Demonstration of Effectiveness of Chemigation of Pre-emergence Herbicides Applied through Low-Volume Irrigation Systems

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Study 221

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Introduction

The California Department of Pesticide Regulation had adopted mitigation measures to prevent further contamination of ground water. A summary of the changes is available at http://www.cdpr.ca.gov/docs/empm/gwp_prog/gwp_prog.htm. The proposed regulations allows for continued used of ground water contaminants but a permit for use is required. The permit specifies management practices based on predominant soils of vulnerable areas (Troiano et al., 2000). Two pathways of pesticide movement to ground water have been determined. In coarse, permeable soils residues leach with water during normal percolation processes and in less permeable soils with a hardpan layer residues are moved offsite in runoff water to sensitive sites (Braun and Hawkins, 1991). Vulnerable areas are listed as ground water protection areas (GWPAs) and they are classified as susceptible to either the leaching or runoff pathway to ground water contamination. Recommended management practices for each pathway have been developed based on studies conducted in small plots. For example, in areas of low rainfall and for coarse soils where pesticides leach to ground water, management of percolating water produced as a result of irrigation has been shown to be effective in maintaining residues in the upper surface layers (Troiano et al., 1993). In contrast, for soils with low permeability, use of mechanical incorporation instead of rainfall is an effective method to decrease offsite movement of pre-emergence residues (Troiano and Garretson, 1998).

Chemigation is a potential mitigation measure for both leaching and runoff pathways to ground water. However, pesticide labels must either contain directions for chemigation or they must contain the statement 'Do not apply through an irrigation system'. Most of the pre-emergence herbicide residues detected in ground water are not labeled in

California for application through low-volume irrigation systems. The application of herbicides through low-volume systems is not a novel procedure as evidenced by a number of studies on the soil movement and efficacy of herbicides applied through low-volume irrigation systems (Del Amor et al., 1981; Gerstl and Albasel, 1984; Gerstl and Yaron, 1983; Ogg, 1986).

The objectives of this study were to develop data on the effectiveness of chemigation and to demonstrate the application of pre-emergence herbicides through low-volume irrigation systems. The Department of Pesticide Regulation (DPR) invited participation from registrants of ground water contaminants with respect to technical expertise on the products to be applied through the system. Since the pesticides of interest were not labeled for chemigation through low volume systems, their support was requested in order to obtain a research authorization. It is anticipated that the data generated from the study will be useful in pursuing a label amendment to add chemigation, thereby, providing another mitigation measure for use of pesticides in ground water protection areas. DPR contracted with the Center for Irrigation Technology (CIT) at the California State University, Fresno to provide expertise in renovation, implementation, and management of the irrigation systems of the cooperating growers. Cooperators in the study were:

Environmental Monitoring Branch of the DPR:
Alfredo DaSilva, Frank Spurlock, Carissa, Cindy Garretson, Mark Pepple, and John Troiano.

Center for Irrigation Technology, California State University, Fresno:
Tim Jacobsen and Lisa Basinal.

Grower Cooperators:
Cliff Loeffler, Michael Noell, Louise Fisher, and Trudy Wischemann.

Registrant Cooperators:
Syngenta cooperators were Paul Reising, David Laird, and Debbie Stubbs.
Dupont Agricultural Products cooperator was Aldos Barefoot.

Materials and Methods

Study Sites

Three citrus growers in Strathmore and Lindsay, CA Tulare County were selected and agreed to participate in the study (Cliff Loeffler, Michael Noell, and Louise Fisher). The three ranches were visited and site evaluations were performed.

Irrigation systems of cooperating growers were evaluated and renovated as required for chemigation. For example, backflow prevention devices were installed if they were not present.

The Pond-Shafter-Wasco Resource Conservation District Mobile Lab Program for Irrigation System Evaluations performed evaluations at all three sites. Project cooperators and study personnel were provided with copies of the evaluation report (see Appendix), and irrigation systems were renovated if necessary.

Cliff Loeffler's ranch is located on the northeast corner closest to Ave 220 (Waddell) and Road 236 in Strathmore, California. A 3 acre block of oranges was selected for the study area. This block contains 10 rows with 36 trees per row = 360 trees, spaced 19' between rows x 17' along rows. The irrigation system is micro-fanjet with rotating heads.

Mobile lab evaluations were performed on 10/28/03 and 11/10/03. The evaluation on 10/28/03 reported an overall distribution uniformity of 69% (due to the variety of different sprinklers and emitters of the same variety displaying substantial variability) and the evaluation on 11/10/03 reported an overall distribution uniformity of 94% (due to the replacement of all emitters).

