**Department of Pesticide Regulation**
**Environmental Monitoring and Pest Management Branch**
**830 K Street**
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# Citrus herbicide mitigation practices: demonstration and evaluation
# DPR/UCCE Sampling Plan (Study 188)

**1999**

## I. INTRODUCTION

The two California counties with the largest number of confirmed premeergent herbicide detections in well water are Fresno and Tulare. One mechanism of preemergent herbicide movement to ground water is through surface water runoff to dry wells or other drainage structures. Concentrations of simazine, diuron, and bromacil ranging up to 1100 ppb have been detected in rainfall runoff water entering dry wells in and around citrus orchards (Braun and Hawkins, 1991). This direct transport mechanism is most important in impermeable hardpan or compacted soils.

In experimental plots, shallow mechanical incorporation (using a small rototiller) has been shown to be effective in mitigating herbicide movement off-site in simulated rainfall runoff from middles of citrus orchards (Troiano and Garretson, 1998). However, the effect of shallow mechanical incorporation using more commonly available implements in production agriculture under actual rainfall conditions has not been demonstrated. In addition, many citrus growers are reluctant to disturb soil in orchard middles so that additional alternatives for mitigating herbicide movement off-site from citrus orchard middles are desireable.

## II. OBJECTIVE

The overall purpose of this project is to (1) demonstrate and (2) compare selected management practices for mitigating preemergent herbicide movement in rainfall runoff from citrus orchard middles. All data will be used to educate growers on different aspects of citrus orchard floor management practices, especially as they relate to weed control and frost protection. The study will consist of three experiments with the following objectives, respectively:

**Experiment 1.** Evaluate weed control efficacy under selected weed management practices that avoid broadcast application of preemergent herbicides during the rainy season when runoff potential is high. Weed population densities under such management regimes will be compared to a control consisting of a typical citrus preemergent weed control program. The results will be used in citrus grower outreach and education programs to demonstrate the effect of ground water protection management strategies on weed control in citrus. All data will be used to educate growers on different aspects of citrus orchard floor management practices, especially as they relate to weed control and frost protection.

**Experiment 2.** Evaluate the potential frost protection risk from cover cropping by comparing canopy temperatures in cover cropped citrus to a control consisting of a typical citrus preemergent weed control program. The results will be used to determine if there is a statistically significant difference in canopy temperatures under cover crop vs. bare ground citrus orchard floor management practices. An alpha value of 0.05 will be used for hypothesis testing.

**Experiment 3.** Evaluate the effect of different methods of herbicide incorporation on mass export of preemergent herbicide from citrus orchard middles in post-application rain runoff. Because simazine is the most widely detected herbicide in ground water of citrus producing areas in Tulare County, simazine will be the representative preemergent herbicide analyte. The relative effect of different treatments will, however, be general for common preemergent citrus herbicides as they display very similar runoff behavior (Spurlock et al., 1997). The results will be used to document the effect of different incorporation strategies on off-site movement of simazine from citrus orchard middles relative to rainfall incorporation. An alpha value of 0.05 will be used for hypothesis testing.

## III. PERSONNEL

This study will be conducted by the University of California Cooperative Extension (UCCE), Kearney Agricultural Center, in cooperation with the Environmental Hazards Assessment Program (EHAP) under the general direction of Timothy Prather (UCCE), Integrated Pest Management Weed Specialist and Frank Spurlock, EHAP Senior Environmental Research Scientist. Key personnel are listed below:

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| Project Leader: | Tim Prather (UCCE)/Neil O'Connell (UCCE) |
| Field Coordinator: | Fuhan Liu (UCCE) |
| Laboratory Liaison/Quality Assurance: | Cindy Garretson (EHAP) |
| Project QA Manager | Carissa Ganapathy (EHAP) |

Questions concerning this monitoring program should be directed to Frank Spurlock at (916) 324-4124 or FAX (916) 324-4088.

