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# Study 277: Pesticide Runoff from a California Alfalfa Field—a Field Study

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## Introduction

The Department of Pesticide Regulation (DPR) is developing modeling tools to assist in pesticide risk assessment. Several models are under evaluation for their performance in simulating pesticide runoff under California agricultural conditions (Zhang, 2009). Preliminary evaluation of the models has been conducted based on data generated by two historical field studies in California. These two studies were conducted in orchards with runoff generated by natural and simulated rainfall. While they provide valuable information on pesticide runoff in orchards as generated by rainfall, they do not reflect pesticide runoff from field crops especially when runoff is from irrigation.

Pesticide runoff from field crops during the irrigation season can contribute to pesticide contamination in surface waters in some agricultural regions of California (Prichard, 2007). Understanding the processes that govern pesticide runoff arising from irrigation is essential to the protection of surface waters in California. Models developed to assist pesticide risk assessment must also capture this important scenario. To validate the simulation models currently under evaluation by DPR, field studies that reflect the pesticide runoff patterns from field crops are needed. This study uses alfalfa as a testing crop due to its large cropping acreage and widespread use of flood irrigation that results in tailwater runoff.

## Objectives

The goal is to quantify pesticide runoff in alfalfa as generated by irrigation. The data will be used to examine the performance of pesticide simulation models currently under evaluation by DPR. The objectives are twofold: (1) quantify pesticide runoff patterns from irrigated field crops in California; (2) measure important parameters and runoff patterns for validation of simulation models.

## Personnel

This study will be conducted by staff from the CDPR's Environmental Monitoring Branch Under the general supervision of Senior Environmental Scientist Sheryl Gill and Environmental Program Manager I Kean Goh. Key personnel are listed below:

Project Leader: Xuyang Zhang , Ph.D.
Field Coordinator: Xin Deng, Ph.D.
Senior Scientist: Frank Spurlock, Ph.D.
Laboratory Liaison: Sue Peoples
Analytical Chemistry: Center for Analytical Chemistry, Department of Food and Agriculture (CDFA)
Collaborators:

- Rachael Long, Cooperative Extension Farm Advisor, UC Davis
- Blaine Hanson, Ph.D.,Prof. Emeritus, Irrigation Specialist , UC Davis
- Mark Rubio, Field Manager, Department of Animal Sciences, UC Davis

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**Study Plan**

Study site

The study will be carried out in a 32-acre alfalfa field located at the University of California, Davis (Latitude: 38.5317N, Longitude: 121.7989W) (Fig 1). The field has been farmed with alfalfa for several years, and the alfalfa stands have been well established. Soils are Brentwood silty-clay loam with high silt (47.8%) and clay (33.5%) content. The field is relatively flat with a slope of 2%. A drainage ditch collects tail water at the north end of the field and drains into a pipe that goes underground. Irrigation water is applied using check flood irrigation. The study area contains two blocks, each of which is about 625- ft long and 60- ft wide (Fig 1). The north end of each block will be dammed so that tailwater flows directly to the ditch. A levee separates the two blocks keeping water contained within each of the block.

Fig 1. Location of the study site

Pesticide treatment

The field will be sprayed with herbicides and insecticides for weed and insect control (Table 1). Diuron and chlorpyrifos will be applied. The soil adsorption coefficients are 813 and 8151 for diuron and chlorpyrifos, respectively (Table 1). Diuron will be applied during winter and early spring to control weeds. Chlorpyrifos will be applied during spring to control alfalfa weevil and army worm.

Table 1: Pesticides that will be applied on the alfalfa field

| Product name | Active Ingredient | Application rate | Restricted entry interval (hours) | KOC | DT50 (days) |
|---|---|---|---|---|---|
| Karmex DF | **Diuron** | **1.2-2.4 lbs/acre** | **12** | **813** | **75.5** |
| Lorsban Advanced | **Chlorpyrifos** | **1 pint/acre** | **24** | **8151** | **50** |

Irrigation practices

Water is applied by check flood irrigation, which is commonly used in alfalfa fields in the Central Valley of California. A stand pipe supplies irrigation water at the south side of the field (Fig. 1). Water flows out of the standing pipe and then flows through a plastic pipe to the field.

Measurements

At the beginning of the study, soil samples will be taken to identify soil characteristics including soil texture, organic matter content, soil pH, bulk density, soil moisture curve and saturated hydraulic conductivity and infiltration rate. For each pesticide application, deposition on foliage will be measured by placing adsorbing sheets on the plant foliage. After application, soil and leaf samples will be collected at incremental time intervals to quantify pesticide persistence. During each runoff event, runoff flow will be measured. Runoff water samples will be collected to measure the amount of pesticide dissolved in water and adsorbed to suspended sediment.