It was noted in the Mobile Lab report that the pressures varied on the two evaluation dates, possibly due to a change in the set pattern (the block north of the study area was being irrigated on the day of the first evaluation and the block to the west of the study area was being irrigated on the day of the second evaluation) or a leak in a riser (second evaluation), and to take this into consideration when conducting field trials.

Michael Noell's ranch is located on the northeast corner closest to Ave. 212 and Road 240 in Lindsay, CA. A 10 acre block of oranges, was selected for the study area. The

block contains 30 rows with 29 trees per row=870 trees, spaced 22’ between rows x 22’ along rows. The irrigation system is micro-fanjet with fixed heads.
The mobile lab evaluation that was performed on10/15/03 determined an overall distribution uniformity of 97%.

Louise Fisher’s ranch is located on the southeast corner of Road 180 and Avenue 200 in Strathmore, CA. A 4 acre block of oranges was selected as the study area. The block contains 21 rows with 24 trees/row = 504 trees, spaced 20’ between rows x 20’ along rows. The irrigation system is micro-fanjet with rotating heads.
Mobile lab evaluation (9/12/03) of overall distribution uniformity was 88%.

Study Design

There were three treatments per site/location. The first was the chemigation treatment (a tank mix of diuron and simazine), the second was control (no chemical treatment of any kind), and the third was growers’ standard practices. Standard practices for Mike and Louise were a tank mix of diuron and simazine, and standard practices for Cliff were to spray Roundup.

The application of diuron and simazine is the predominant combination used on citrus orchards in Fresno and Tulare Counties in California. For this project, a combination of the two products, diuron (Direx 4L, Griffin, donated by Dow) and simazine (Princep 4L, donated by Syngenta), were used in a tank mixed chemigation application.

A Cole-Parmer peristaltic metering/injector pump was used for each of the applications. The application rate for simazine was 2 quarts per acre at all three sites. The application rate for diuron was 3.2 quarts per acre at Mike’s and Louise’s orchards (Table 1). Due to an error, the application rate for diuron was 2 gallons per acre at Cliff’s orchard.

Table 1.

Grower	**Date**	**Area Treated**	**Simazine Application Rate**	**Diuron Application Rate**	**Injection Time**	**Pre-Irrigation**	**Post-Irrigation**
Cliff	11/25/03	1 A	2 q./A	2 gal./A	1.5 hours	2 hours	45 mins.
Mike	12/2/03	3 A	2 q./A	3.2 q./A	1.8 hours	2 hours	1.5 hours
Louise	12/4/03	1 A	2 q./A 32 oz./set	3.2 q./A 51 oz./set	1 hour	2 hours	1.5 hours

Soil and Water Sampling

1. Soil

Soil samples were collected according to DPR Standard Operating Procedures (Garretson 1999a; Garretson 199b; and Garretson 1999c).

a) Background Samples

Soil was sampled prior to chemigation applications to determine the background concentration of pre-emergence herbicides, as well as for physical properties. Samples (3 replications per site) were obtained to the 5 foot depth at 6-inch intervals. Each sample was a composite of soil (collected at the same depth) from two cores. The two cores were taken on a transect that crossed the treeline.

b) Post-Chemigation Samples

Soil was also sampled after chemigation to determine the concentration and location of the applied simazine and diuron. Soil samples were collected 1, 45, and 120 days after chemigation. At each sampling interval, three replications were performed at each site. Each sample was a composite of soil (collected at the same depth) from two cores. The two cores were taken on a transect that crossed the treeline.

One day after chemigation, limited movement of the chemicals was expected, so a shallow core (in 3-inch and 6-inch segments, down to the 18-inch depth) was collected. The segments were 0-3 inches, 3-6 inches, 6-12 inches, and 12-18 inches.

Forty-five and 120 days after chemigation, soils were sampled in segments, to a maximum depth of 5 feet. The samples were collected in 3 inch segments from 0-6 inches, 6 inch increments from 6-24 inches, and 12 inch increments to the maximum depth.

2. Water

a) Background

Water samples were collected according to DPR Standard Operating Procedures (Spurlock 1999). Water was sampled from emitters prior to chemigation applications to determine the background concentration of simazine and diuron. Five replications of water per site were collected.

b) During chemigation

Water from the emitters was sampled to determine the distribution of herbicides applied. Five replications of water per site were collected. Water was collected after the herbicides were detected from the last emitter in the irrigation block.

c) Runoff water

Due to lack of rainfall, no samples were collected.

