aforementioned obstacles, CCVT consulted with the technical committee and it was decided to build a rainfall simulator. The rainfall simulator (RS) allowed CCVT staff to generate artificial storms in a controlled environment in order to obtain consistent data which in turn helped characterize the movement of the target material at a particular site.

During the months of March and April, significant progress was made on the monitoring of surface water runoff for the presence of chlorpyrifos and simazine at two different sites. The following report addresses the materials and methods, and interprets the results.

7.4.2.2 Materials and Methods

Rainfall Simulation and Water Collection

To characterize the movement chlorpyrifos and simazine in field surface water runoff during simulated storm events, a replicated trial was set up on two typically managed hillside vineyards. A rain simulator was built based on a design by Battany and Grismer (2000 a and b) and was used to simulate the storm event. Runoff rates from each plot were evaluated through volumetric measurements taken at two minute intervals. Water from the storm events were collected and gathered in 1L amber bottles, which were then sent to Creek Environmental Labs for analysis. Chlorpyrifos was analyzed using EPA method 8141. Simazine was analyzed using EPA method 619. In addition to the water samples collected, equipment blanks, and field blanks were collected to ensure that the water and equipment used during sampling was not contaminated with the target materials.

Simulated rainfall events mimicked one-hour, 100-year storm for the area where the study was conducted. Information on the storm intensity for the area was gathered from the National Oceanic and Atmosphere Association Atlas (NOAA) 2, which can be accessed online at: http://hydrology.nws.noaa.gov/oh/hdsc/noaaatlas2.htm.

The chlorpyrifos trial was conducted at Paragon Vineyards in Edna Valley. At this site there were 12 rows treated with chlorpyrifos at 2lbs. a.i. (active ingredient in the solution)/acre, and 12 untreated rows acting as the control. Because this material is applied to the trunks during winter, the collection trays were placed in between vine rows where spray drift of this material occurs. Four plot frames, each acting as a replicate were placed in one row to minimize the variation between replicates. All sampling equipment was triple rinsed with de-ionized water between each storm event. When the project staff moved the simulator from the treated site to the untreated control site, sampling equipment was either replaced or rinsed 5 to 6 times with de-ionized water. A newly constructed plot frame was utilized in the control plots so that cross contamination between the plots treated with chlorpyrifos and the control plots was eliminated.

The simazine trial was conducted at Sunnybrook Vineyards in Paso Robles. At this site there was 1 row treated with simazine at a rate of three pounds per acre with a backpack sprayer, and 1 row left untreated acting as the control. There were 4 replications per treatment, all placed within one row in order to minimize variability among the replicates. The control plot replicates were conducted first. The rain simulation for the simazine plot took place one day (24 hours) after the simazine application to represent a worst case scenario.

Because of the inherent variability that comes with field trial, several other measurements were made to identify and minimize these potential sources. The methodologies used to evaluate these variables are discussed in sections 7.4.2.2.2 and 7.4.2.2.3.

Slope

Slope within the plot was determined through the use of two, one meter sticks joined together at one end with a bubble gauge on each stick to ensure it was level at the time of the measurement. When the bubble gauge was level, the height from the bottom of the plot to the top of the plot was measured. Then, the leveled length from the top of the plot to the front of the plot was measured. From this, the degree of slope was determined.

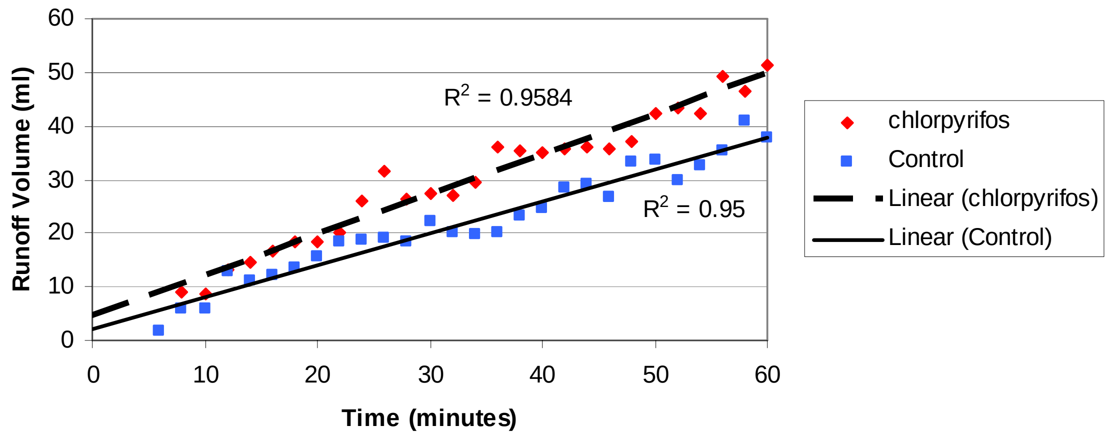
Ground Cover Assessment

The amount of ground cover (i.e., vegetation, plant residues, pruning residues, rocks, etc.) can lead to variability within the plots. In order to determine the variation in ground cover between plots, equipment developed at Cal Poly San Luis Obispo Biological Resource and Agricultural Engineering Department was used. This equipment utilizes 10 lasers in an 80 point analysis. The point at which the laser hits the ground was evaluated as bare ground or cover. If there was cover then the type of cover was identified. The amount of hits by the laser out of 80 was then used to determine the percent cover.

7.4.2.3 Results

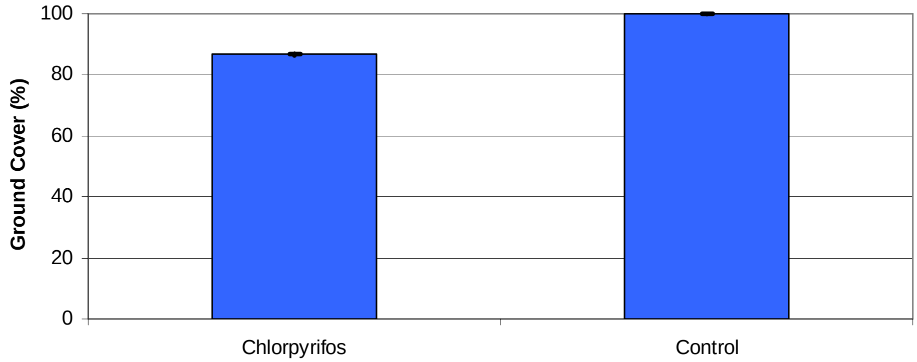
Edna Valley Project Site: Chlorpyrifos Monitoring

The runoff rate (ml/min) for the chlorpyrifos plot was 0.78ml/minute and the runoff rate for the control was 0.58 ml/minute (Graph 20), which were not significantly different. Runoff rates were properly described using linear regression ($r^2 > 95\%$) and no significant differences were observed between the chlorpyrifos and control treatments.