## IV. STUDY DESIGN

This study will be conducted in a mature citrus grove located in runoff prone soils in Tulare County. These soils are classified according to the statistical clustering/profiling method of Troiano et al. (1994, 1997). The treatments listed in Table 1 will be studied using a randomized complete block design. A map of the study site location and plot layouts are shown in Figures 1 and 2, respectively.

The plots (experimental units) for treatments 1 and 2 be 2 rows wide x 10-12 trees long (approximately 40 x 200 feet). The plots for treatments 3, 5-8 will be 1 row x 10-12 trees long. All treatments will be replicated six times for a total of 5x8 = 40 plots (experimental units).

Field data and all relevant observations will be collected in a field notebook. The UCCE project leaders will be responsible for reviewing all field data for completeness and accuracy. Any variances or deviations from the SAP will be documented by the UCCE project leaders.

**Experiment 1**
treatments 1-3, 8

Glyphosate will be applied during late fall/winter on as-needed basis using a $CO_2$ pressurized back pack sprayer. Weed control in spring will consist of a chemigation application of thiazopyr (treatment 1), chemigation application of simazine and diuron (treatment 2), and spot treatment with glyphosate (treatment 3). Representative weed counts will be conducted in January and April by counting all emerged weeds within the wetted pattern of 3 emitters per plot and 3 plots in middles that are 4.5 m by 6 m in size.

**Experiment 2**
treatment 4, 8

A cover crop mix of annual medics, subterranean clover, and annual grasses will be planted in treatment 4a orchard middles. A filter strip mixture of sheep fescue and hard fescue will be planted adjacent to the orchard and in the bottom 10% of the irrigation run in treatment 4b. The cover crop will be planted in October 1999 using a cover crop seeder or grain drill. Canopy temperatures will be measured with Hobo temperature recorders set to record at 24 minute intervals and located within the orchard canopy. The probes will be calibrated seasonally based on previous experience of UCCE scientists. Temperature probes will be located in the citrus canopy based on professional judgement of UCCE scientists.

**Experiment 3**
treatments 5-8

All bucket auger soil core sampling will be conducted in accordance with EHAP SOP FSSO 002.00, all surface soil sampling will be conducted in accordance with EHAP SOP FSSO 003.00, and all runoff water sampling will be conducted in accordance with EHAP SOP FSWA 008.00. The soil and water sampling discussed below applies to treatments 5-8.

*Background soil samples*
Two background soil samples will be collected from each plot: one taken from the row middle and one from the plot furrows. The row middle soil sample will be a composite of three individual randomly located 10 cm cores. The plot furrow soil sample will be a composite of four soil cores, two taken from each furrow within the plot. The total number of background soil samples for simazine chemical analysis will be 2 samples per plot x 4 treatments x 5 replicates plots = 40 samples; these composite samples will be obtained from (20 x 3, middles) + (20 x 4, furrows) = 140 individual soil cores.

*Herbicide deposition sampling*
The herbicide will be broadcast applied using a $CO_2$ pressurized ground sprayer at a nominal rate of 20 gallons acre$^{-1}$. Each treatment will include application of simazine and diuron at 2 lbs a.i. acre$^{-1}$. Herbicide deposition rates will be measured in each plot using three randomly positioned kimbies located in row middles.

*Runoff collection*
Runoff water from the rainfall events will be collected immediately past the downstream end of the plot furrows using a runoff sampler (Figure 3). One L aliquots will then be collected and stored (unfiltered) refrigerated in 1L amber bottles at 4C until analysis. Total runoff volume will be measured by the runoff sampler. Three runoff events will be sampled, with two 1L samples per plot per runoff event. Total rain runoff samples will range from (4 treatments x 6 replicates x 3 runoff events x 2 samples = 144 samples.