3. Analyses

Soil samples collected for background and post chemigation, and split water samples were sent to CDFA laboratory in Sacramento for analysis. Soil samples collected for physical analysis (soil texture), and split water samples were sent to the DPR lab at Fresno State for analysis. Quality control procedures for both analytical methods followed DPR established Standard Operating Procedures for Chemistry Laboratory Quality Control (Segawa 1995).

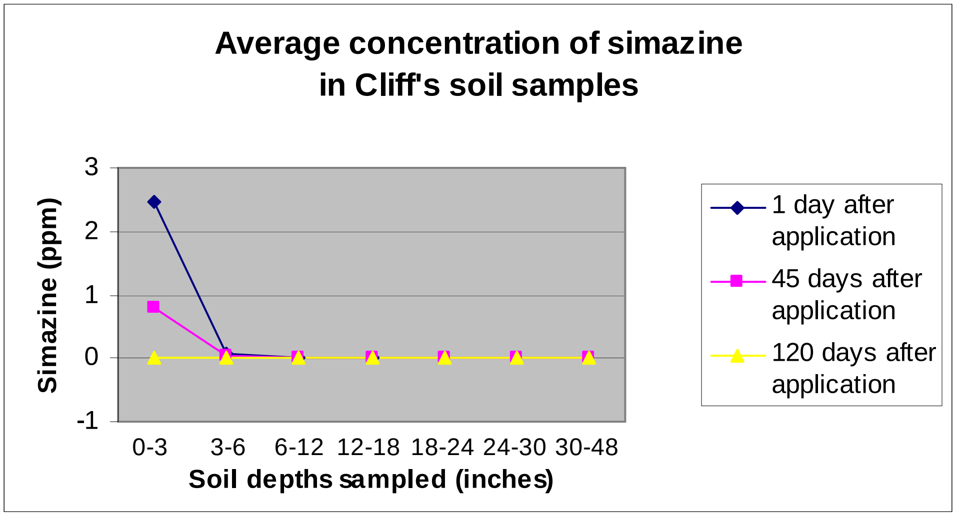
Efficacy Measurement

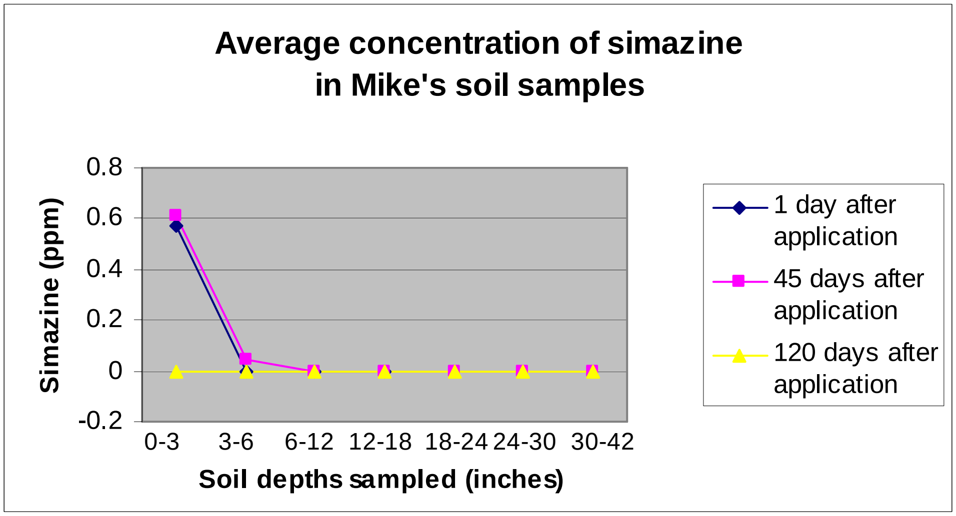
The level of weed control was monitored in randomly chosen plots throughout the sites. Weed control was determined through visual observation, and digital pictures were taken at each evaluation.