Graph 20. Surface water runoff rates for the untreated control plots and treated chlorpyrifos plots in Edna Valley California in 2007

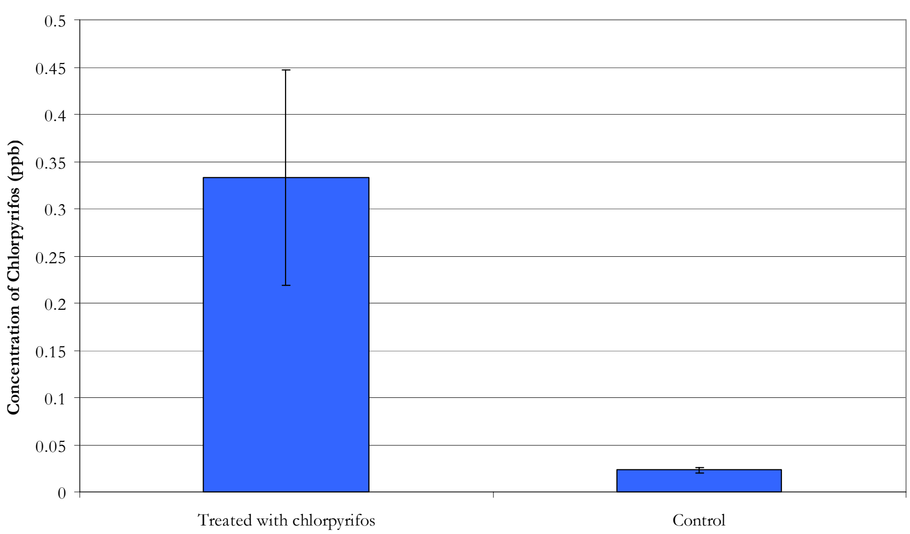
The chlorpyrifos treated plots had an average of 86.6% ground cover and the control plots had an average of 100% ground cover (Graph 21). The percent cover of the two treatments were not significantly different using simple T-test.



Graph 21. Percent ground cover comparison between the untreated control plots and plots treated with chlorpyrifos in Edna Valley California in 2007. Error bars represent standard error of the mean (s.e.m.)

The average plot slope for the chlorpyrifos treated plots was measured at 8.7 degrees of slope and the control plots were measured at an average of 9.8 degrees of slope. The slopes were not significantly different using a 2 sample T-test.

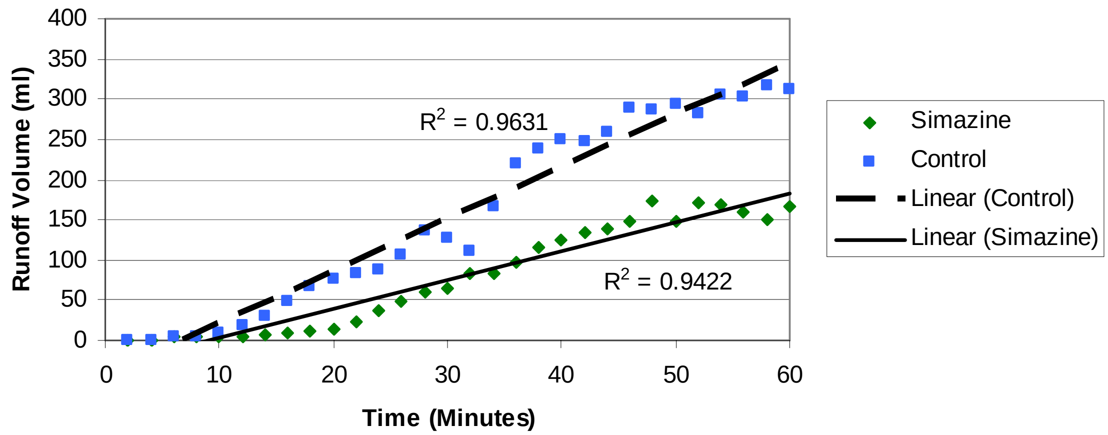
The concentration of chlorpyrifos was measured in the surface water runoff in the plots treated with chlorpyrifos, and the control plots not treated with chlorpyrifos. The average concentration of chlorpyrifos in the surface water runoff of the chlorpyrifos treated site was fifteen times greater than the control. The concentration of chlorpyrifos in the surface water runoff of the site treated with chlorpyrifos was 0.33 ppb and 0.02 ppb in the untreated sites (Graph 22). The differences in the amount of chemicals found were not significantly different due to one collected value in the chlorpyrifos plot being zero. This zero was not likely an outlier, but if this data point were removed from the analysis, the data was much more consistent.



Graph 22. Concentration (ppb) of chlorpyrifos in surface water runoff from a 0.8m^2 plot frame during a 1 hour 100 year simulated storm event in the Edna Valley, California in 2007. Error bars represent s.e.m.

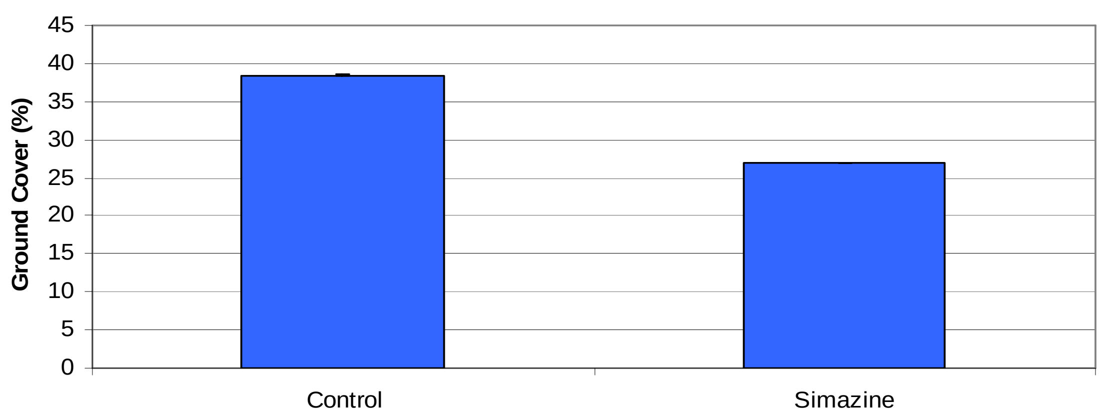
Paso Robles Project Site: Simazine Monitoring

The runoff rates (ml/min) for the simazine plots were 3.61 ml/minute and 6.5 ml/minute for the control plots (Graph 23). The rates were not significantly different. Runoff rates were properly described using linear regression ($r^2 > 94\%$).



Graph 23 Surface water runoff rates for the untreated control plots and treated simazine plots in Paso Robles California in 2007

The percent cover was evaluated for the simazine treated plots and the control plots. The simazine treated plots had an average of 38.4% ground cover, and the control plots had an average of 26.9% ground cover (Graph 24).



Graph 24. Percent ground cover comparison between the untreated control plots and plots treated with simazine in Paso Robles, California in 2007. Error bars represent s.e.m.

The average plot slope for the simazine plots was measured at 68.2 degrees of slope and the control plots were averaged at 67.2 degrees of slope and were not significantly different.

