CA Department of Pesticide Regulation
Environmental Monitoring Branch
Surface Water Protection Program
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# Runoff Potential of Esfenvalerate From a Prune Orchard With Managed Floors

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Esfenvalerate application at study site Photo by R. Sava

## Objectives

The objectives of this study were to (a) evaluate the potential for runoff of esfenvalerate from dormant-season applications in orchards and (b) compare the effects of two orchard floor management practices on runoff. These evaluations were based on three types of samples:

1. Whole-water rainfall runoff samples taken from orchard floor row middles,

2. Edge-of-field whole-water samples taken from a drainage ditch receiving runoff from the treated orchard, and

3. Post-runoff soil and sediment samples from the orchard floor and drainage ditch.

## Study Site

The study site was a 300-acre French prune orchard located near the town of Artois, Glenn County, California (Figure 1). Orchard soil consists mainly of Tehama Silt Loam transitioning at the extreme upper edge from Cortina Very Gravelly Sandy Loam (USDA, 1968).

Samples were collected from twelve plots (rows) within the orchard. Six rows consist of a well-established perennial sod cover crop that had been maintained and periodically re-seeded with dwarf perennial rye (60%), creeping red fescue (20%), and Chewing's fescue (20%) over 5 years. The other six rows have bare ground floors that are treated several times a year with both contact and pre-emergent herbicides to control vegetative growth.

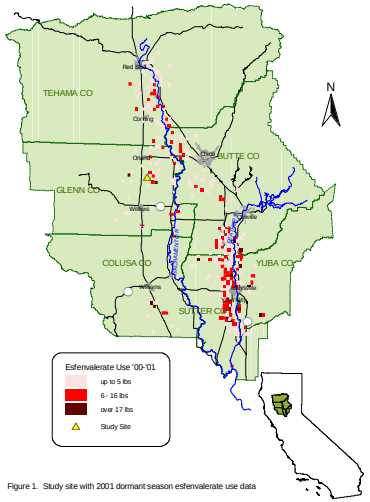



Figure 1. Study site with 2001 dormant season esfenvalerate use data

Table 1. Esfenvalerate runoff concentrations in whole-water samples (µg/L)

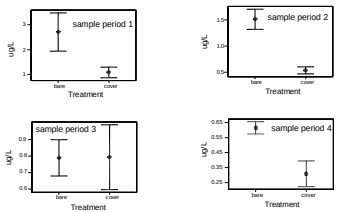
| | | Esfenvalerate Concentration ug/L | | | |
|---|---|---|---|---|---|
| | | Precipitation Event 1 | Precipitation Event 2 | | |
| Row | Treatment | | Time 1 | Time 2 | Time 3 |
| 1 | Cover Crop | 0.705 | 0.589 | 0.849 | 0.293 |
| 3 | Cover Crop | 0.562 | 0.367 | 0.215 | 0.154 |
| 6 | Cover Crop | 1.23 | 0.528 | 0.561 | 0.615 |
| 7 | Cover Crop | 1.78 | 0.769 | 1.52 | 0.518 |
| 9 | Cover Crop | NS* | 0.332 | 0.456 | 0.168 |
| 12 | Cover Crop | 1.12 | 0.618 | 1.16 | 0.103 |
| | | | | | |
| 2 | Bare Ground | 1.39 | 1.99 | 0.711 | 0.784 |
| 4 | Bare Ground | 2.37 | 1.78 | 0.963 | 0.481 |
| 5 | Bare Ground | 3.44 | 1.9 | 1.26 | 0.635 |
| 8 | Bare Ground | 3.68 | 0.928 | 0.584 | 0.597 |
| 10 | Bare Ground | 5.39 | 1.53 | 0.578 | 0.639 |
| 11 | Bare Ground | N/D** | 0.948 | 0.643 | 0.555 |
| Canal 1 | | NS* | | | 0.476 |
| Canal 2 | | 3.06 | | | 0.424 |
| Pond 1 | | 0.167 | | | 0.473 |
| Pond 2 | | 0.0725 | | | 0.452 |

* NS- No sample taken- insufficient runoff.

** N/D Non-detect, concentration below reporting limit (0.05 µg/L).

Collecting runoff water samples Photo by K.Goh

Fig 2. Esfenvalerate concentrations (treatment mean ± standard error) for each sampling period. Treatment means for periods 2 and 4 were significantly different (p=0.001 and 0.03, respectively).




## Materials and Methods

A. Esfenvalerate Application

Esfenvalerate (Asana ® XL, Dupont) was aerially applied to the entire orchard at an application rate of 9.6 ounces/acre (0.05 lbs active ingredient/acre). Label rates for dormant applications of Asana ® XL range from 8 to 14.5 fluid ounces per acre (0.04 - 0.075 lbs active ingredient/acre) (Dupont, 2003).