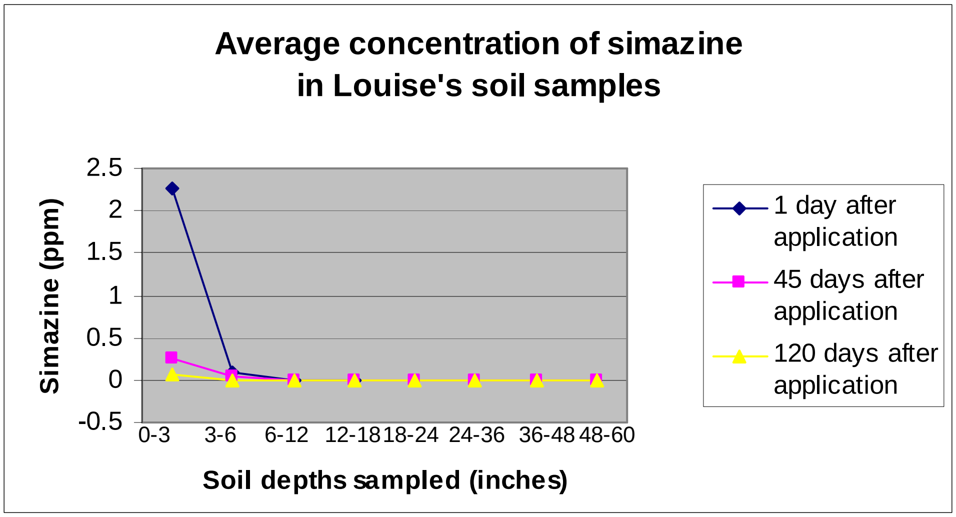
Results

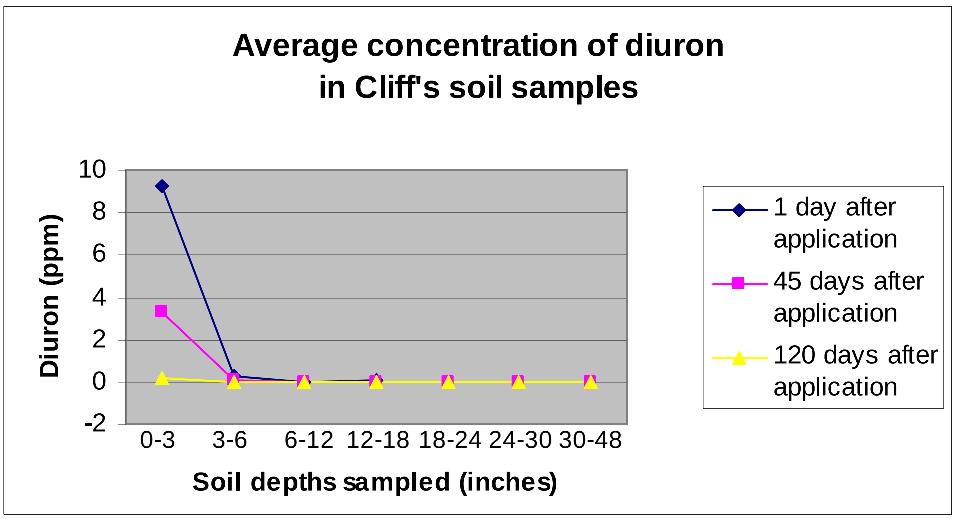
Soil

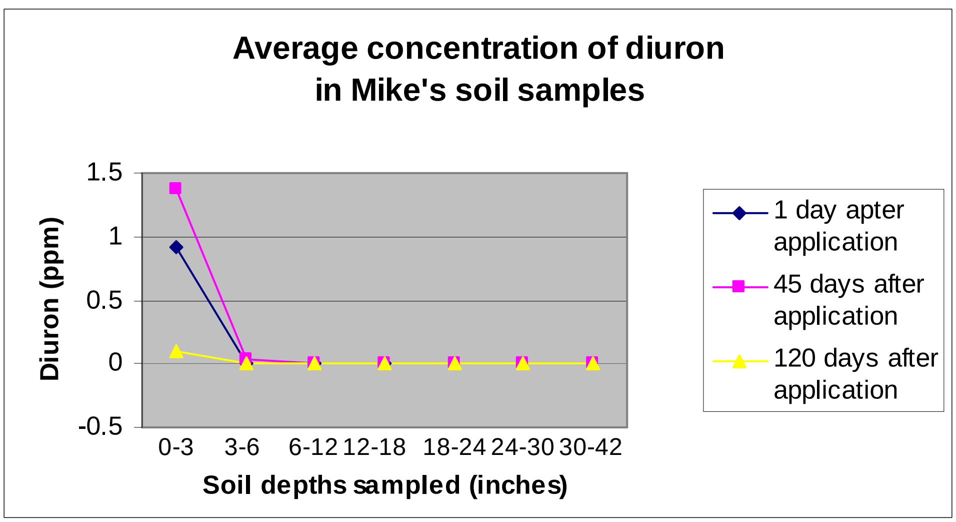
Soil herbicide concentration was significantly related to soil depth (see Appendix A-statistics). Soil samples collected 1 and 45 days after application revealed that the majority of the herbicides remained in the upper three inches of soil, as was expected with the soil types (heavy clay). Retaining the herbicides in the uppermost inches of the soil is important for controlling weeds and avoiding groundwater contamination. Soil samples collected 120 days after application revealed that simazine was undetectable at two of the three sites, and that very low concentrations of diuron were detectable at all three sites.