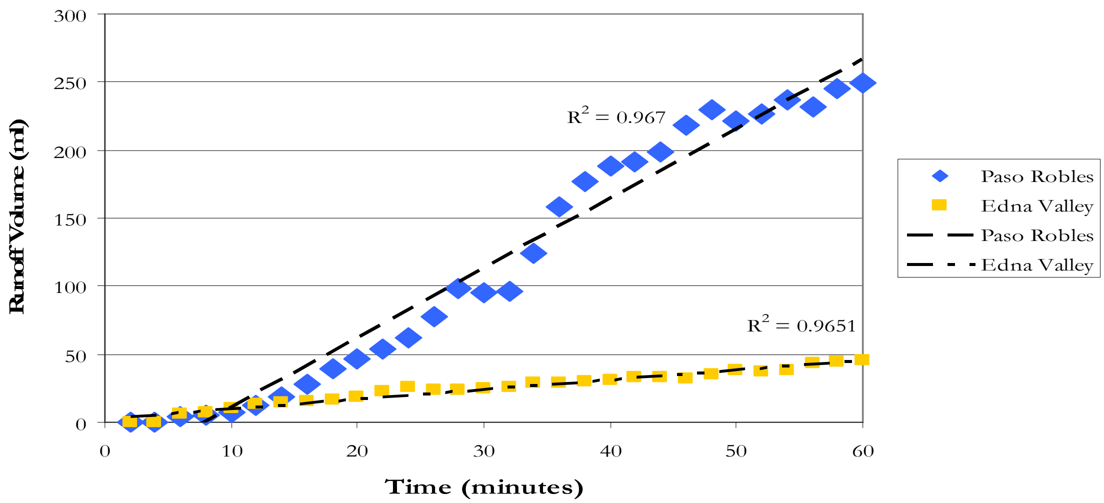
Table 7. The average concentration (ppm) of simazine in surface water runoff during a 1 hour 100 year simulated storm event in Paso Robles, California, 2007.

Treatment	Simazine	Control
Concentration (ppm)	2.84 + s.e. 1.1	0

The concentrations from the simazine plots (Table 7) were significantly different at the 90% confidence interval.

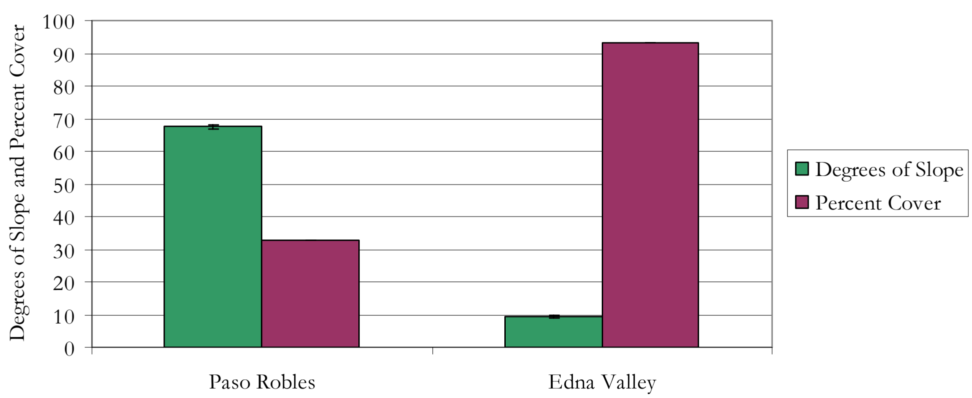
Site Comparison: Runoff Characteristics from two different Central Coast Vineyards

Two runoff rates are compared in Graph 25. The runoff rate from the Paso Robles site is greater than the Edna Valley site.



Graph 25. Surface water runoff rates from two Central Coast, Californian vineyards in 2007 during a 1-hour 100-year simulated storm event. One rate is from the Paso Robles site, in blue, and the other rate is from the Edna Valley site, in yellow.

There is a visible difference in the average degrees of slope between the Paso Robles site and the Edna Valley site (Graph 26). The Paso Robles site has a much greater slope than the Edna Valley site. In addition, the Edna Valley site had a greater amount of ground cover compared to the Paso Robles site. Both of these factors influenced the difference in runoff between the two sites.



Graph 26. Average degrees of slope and average percent cover evaluation for each of the project sites.

7.4.2.4 Discussion

Edna Valley Project Site: Chlorpyrifos Monitoring

Surface water runoff rates and total volume between the two treatments were fairly similar. The increased amount of water coming off of the chlorpyrifos was thought to be a result of less vegetation when compared to the control plot (Graph 21). Certain species of cover crops have been shown to increase the infiltration rate of the soil. This is accomplished through the improvement of the soil structure leading to reduced penetration resistance and increased water infiltration (USDA 2001a). What was evaluated, but is not shown in the results, is the difference in the type of vegetation. The chlorpyrifos treated plots had a larger number of weeds acting as the vegetative coverage in comparison to the control plots which were mostly comprised of grasses. These weed species generally have one tap root with an expanse of above ground biomass. The grasses generally have an expansive root system providing the soil with greater structure, which in turn could lead to increased infiltration rates.

Furthermore, if there is a greater amount of exposed soil, there is a larger potential for runoff and erosion through several mechanisms. For water erosion there are two general mechanisms: splash and sheet erosion. Splash erosion is the detachment and airborne movement of small soil particles caused by the impact of raindrops on soil. Sheet erosion is the result of heavy rain on bare soil where water flows as a sheet down any gradient, carrying soil particles with the movement of water. The greater the area of exposed soil the greater chance there is for these two types of erosion to take place (USDA 2001b).

Due to the similarity in degrees of slope for the different plots, it can be assumed that the slope did not have an effect on the volume of runoff rates. This can be further substantiated by the fact that the control plots had a steeper slope than the treated plots but did not have more water running off of them.

However, after a statistical analysis of the data there were no significant differences in the site characteristics, and the volumes of water running off the site. Therefore, the site and volume of runoff did not impact the concentration of chlorpyrifos in the surface water runoff.

During the monitoring of surface water runoff for chlorpyrifos, several obstacles were faced. Chlorpyrifos is applied during the dormant season, and there is a narrow window for application. The material was applied on January 25th 2007. After the material was applied it rained for approximately 4 days totaling 1.4 inches of rain. During this period, project staff could not access the project site due to the restricted entry interval for the material and the wet ground. Additionally, the RS was not fully constructed at the time of application. This meant that the commencement of the trial was put on hold and the material was still exposed to the elements for an extended period of time. In order to protect the target materials from the elements, tarps were laid over the treated site so that the material would still be there upon testing.