B. Samples

*Background Samples*

Background soil samples were taken prior to treatment in the study rows to determine residual levels of esfenvalerate. Samples were collected by driving two-inch diameter steel tubes into the soil to a depth of 1 inch. Samples were composited into glass mason jars.

*Whole-Water Runoff Samples*

Within row whole-water samples were taken - from holes augered into the orchard floor - during the first significant precipitation event, 5 days following application. Additional water samples were taken from each row at regular intervals during a second rain event, 7 days following application, for a total of 48 samples. Post-event soil samples were taken at each plot 25 days after application to determine the amount of esfenvalerate remaining on site.

Water was collected directly into 1 liter amber glass bottles and capped with Teflon® lined lids. Samples were stored on wet ice for transport to the lab for analysis.

C. Chemical Analysis

*Esfenvalerate*

All esfenvalerate analyses were conducted by the California Department of Food and Agriculture Center for Analytical Chemistry (CDFA). The esfenvalerate water samples were extracted *in toto*, without filtration, and extracting solvent was used to rinse the sample bottles to ensure complete removal of any esfenvalerate adsorbed to the glass container.

Analyses of esfenvalerate in water, soil and sediment were accomplished using gas chromatography with electron capture detection (GC/ECD). Gas chromatography with a mass selective detection (GC/MSD) was used to confirm the soil and sediment samples.

## Results

A. Esfenvalerate whole-water samples

Esfenvalerate concentrations (Table 1) in whole-water rain runoff were highly variable, ranging from below the reporting limit of 0.05 µg/L up to a maximum of 5.39 µg/L . Within each orchard floor treatment, esfenvalerate concentrations generally decreased as sampling progressed (Table 2). A multiple analysis of variance (MANOVA) indicated a significant difference between mean esfenvalerate concentrations in the cover crop and bare ground treatments for at least one sampling period (p=0.016). Subsequent univariate t-tests demonstrated that although mean concentrations at sampling times 1, 2 and 4 were lower in the cover crop treatment than in the bare ground treatment, only sampling times 2 and 4 were significantly different at the $\alpha$ = 0.05 level (Figure 2).

The number of drainage ditch water samples was limited, but those concentrations were comparable to the esfenvalerate concentrations measured in the field runoff samples, ranging from 0.424 to 3.06 µg/L (Table 1). Concentrations of esfenvalerate measured in the drainage pond ranged from 0.0725 to 0.473 µg/L.

Suspended sediment concentrations in runoff samples ranged from 0.01 to 0.60 g/L.

B. Post-runoff event samples

Esfenvalerate concentrations in post-runoff row middle soil samples were highly variable, ranging from less than reporting limits to 0.479 µg/g dry soil. Although the median post-runoff row middles soil concentrations were higher in the cover crop treatment (0.043 µg/g dry soil) than the bare ground treatment (0.018 µg/g dry soil), the differences were not significant at the $\alpha$ = 0.05 level based on a nonparametric Kruskal-Wallis test for equality of medians. By way of comparison, the application rate of 0.05 lbs esfenvalerate/acre corresponds to a soil concentration of ~ 0.33 µg/g soil assuming a bulk density of 1.5g soil/cm$^3$. Based on a similar calculation the overall median soil concentration of 0.028 µg/g dry soil corresponds to a recovery of approximately 10% of the initial esfenvalerate application in the row middles.

Table 2.
Treatment mean esfenvalerate runoff concentrations in whole-water samples.

| | COVER CROP | | BARE GROUND | |
|---|---|---|---|---|
| Sample period | mean conc. ± standard error µg L$^{-1}$ | N | mean conc. ± standard error µg L$^{-1}$ | N |
| 1 | 1.08 ± 0.22 | 5 | 2.72 ± 0.77 | 6[A] |
| 2[B] | 0.53 ± 0.07 | 6 | 1.51 ± 0.19 | 6 |
| 3 | 0.79 ± 0.20 | 6 | 0.79 ± 0.11 | 6 |
| 4[B] | 0.31 ± 0.09 | 6 | 0.62 ± 0.04 | 6 |

[A] One nondetection assigned value of 1/2 reporting limit, = 0.025 µg L$^{-1}$

[B] Significant treatment effect, p=0.001 and 0.03 for sampling periods 2 and 4, respectively.

**References:**

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**USDA, 1968**. Soil survey of Glenn County, California. United States Department of Agriculture, 1968.

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Full report and poster available at http://www.cdpr.ca.gov/docs/sw/index.htm