*Post-simulated rainfall soil samples.*
Six post-rainfall soil samples will be collected from each plot after the second runoff event: three taken from the row middle and three from the plot furrows. Each row middle soil sample will be a composite of two individual 10 cm cores. The plot furrow soil sample will be a composite of two soil cores, one taken from each furrow at the locations specified in Figure 4. The total number of post (second rainfall) soil samples for chemical analysis will be 6 samples per plot x 20 plots = 80 samples; these composite samples will be obtained from (2 x 80) = 160 individual soil cores.

## V. CHEMICAL ANALYSIS / QUALITY CONTROL

Total number of field samples for chemical analysis will be:

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| KIMBIES: | deposition (60) = 60 kimbie samples |
| SOIL: | background (140) + final (160) = 300 soil samples |
| WATER: | runoff = 144 water samples |

Samples will be analyzed for simazine by California Food and Agriculture Analytical Chemistry Laboratory (CDFA) in Sacramento using the ELISA immuno-assay method (method 62.7, copy attached); the detection limit in soil is 15 µg kg$^{-1}$ , while that for water is 0.5 ug L$^{-1}$. The soil ELISA QA/QC procedures will consist of a matrix blank plus two matrix spikes to be included with each extraction set. Results from the matrix spikes will be evaluated to determine if they fall within predetermined control limits as specified in EHAP SOP QAQC001.001 based on recovery data reported in CDFA method 62.7. Water samples will be stored refrigerated (4C) and soil samples will be stored frozen for a period of no longer than 16 weeks (see attached simazine storage stability study data sheet).

## VI. DATA ANALYSIS

*Experiment 1*. The response variable weed density will be analyzed using analysis of variance (ANOVA). Mean separation between treatments will be determined using Fisher's Protected Least Significant Difference procedure.

*Experiment 2.* The response variable weed density will be analyzed ANOVA . A variable will be defined as the sum of the number of hours each day below the critical temperature (27 F) at which damage to citrus fruit takes place. This variable will be the reponse variable to be analyzed using ANOVA to determine the effect of cover crop treatment. An $\alpha$ - value of 0.05 will be used for hypothesis testing.

*Experiment 3.* Data collected will include (a) total runoff volume from each plot, and (b) simazine concentration in the runoff water. Together these data also provide a measurement of total simazine that move off the plots in runoff. Normal-based statistical methods, including ANOVA, will be used to compare incorporation methods on simazine mass transported off of the plots in runoff. Soil furrow and middle samples will be used to determine mass balance and incorporation effects, if any, on herbicide redistribution after simulated rainfall. An $\alpha$ - value of 0.05 will be used for hypothesis testing.

## VII. TIMETABLE

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|---|---|
| runoff/soil sample collection | November 1999 - February 2000 |
| temperature data collection | November 1999 - April 2000 |
| | November 2000 - April 2001 |
| weed counts | January 2000 and April - May 2000 |
| herbicide analysis | December 1999 - May 2000 |
| data analysis | May 2000 - May 2001 |
| final report | June 2001 |

## VIII. REFERENCES


Braun, A.L. and L.S. Hawkins. 1991. Presence of Bromacil, Diuron, and Simazine in Surface Water Runoff From Agricultural Fields and Non-Crop Sites in Tulare County, California. report PM91-1. Environmental Monitoring and Pest Management Branch, California Department of Pesticide Regulation.

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Troiano, J., B. Johnson, S. Powell, and S. Schoenig. 1994. Use of cluster and principal component analyses to profile areas in California where ground water has been contaminated by pesticides in California. Environmental Monitoring and Assessment, 32:269-288.

Troiano, J., C. Nordmark, T. Barry, and B. Johnson. 1997. Profiling areas of Ground Water Contamination by Pesticides in California: Phase II - Evaluation and Modification of a Statistical Model. Environ. Monitor. Assess. 45:301-318.

Troiano, J. and C. Garretson. 1998. Movement of Simazine in Runoff Water from Citrus Orchard Row Middles as Affected by Mechanical Incorporation. J. Environ. Qual. 27: 488-494.