Obstacles continued to occur with the RS at this project site. CCVT project staff eventually fixed all problems and moved the RS into the field. Once the RS was available for evaluation, the tarps had been on the experimental plots for approximately two months. During this time, the inhibition of light to the experimental plots severely altered the ground cover characteristic from the treated plot to the untreated plot. The untreated plots were not covered so they had full sunlight during this period of time. Hence, it was decided to not use the plots that had been covered by tarps. This was decided because CCVT project staff considered it important to measure the runoff and the concentration of the material in an unaltered environment. Also, in order to compare the treated and the untreated plots, the ground cover needed to be similar. This could only be accomplished if the monitoring site was moved slightly downhill to a spot that had not been covered with a tarp for two months. The new monitoring site, slightly downhill, was very similar to the original site. The only difference between the original site and the new site, is that the new site had more ground cover due to the grass being exposed to the sunlight, as opposed to being covered by a tarp, which inhibiting the growth of the grass.

The concentrations of chlorpyrifos coming off the treated plots compared with that of the untreated plots were fourteen times higher in concentration, but were not significantly different. The control plots, which had not been treated in 2007, but were treated the previous year, still had chlorpyrifos detected in the water samples. This is explained by two possible mechanisms. Firstly, the material was persistent in the environment from one year to the next. Secondly, the levels seen in the control plot are the same as the equipment blanks and are, therefore, not moving in the surface water runoff because there may have been a case of cross contamination during the movement of the equipment from the treated site to the untreated site. Therefore, the concentration of the material may have been located somewhere on the sampling equipment and not in the water moving off the test plots.

Species	Rainbow Trout	Lake Trout	bluegill
LC50*	0.9ug/L	98ug/L	10ug/L
Concentration from project site (0.33ug/L) exceeds these levels	No	No	No

(From Extoxnet: Extension Toxicology Network. Pesticide Information Profiles: Chlorpyrifos)
* LC50 is defined as the Median Lethal Concentration - the concentration of material in water that is estimated to be lethal to 50% of organisms. The LC50 is normally expressed as a time-dependent value, eg 24-hour or 96-hour LC50, the concentration estimated to be lethal to 50% of the test organisms after 24 or 96 hours of exposure.

It needs to be taken into consideration that even though the levels seen in this experiment are not considered to be toxic to the aquatic species mentioned above and that the evaluations were done approximately one and a half months after the application took place. During this time, several rainfall events took place, which likely washed away some of the target material. Therefore, it could be deduced that the concentration of the target material in the surface water runoff could potentially be higher if the simulation was conducted immediately after the application of the material.

Chlorpyrifos moves mostly with soil particles. It was observed in this experiment that the movement of soil with the surface water runoff was minimized due to the extensive vegetative cover in the plots of the treated and untreated plots.

<u>Paso Robles Project Site: Simazine Monitoring</u>

The surface water runoff rates and volumes between the two treatments at this site were fairly similar. The control plots had slightly higher runoff rates and total volume of surface water runoff, but they were not significantly different. This was thought to be attributed to the percent coverage difference between the plots. The control plots had approximately ten percent more cover in comparison to the simazine plots. This increase in cover can minimize the energy of the raindrop on the soil surface. This leads to a decrease in the amount of soil and water runoff from the plots. The cover can also act as a barrier to the movement of water along the soil. For example, if water was pooling in a given spot and begins to drain into a channel, a pruning cutting or a weed may slow or stop the movement of the water in that channel, thus minimizing the runoff. However, upon analysis, the percent cover between treatments was not significantly different. The degrees of slope did not influence the volume of runoff, as the difference in slope between the two treatments was about a 1 degree difference and were not significantly different.

As this was the second site that the rain simulator was used at and field staff had performed a dozen replicates at a previous site, and most equipment glitches were fixed, there were little to no obstacles at this site.

Simazine is a selective herbicide and has been shown to be slightly to moderately toxic to fish and aquatic invertebrates, and is highly toxic to vascular plants. Modeling of potential simazine estimated environmental concentrations (EECs) indicates that with the highest application rates, the most vulnerable soils and a very high runoff potential, the upper percentile EECs do not exceed any level of concern (Turner 2003). EECs are used by the Environmental Protection Agency (EPA) and Office of Pesticides (OPP). OPP uses a variety of chemical fate and transport data to develop EECs from a suite of established models, such as GENEEC, PRZM-EXAMS. The highest level of EEC from the PRZM-EXAMS model is 0.1122 ppm for two applications of 4 lbs/ai/acre of simazine in Florida Citrus. Florida citrus is intended to yield the highest EECs nationally for citrus. California citrus should be much less (Tuner 2003). In the Central Coast, citrus could be planted in areas where grapes would likely be planted. Additionally, for grapes in California, the label rate only allows one application at a maximum of five pounds per acre. Therefore, it could be assumed that the EECs for simazine in California grapes are lower than the EECs for Florida Citrus. Furthermore, the models used by OPP to get the EECs are on farm models and provide levels for first order streams. It can therefore be assumed that larger streams, rivers and lakes will likely have considerably lower concentrations of pesticides due to dilution by the receiving waters (Turner 2003)

The concentrations of simazine coming off the test plots are high (Table 7). Sharply and Kleinman (2003) stated that concentrations of target materials are likely to be higher in smaller test plots. The methodology used in this study, due to its small and compact size, may not be the best method to quantify the actual movement of pesticides within the vineyard. The small scale effect on the concentration of materials is similar to a study conducted by Troiano and Garretson (1998) where they found simazine moving within an orchard system at levels one-third of what was seen in CCVT's test plots, and the test plots were approximately fifteen times greater in size than the test plots used in the CCVT study. However, due to the limitations of many other sampling systems, this may be one of the best options to qualify the potential for movement of materials within the vineyard.

This site represented an extreme, worst case scenario for the evaluation of the movement of this material. The slope at this site is greater than, although not uncommon to, most other vineyards in the Paso Robles area. The intensity of rainfall was equal to a 100 year storm and, therefore, a lot of rain was produced. The rainfall took place one day after the application of the material. It is recommended to apply pre-emergent herbicides before a light rainfall event in order to incorporate the material into the soil profile. Most growers are able to time this application with a light rainfall event. However, a light rainfall event can easily transition into a heavy storm without warning. Additionally, it is exceedingly rare that rain would fall only on the area that had been treated. Therefore, the runoff water from an entire area would provide substantial dilution to the simazine in the runoff water from a field.

Another element that should be considered in terms of the toxicity to the surrounding environment is that these measurements were done in the field. This is the movement of the materials within the field, and is not necessarily what is moving off site into nearby waterways. Chemicals are continually moving within a field, and do not necessarily pose a threat to waterways. If the area treated with simazine were directly near a waterway, then it could be suggested that there is a potential for high concentrations of this material to move into the water body. However, most vineyards are not planted directly next to a waterway especially with such an extreme slope. Furthermore, there are often some sort of vegetative buffer zones between vineyards and waterways within a vineyard. This buffer zone helps to minimize the movement of surface water runoff and thus minimize the movement of these materials in the surface water runoff.