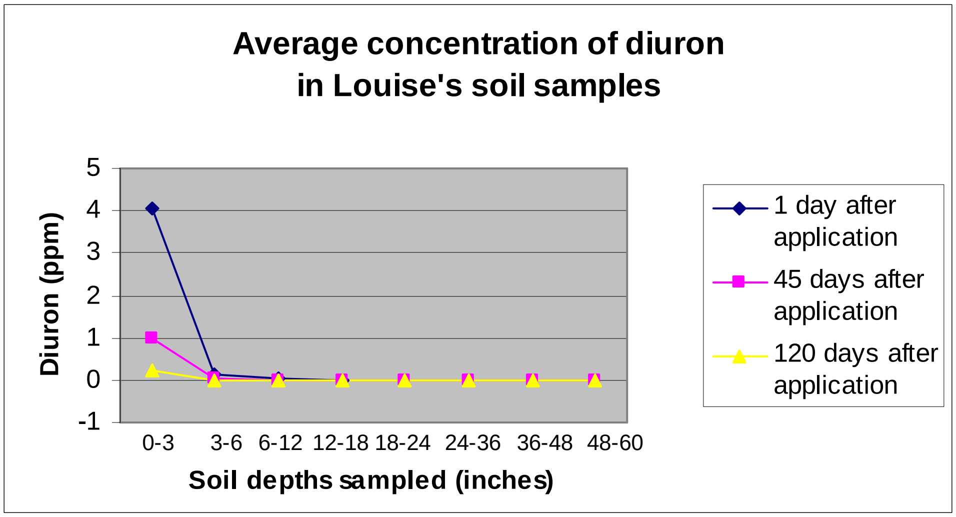





Average concentration of simazine
in Louise's soil samples
Simazine (ppm)
2.5
2
1.5
1
0.5
0
-0.5
0-3
3-6
6-12
12-18
18-24
24-36
36-48
48-60
Soil depths sampled (inches)
1 day after application
45 days after application
120 days after application


Average concentration of diuron
in Cliff's soil samples
Diuron (ppm)
10
8
6
4
2
0
-2
0-3
3-6
6-12
12-18
18-24
24-30
30-48
Soil depths sampled (inches)
1 day after application
45 days after application
120 days after application


Average concentration of diuron
in Mike's soil samples
Diuron (ppm)
1.5
1
0.5
0
-0.5
0-3
3-6
6-12
12-18
18-24
24-30
30-42
Soil depths sampled (inches)
1 day apter application
45 days after application
120 days after application



Efficacy

First Evaluation (51 days after chemigation)

Grower's standard practices and *chemigation* both provided (100% weed control) and some weeds were growing in the (*control*) no chemical treatment area (0% weed control)

Second Evaluation (73 days after chemigation)

Grower's standard practices provided 85-95% weed control compared to *control* (no chemical treatment), while *chemigation* treatment provided 80-90% weed control.

Third Evaluation (94 days after chemigation)

Grower's standard practices provided 90-95% weed control compared to *control* (no chemical treatment), while *chemigation* provided 80-90% weed control.

a) Grower's opinion

Mike Noell felt that the chemigation efficacy was the same as his standard practices. It was also noted that a major advantage of using chemigation is that application may be done anytime, because it is not dependent on the weather.

Conclusions and Suggestions for Next Year

It is planned to repeat the study this year with one or two of the field plots. Some changes that would be incorporated in the study include more control over grower's standard practices (keeping records of products applied, application rates, and placement of absorbent paper in random locations in the field to study product application rates), and uniformity.

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Appendix A
Statistics

Citrus Project Final Output for Diuron

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	0.15	1	0.15	0.03	0.864	0.001
Covar2	10.022	1	10.022	1.996	0.166	0.051
Days	26.371	2	13.185	2.626	0.086	0.124
Soil Depth	125.281	4	31.32	6.239	0.001	0.403
Error	185.748	37	5.02			

Citrus Project Final Output for Simazine

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	0.374	1	0.374	0.408	0.527	0.011
Covar2	0.574	1	0.574	0.627	0.433	0.017
Days	5.229	2	2.614	2.856	0.07	0.134
Soil Depth	18.417	4	4.604	5.029	0.002	0.352
Error	33.876	37	0.916			