The lowest LC50 for technical simazine is 6.4 ppm for fathead minnow. OPP's level of concern for endangered species is 0.05 times the LC50. Thus, OPP would consider endangered fish to be at acute risk when simazine concentrations exceed 0.320 ppm (Turner 2003). The most sensitive aquatic invertebrate acute study is and EC50 of 1.1 ppm for *Daphnia magna*. OPP's criteria consider that an EEC greater than 0.5 times the LC50 could have an effect on populations of aquatic invertebrates that may serve as a food source for listed fish. Therefore, concerns for indirect effects on the food supply for fish would occur at concentrations greater than 0.550 ppm (Turner 2003). The most sensitive aquatic vascular plant data is an EC50 (EC50: Effective concentration; the dosage at which the desired response is present for 50 percent of the population) of 0.140 ppm for *Leman gibba*. OPP's criteria consider that an EEC greater than the EC50 could have an effect on populations of aquatic plants that may serve as a cover for listed fish (Turner 2003).

Table 8. The lowest and highest standard acute toxicity tested for simazine for several different species

Species	Scientific Name	% a.i.	96-hour LC50 (ppm) Mininmum	96-hour LC50 (ppm) Maximum	Toxicity Category	Reference
Fathead minnow	*Pimephales promelas*	Technical grade	6.4		Moderately toxic	EFED*
Fathead minnow	*Pimephales promelas*	98.1		>100	Practically non-toxic	Bathe et al., 1975
Water Flea	*Daphnia magna*	98.1	1.1 (48hr)		Moderately toxic	EFED (Johnson and Finley, 1980)
Water Flea	*Daphnia magna*	98.1		>10	Slightly toxic	EFED

*EFED: EPA Environmental Fate and Effects Division

Table 9. Acute toxicity of simazine to two green algae.

Species	Scientific Name	% a.i.	Length (Days)	EC50 (ppb)	Reference
Green Algae	*Dunaliella tertiolecta*	98	10	5000	EFED
Green Algae	*Chlorella fusca*	98	1	73	Turner, 2003

*EFED: EPA Environmental Fate and Effects Division

Tables 8 and 9 illustrate the toxic levels for several different species. These levels can be compared to the detected levels in Table 7. There can be comparisons made in terms of the toxicity of the concentrations found in the simulated plots from the Paso Robles site to the toxicity levels in tables two and three. In certain instances, there are some toxic levels. However, much of the prior discussion about the methodology needs to be taken into account.

Vineyards and other agricultural commodities generally coexist in the Central Coast of California. Vineyards are typically planted on hillsides, and the other agricultural commodities, for example, vegetable production, lay in the lowlands and valleys beneath these vineyards. Given that CCVT's experiments showed that simazine is moving with heavy rainfall events, growers may want to consider not applying simazine on a hillside, where the deposition of the chemical into the vegetable field during a heavy rainfall event may take place. Due to the small size of the plots, it is difficult to extrapolate the information to a larger scale. Therefore, the concentration of simazine moving in CCVT's study may not translate to the naturally occurring environment. However, the materials are moving and precautions need to be taken in areas with a steep slope.

The concentrations moving from the experimental plots should be interpreted carefully. At first glance, these concentrations might appear to be high, but through careful interpretation, these levels, even in a worst case scenario, may not be a significant threat to the environment.

Site Comparison: Edna Valley and Paso Robles

The two sites that were evaluated for surface water runoff were very different. The Edna Valley site had a significant stand of vegetation on the vineyard floor and had a moderate slope. In comparison, the Paso Robles site had very little vegetative coverage on the vineyard floor and a very steep slope. The volume of surface water runoff moving from the two sites had a significant impact on the volume of water that was collected from the simulated storm events. It has been shown in several studies that the amount of water moving from a site can be directly related to the amount of vegetation and the degrees of slope at a site.

7.4.2.5 Suggestions for Further Study

There were several obstacles faced at the Edna Valley site in terms of site accessibility due to the weather and the timing of the application in terms of the weather. Ideally, if a future study were to take place, the simulations should happen immediately after the re-entry interval expires for that material. Conducting the simulations directly after the application will provide insight into the concentration of chlorpyrifos moving directly after the application.

The effect of different management practices should be evaluated on the movement of simazine and chlorpyrifos. Different types of vegetation or other cultural practices are likely to have an impact on how these chemicals move. Since these chemicals are moving, it could be beneficial to determine which management practice is having the greatest impact on the mitigation of their off-target movement.

7.5 DISSEMINATION OF INFORMATION

All the information obtained was disseminated to our membership and beyond through our outreach and education programs. The majority of the information was shared through tailgate meetings and newsletters prepared by CCVT outreach and education staff and project staff. See Section 8 for details.

7.6 REFERENCES

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8.0 OUTREACH AND EDUCATION

8.1 ARTICLES AND PUBLICATIONS

Central Coast Vineyard Team published fourteen articles and publications circulating to 308,000 people. Publication topics include information on CCVT programs, sustainable agriculture, composting, cover crops, water quality, and vine health. This information was published in industry magazines, local newspapers, agriculture publications and environmental magazines.

Date	Article Title	Publication	Circulation	Type
10.1.2004	Winning Wines	Telegram Tribune	60,000	Newspaper
10.1.2004	CCVT: Bringing Innovation & Collaboration to Central Coast Vineyards	Farmer & Rancher Magazine	5,000	Ag Publication
3.1.2005	What's Happening in Local Vines	Vintages	15,000	Special Publication
7.7.2005	Healthy Vines for Healthy Wines	The New Times	15,000	Newspaper
9.1.2005	Sustainable Ag Expo Comes to the Central Coast	Farmer & Rancher Magazine	5,000	Ag Publication
9.23.2005	A Model for Change	San Luis Obispo Telegram Tribune	60,000	Newspaper
9.30.2005	CCVT BIFS Project Wins EPA Award	SAREP News Release		Special Publication
10.1.2005	A More Sustainable Approach to the Wine Grape Industry	Gardens for Life	3,000	Other
10.1.2005	Sustainable Ag Expo Comes to the Central Coast	San Luis Obispo County Farmer & Rancher Magazine	5,000	Ag Publication
10.14.2005	North County Ag Expo Set for Nov. 15	The Tribune	60,000	Newspaper
11.1.2005	Winegrape Growers On Central Coast Use Compost to Improve Soils.	BioCycle	10,000	Other
11.17.2005	Sustainable Ag: Paso Expo Attracts Diverse Audience	The Tribune	60,000	Newspaper
10.1.2006	Comprehensive Evaluation of Cover Crops to Protect Water Quality	Behind the Wines	5,000	Industry Magazine
3.1.2007	Sustainable Agriculture Q & A	Behind the Wines	5,000	Industry Magazine
Total	14		308,000	

8.2 CCVT SPONSORED EDUCATIONAL EVENTS

Central Coast Vineyard Team hosted 65 educational events with 2,617 attendees representing 582,036 acres. Tailgates and workshops were held in San Luis Obispo, Santa Barbara and Monterey Counties. Topics included weed control, pest identification and management, ecosystems management, irrigation, organic methods, communicating sustainability, vineyard nutrient management, composting, and sustainability economics. Among these were CCVT's annual meetings that included the Sustainable Ag Expo, Positive Points System Workshops, and Spanish Language Pesticide Handler Training.

Date	Meeting Title	Location	Number of Attendees	Number of Acres
12.3.2004	Economics of Sustainability: Increasing Efficiency	Cliffs Resort, Shell Beach	128	40,000
12.7.2004	Positive Points System Workshop	J. Lohr Vineyards, Paso Robles	74	15,264
12.8.2004	Positive Points System Workshop	Paraiso Springs Vineyard, Soledad	13	9,850
12.9.2004	Positive Points System Workshop	Premiere Coastal Vineyard, Los Alamos		
12.14.2004	Positive Points System Workshop	Pacific Vineyard Company, San Luis Obispo	15	6,700
1.7.2005	Positive Points System Workshop	Melville Winery, Lompoc	12	1,280
1.14.2005	Positive Points System Workshop	Pine Creek Vineyard, San Ardo	2	500
1.21.2005	Positive Points System Workshop	J. Lohr Vineyards, Paso Robles	48	2,600
2.25.2005	Ag Waiver Update & PPS	Paso Robles Golf Course	85	12,067
3.17.2005	Pest Management & Irrigation Readiness	Paso Robles Golf Course	84	12,126
3.23.2005	Positive Points System Workshop	Kendall Jackson, Soledad	7	3506
3.30.2005	Pesticide Handler & Calibration Trainings SPANISH	Pinnacles Vineyard, Soledad	25	5,313
3.31.2005	Pesticide Handler & Calibration Trainings SPANISH	Cat Canyon Annex, Los Alamos	35	3,885
4.1.2005	Pesticide Handler & Calibration Trainings SPANISH	Estancia Vineyard, Paso Robles	40	990
4.6.2005	Mealybug Control & Irrigation Readiness	Zabala Vineyards, Soledad	15	12,981
4.7.2005	Mealybug Control & Irrigation Readiness	Firestone Vineyard, Santa Ynez Santa Ynez	20	3,138
4.15.2005	Vineyard Design & Maintenance	Paso Robles Library	74	20,000
4.22.2005	Road Maintenance & Cover Crops	Chalone Vineyards, Soledad	11	2,780
4.26.2005	Road Maintenance & Cover Crops	Premiere Coastal Vineyard, Los Alamos	17	4,874
5.13.2005	Mechanical Weed Control Equipment Demo	Westerly Vineyard, Santa Ynez	25	6,828
5.202005	Mechanical Weed Control Equipment Demo	Santa Lucia Vineyard, Gonzales	30	20,000
6.2.2005	Mechanical Weed Control Equipment Demo	Huerohuero Vineyard, Paso Robles	39	4,838
11.16.2005	Sustainable Age Expo	Paso Robles Event Center	250	85,000
12.1.2005	Post Harvest Check & PRISM Project Update	J. Lohr Vineyards, Paso Robles	37	8,786
1.12.2006	Positive Points System Workshop	J. Lohr Vineyards, Paso Robles	59	4,230

Date	Meeting Title	Location	Number of Attendees	Number of Acres
1.13.2006	Positive Points System Workshop	Firestone Vineyard, Santa Ynez	14	1,160
1.17.2006	Positive Points System Workshop	Paraiso Vineyard, Soledad	4	4,942
2.9.2006	Pesticide Laws & Regulations Update	Paso Robles Library, Paso Robles	40	10,000
2.13.2006	Sustainable Ecosystem Management	Paso Robles Library, Paso Robles	80	15,000
2.14.2006	Sustainable Ecosystem Management	Historic Santa Maria Inn, Santa Maria	25	8,000
3.15.2006	Pesticide Handler & Pest ID Training	Estancia, Soledad	24	1,500
3.16.2006	Pesticide Handler & Pest ID Training	Premiere Coastal Vineyard, Los Alamos	47	4,000
3.17.2006	Pesticide Handler & Pest ID Training	Meridian Vineyards, Paso Robles	44	2,000
4.28.2006	Exploring Eco Labels	JanKris Winery, Templeton	15	639
5.11.2006	Sprayer Rodeo	Blind Faith Vineyard, San Miguel	19	1,000
5.24.2006	Weed Management – PRISM	Sunnybrook Vineyard, Paso Robles	41	7,022
5.26.2006	Sprayer Rodeo	Gaia Vineyard, Lompoc	42	1,700
6.15.2006	Cover Cops and Water Quality	Halter Ranch Vineyard, Paso Robles	85	11,929
7.18.2006	Argentine Ant & Mealybug Solutions	Paragon Vineyard, San Luis Obispo	47	14,318
7.19.2006	Energy Efficiency	Chateau Julien Wine Estate, Carmel	42	8,000
8.2.2006	"Cut The Crap"	Paso Robles Inn, Paso Robles	40	4,072
8.2.2006	"Cut The Crap"	SLO County Ag Extension Auditorium, San Luis Obispo	23	14,904
11.2.2006	Sustainable Ag Expo	Monterey Fairgrounds, Monterey	250	85,000
1.16.2007	Positive Points System Workshop	Hahn Estates, Soledad	4	1,152
1.17.2007	Positive Points System Workshop	Clos Pepe Vineyards, Lompoc	15	2,092
1.18.2007	Positive Points System Workshop	J. Lohr Vineyards, Paso Robles	51	6,923
2.20.2007	Exploring Organic Methods 1: Fertility & Pest Control	Castoro Cellars, Templeton	54	12,000
2.28.2007	Vineyard Nutrient Management	Templeton CSD Board Room, Templeton	54	1,400
3.13.2007	Exploring Organic Methods 2: Weed Control	Pomar Junction Vineyard, Templeton	37	10,350
3.27.2007	Spanish Pesticide Handler & Label Review	Grassini Family Vineyard, Santa Ynez	28	1,200
3.28.2007	Spanish Pesticide Handler & Label Review	Monterey Wine Company, King City	6	200
3.29.2007	Spanish Pesticide Handler & Label Review	Centennial Park Live Oak Room, Paso Robles	16	800
4.10.2007	Communicating Sustainability in the Tasting Room	Lafond Vineyard, Buellton	10	2,000
4.12.2007	Communicating Sustainability in the Tasting Room	Firestone Vineyard, Paso Robles	18	4,000
4.13.2007	Sustainable Winegrowing Self-Assessment Workshop	Castoro Cellars, Templeton	62	12,000
4.18.2007	Exploring Organic Methods 3: Certification	J. Lohr Vineyards, Paso Robles	16	867
5.3.2007	CCVT Research Site Visit: Pesticide Mitigation & Mealybug	Sunnybrook Vineyard, Paso Robles	36	6,594

Date	Meeting Title	Location	Number of Attendees	Number of Acres
	Solutions			
5.15.2007	Vineyard Floor Management: From Cover Crops to Irrigation	Barham Vineyard, Los Alamos	26	1,726
5.17.2007	Vineyard Floor Management: From Cover Crops to Irrigation	Halter Ranch Vineyard, Paso Robles	30	6,084
6.5.2007	Beneficial Insect Rodeo	Sierra Madre Farms, Santa Maria	13	4,226
6.6.2007	Beneficial Insect Rodeo	Carriage Vineyard, Templeton	38	3,400
6.14.2007	Monterey County Annual Meeting	Farm Bureau Conference Room, Salinas	14	20,000
6.20.2007	Oak & Wildlife Habitat Restoration	Luft Vineyard, Templeton	27	2,300
Total	65		2,582	582,036

8.3 COMMUNITY EVENTS

In an effort to educate community members on sustainability issues, Central Coast Vineyard Team attended 40 community events with 56,715 attendees. Information about CCVT programs, sustainable agriculture, and the winegrape industry were available for the community. These events include farmers' markets, wine festivals, business expos, earth day events, environmental celebrations, and agriculture showcases. CCVT used mediums like brochures, newsletters, 'Fast Facts' about current research and programs, calendars, and photos to communicate sustainability to the public. Our presence at community events encouraged conversation about sustainable winegrowing and agriculture.

Date	Event Title	Host City	Event Attendance
7.14.2004	San Luis Farmer's Market	San Luis Obispo	10000
7.16.2004	Santa Barbara Farmer's Market	Santa Barbara	4000
8.6.2004	Grape Escape Day - Mid State Fair	Paso Robles	500
10.3.2004	Nipomo Creek Clean Up Day	Nipomo	30
10.9.2004	Pismo Creek Day	Pismo Beach	10
10.23.2004	TEECH Festival	San Luis Obispo	25
4.2.2005	Oxnard Earth Day	Oxnard	1000
4.7.2005	Alan Hancock Ag Expo	Santa Maria	1000
4.9.2005	Children's Day in the Plaza	San Luis Obispo	800
4.16.2005	Charles Paddock Zoo Earth Day	Atascadero	250
4.17.2005	Goleta Earth Day	Goleta	400
4.23.2005	Santa Barbara Earth Day	Santa Barbara	3000
4.23.2005	San Luis Obispo Earth Day	San Luis Obispo	1000
4.30.2005	Paso Robles Farm & Ranch Expo	Paso Robles	1000
5.19.2005	San Luis Obispo Farmer's Market	San Luis Obispo	5000
5.21.2005	Paso Robles Wine Festival	Paso Robles	6000
8.5.2005	Grape Escape Day - Mid State Fair	Paso Robles	200
10.8.2005	San Luis Obispo CreekFest	Arroyo Grande	500
10.15.2005	Green Earth Expo	San Luis Obispo	200
4.1.2006	Malibu Wine Festival	Malibu	700
4.8.2006	Santa Barbara Vintner's Festival	Santa Ynez	1000
4.22.2006	San Luis Obispo Earth Day	San Luis Obispo	200
4.23.2006	Santa Barbara Earth Day	Santa Barbara	1000

Date	Event Title	Host City	Event Attendance
4.29.2006	Cal Poly Wine Festival	Santa Margarita	500
5.29.2006	Paso Robles Farm & Ranch Expo	Paso Robles	500
7.13.2006	San Luis Obispo Farmers Market	San Luis Obispo	200
7.16.2006	Central Coast Wine Classic	Shell Beach	500
9.14.2006	Taste of the Valley	Soledad	250
3.1.2007	SLO Farmers Market	San Luis Obispo	500
3.15.2007	SLO Farmer's Market	San Luis Obispo	900
3.17.2007	Santa Barbara Farmer's Market	Santa Barbara	900
3.29.2007	SLO Farmer's Market	San Luis Obispo	1000
3.31.2007	Templeton Farmer's Market	Templeton	600
4.2.2007	Los Osos Farmer's Market	Los Osos	300
4.7.2007	Santa Barbara Farmer's Market	Santa Barbara	1100
4.9.2007	Los Osos Farmer's Market	Los Osos	500
4.11.2007	Paso Robles Business Expo	Paso Robles	1200
4.12.2007	SLO Farmer's Market	San Luis Obispo	1200
5.5.2007	WaterFest 2007	San Luis Obispo	750
5.19.2007	Paso Robles Wine Festival	Paso Robles	8,000
Total	**40**		**56,715**

8.4 INDUSTRY EVENTS

Having the support of the winegrape industry was key to our outreach program. Central Coast Vineyard Team participated in 20 winegrape industry events with 37,191 attendees. At these events, CCVT staff encouraged growers and winemakers to adopt sustainable practices in their operation.

Date	Event Title	Host City	Event Attendance
7.18.2004	Central Coast Wine Classic	Shell Beach	200
11.10.2004	American Vineyard Grape Expo	Paso Robles	200
11.17.2004	California RCD Conference	San Luis Obispo	100
12.6.2004	Sustainable Agriculture PCA Conference	San Luis Obispo	70
1.24.2005	Unified Wine & Grape Symposium	Sacramento	9000
2.7.2005	Farm Water Quality Plan Short Course	Paso Robles	50
2.23.2005	Fresno State Viticulture & Enology Conference	San Luis Obispo	200
4.2.2005	Malibu Wine Classic	Malibu	700
6.25.2005	Atascadero Wine Festival	Atascadero	5000
7.17.2005	Central Coast Wine Classic	Shell Beach	250
7.26.2005	Chilean Exchange with Ag Teachers	Los Angeles, Chile	52
9.11.2005	Paso Robles Wine University	Paso Robles	14
1.24.2006	Unified Wine & Grape Symposium	Sacramento	9500
2.6.2006	Association of Applied Insect Ecologists Conference	Oxnard	200
2.23.2006	Fresno State Conference - Terrior	San Luis Obispo	20
6.28.2006	ASEV	Sacramento	1200
7.14.2006	MCVGA Trade Show	Soledad	200
8.24.2006	PRWCA Tasting Room Managers Lunch	Templeton	35
1.23.2007	Unified Wine and Grape Symposium	Sacramento	10000
2.5.2007	AAIE Conference	Napa	200
Total	**20**		**37,191**

8.5 YOUTH EVENTS

Central Coast Vineyard Team attended 14 youth events reaching 16,790 children. CCVT would participate by having a grape crush where children would mash grapes with a potato masher and then be able to taste the juice. Live beneficial insects were also displayed and discussed.

Date	Event Title	Host City	Event Attendance
10.14.2004	Ag Day	Paso Robles	350
10.21.2004	Farm Day Monterey	Monterey	750
3.4.2005	Farm Day - Paso Robles	Paso Robles	90
3.10.2005	Farm Day - South Monterey County	King City	1500
5.27.2005	Ag Youth Day	Paso Robles	500
10.20.2005	Monterey County Ag Youth Day	Salinas	3000
10.20.2005	Paso Robles Ag Youth Day	Paso Robles	1500
2.2.2006	Salinas Farm Day	Salinas	3500
3.9.2006	Farm Days, South Monterey County	King City	1000
4.8.2006	Kids Day in the Plaza	San Luis Obispo	2000
5.26.2006	Virginia Peterson Farm Day	Paso Robles	400
10.12.2006	Great AgVenture	Paso Robles	1000
3.8.2007	King City Farm Day	King City	1000
5.11.2007	Lillian Larson Ag Day	San Miguel	200
Total	**14**		**16,790**

8.6 ACADEMIC PRESENTATIONS

Central Coast Vineyard Team made 15 academic presentations to university, community colleges, and agricultural organizations to 819 people. Presentations addressed topics like sustainable winegrowing, CCVT research, pest management, and water quality.

Date	Event Title	Host City	Event Attendance
11/19/2004	Cuesta Viticulture	Paso Robles	25
3/1/2005	Cal Poly Presentation	San Luis obispo	15
5/23/2005	Cal Poly Pomology Class	San Luis Obispo	20
5/23/2005	Cal Poly General Viticulture Class	San Luis Obispo	40
5/24/2005	Vines to Wines Club Meerting	San Luis Obispo	50
6/1/2005	Cal Poly Pomology Lecture	San Luis Obispo	20
6/1/2005	Cal Poly General Viticulture Class	San Luis Obispo	40
7/22/2005	Exchange with Chilean Ag Practicioners	Santiago, Chile	65
9/20/2005	NPS Monitoring Conference	Raleigh	100
9/29/2005	Cal Poly Soils Science Club	San Luis Obispo	40
10/21/2005	Cal Poly Advanced Viticulture Class	San Luis Obispo	60
8/8/2006	Future of Agriculture	Sacramento	250
1/10/2007	Presentation to Cal Poly Pest Mangement Class	San Luis Obispo	20
2/8/2007	Vit Issues Class Presentation	San Luis Obispo	50
2.19.2007	Farm Water Quality Short Course	Paso Robles	24
Total	**15**		**819**

8.7 MEETING EVALUATIONS

To conclude Central Coast Vineyard Team educational meetings, attendees were asked to complete an evaluation form to give valuable feedback. They commented on the speakers, expressed positive remarks, suggestions for improvement, what they wanted to learn in the future, and how the practices addressed were applied to their vineyard. Over 450 evaluations were collected from growers and consultants since July 1, 2004. Results show that 59% of the attendees plan to apply the sustainable practices they learned at CCVT events to their vineyard within one year.

Average Scores (scale of 1-5, 5 being highest)						
Year	Were your expectations for this event met?	Given the time limit, were you satisfied with the material covered?	Did the event increase or enhance your knowledge of the subject?	Do you expect to use what you have gained in this event in your work?	Was the interaction with other participants valuable to you?	Were the handout materials useful to you?
2004	4.1	4.2	4.1	3.9	3.8	4
2005	4.3	4.4	4.3	4.3	4.2	4.3
2006	4.2	4.3	4.3	4.1	4.0	4.0
2007	4.2	4.4	4.2	4.1	3.8	4.1

Positive Comments

"Good mix of important issues facing winegrowing, and how to help manage them."

"CCVT always makes me think harder."

"Thank you for having this and other valuable educational seminars!"

"Good start on cover crop research locally - keep at it. Follow up on perennial cover crop monitoring."

"Thank you CCVT for workshops that support the grower!"

"Stimulating presentations - I wanted more!"

Constructive Comments

"More specifics on amendments for vineyards."

"Tried to cover too much too fast with lack or depth for better understanding."

"Have users instead of company reps talk - more specific to winegrapes."

"There was some overlapping of information between lectures."

"More time on each topic-speakers were rushed."

8.8 NEWSLETTERS

Each quarter, Central Coast Vineyard Team distributed a newsletter with information on CCVT programs, timely viticulture practice tips, a grower spotlight, and industry news on sustainable winegrowing. The newsletter circulated to 2,800 recipients each quarter. Newsletters are provided in the attachments.

9.0 CONCLUSIONS AND PAEP REVIEW

9.1 INTRODUCTION

The conclusions for this project are evaluated through the Performance Evaluation and Assessment Plan (PAEP) prepared by the Central Coast Vineyard Team (CCVT) for the Regional Water Quality Control Board (RWQCB). The following discussion will compare the goals and evaluation tools in the PAEP to the products produced in the report.

Many of the goals for the PRISM Project set out by CCVT were met according to the Performance Assessment and Evaluation Plan (PAEP). In terms of the activities listed in the PAEP, 4 out of the 5 non-point source pollution activities were met in full. CCVT project staff was able to:

- Demonstrate new, reduced risk, on farm practices using a collaborative problem solving process.
- Collect and measure in field surface water runoff samples during storm events to analyze samples for target pesticides.
- Extend information to winegrape growers within and beyond the Central Coast.
- Collect and record data regarding population dynamics of pest and weed populations for demonstration and research vineyards.

The collection of the historical and current pesticide use from project and non-project growers in order to compare practices from one season to the next was not completed due to alternative evaluation tools being utilized. The other sampling tools were better indicators for the effectiveness of a management practice.

9.2 EFFECTIVENESS MEASUREMENTS FOR IMPLEMENTATION ACTIVITIES

The management practices listed in CCVT's PAEP includes: monitoring mealybug populations, monitoring weed populations, implementing reduced risk practices, monitoring water quality, and tracking chemical use in project and non-project sites.

Through mealybug monitoring we hoped to reduce the reliance on organophosphates for the control of mealybug species and argentine ants. The success of this was determined through the tracking of population levels and coordinating with the grower to determine if a treatment was needed at the end of the season.

Weed populations and effectiveness of treatments were evaluated through the monitoring of weed populations in accordance with a given treatment. The effectiveness of each treatment was evaluated by the number of weeds and number of species controlled throughout the season.

The implementation of reduced risk practices was evaluated by the number of sites involved that implemented the reduced risk management strategy in lieu of a high risk application.

Water quality monitoring activities included the measurement of high risk chemicals within in-field surface water runoff at project sites. Reduced risk practices should show low to no levels of high risk materials in comparison to the sites that have been treated with the high risk materials.

Most of the management strategies and assessment systems used to evaluate effectiveness were met during the project. Both results and narrative descriptions of each project site were produced with information gained from the experiments and demonstration practices.

Due to other evaluation methods determining the effectiveness of treatments, pesticide use reports were not necessary. Some pesticide use reports were collected from project sites, but because sites were set up in a manner that was not conducive to compare project sites to non-project sites, this methodology was not meaningful. For a comprehensive conclusion and discussion of each project site and management practice, see Section 7.0.

9.3 EFFECTIVENESS MEASUREMENTS FOR OUTREACH AND EDUCATION

CCVT's outreach and education program met all of the activities listed in the scope of work from the grant and from the PAEP. All methods of outreach and education were utilized including: tailgate meetings, newsletters, website development, publications, industry outreach, presentations, community outreach, and youth outreach. Attendance and evaluation of CCVT's tailgate meetings were conducted after each event in order to assess the event's impact. For a comprehensive evaluation see Section 8.0 of the project report.