(1) Characterization of soil properties

The entire study area contains 2 blocks of 190.4 m x 18.3 m. Each block will be further divided into 4 cells. Samples will be collected from each of the cells at two different depths (15 and 30 cm). For each location and depth, two samples will be taken one undisturbed sample for suction vs. moisture curve and one composited sample for other soil properties. Therefore, a total of 32 samples will be collected for soil property analysis. If time allows, soil moisture levels and infiltration rates will be measured at the beginning of each irrigation event using soil moisture sensors and an infiltrometer (Cornell Micro Sprinkler Infiltrometer).

(2) Measurement of foliar deposition

Pesticide mass deposition on plant foliage will be sampled following the standard operation procedure (SOP) FSOT005.00 (Walters, 2003). For each block, four adsorbing sheets will be placed on plant canopy, one on each cell. Mass deposition per unit area will be quantified by dividing the mass extracted from the adsorbing sheets by the sheet area. In addition, foliar vs. ground area ratio will be estimated by visual assessment. Pesticide deposition on foliar and ground will then be calculated by multiplying their area ratio with total mass deposition.

(3) Measurement of pesticide mass in soil and vegetation

Before pesticide application, soil and vegetation samples will be taken to determine background concentrations of the pesticides. After each pesticide application, leaf and soil samples will be taken on days 0 (within 24 hours), 2, 4, 7 and 30. Samples will be tested for persistence of pesticide residuals in soil and plant leaf.

Within each block, soil samples will be taken at two depths (15 cm and 30 cm) on two randomly selected locations. For each depth, a composite sample will be taken underneath the vegetation. Each composite sample will be made from two to four soil plugs using stainless steel cylinders. Soil samples will be collected in glass jars. Each composite sample will weigh a minimum of 50 g (weight required for chemical analysis). Samples will be weighed in the field to determine the wet weight. The concentration of each chemical will be reported in total gram per sample. Prior to chemical analysis, an aliquot of soil will be removed to determine percent moisture, wet weight and dry weight.

Two composite leaf samples will be randomly collected for each block on the same day while soil samples are collected. Each composite will consist of several sub-samples of vegetation. Sub-samples will be collected on different alfalfa plants until 50 to 80 g of leaves are collected. Samples will be kept in glass jars and weighed to determine fresh weights. The concentration of each chemical will be reported in total gram per sample. Prior to chemical analysis, about 10 g of leaves will be removed to determine percent moisture, wet and dry weight of this aliquot.

(4) Measurement of flow

During each irrigation/rainfall event, water inflow and outflow will be measured throughout the entire course. Irrigation inflow will be measured using a propeller flow meter attached in the inflow pipe that connects to a standing pipe. To measure the runoff flow, a flume with known cross-sectional area will be installed in the ditch. In addition, a pressure transducer flow meter will be used to measure flow rate.

(5) Measurement of pesticide mass in water

Before each pesticide application, a sample of the spray tank mixture will be taken to quantify actual concentration following the SOP FSPT007.00 (Sava, 2008). During each runoff event, water samples will be collected at certain time intervals to quantify pesticide concentrations in suspended sediment and runoff water. Whole water samples will be analyzed for pesticide concentration, suspended sediment concentration, and organic matter content in the suspended sediment. A total of four runoff events will be sampled with at least eight grab samples per event.

<u>Data analysis</u>

Pesticide mass balance will be calculated on days 0, 2, 4, 7, 30 when soil and alfalfa samples are taken as well as days with runoff events. Pesticide mass input on day 0 will be calculated as the mass deposited on site from deposition sheets plus initial residues on soil and vegetation. Pesticide mass loss will be calculated as degradation and runoff. Field dissipation rates will be calculated using first order decay function as shown in equation (1).

$$M_t = M_0 \times \exp(-K \times t) \qquad (1)$$

Where $M_t$, $M_0$ are pesticide mass at day t and day 0; t is the number of days after the initial day, and K is the degradation rate. Mass runoff of chlorpyrifos and diuron will be calculated using flow rate and pesticide concentration in runoff water. The data set will be used to determine chlorpyrifos and diuron runoff potential from flood-irrigated alfalfa fields. In addition, simulation inputs will be compiled for PRZM, RZWQM and OPUS models based on measured data. And the resulting model outputs on pesticide runoff will be compared with measured runoff to infer model performance.

Chemical analysis

Soil, vegetation and deposition samples will be sent to the California Department of Food and Agriculture Laboratory for analyzing pesticide concentrations. Water samples will be analyzed at UC Davis Aquatic Toxicology lab using commercial ELISA kits. Method development and validation work will be conducted in accordance with SOP QAQC001.00 (Segawa, 1995), prior to study commencement. Continuing quality control will also be conducted in accordance with this SOP.

Soil physicochemical properties will be analyzed in the West Sacramento lab. Soil hydraulic conductivity will be measured using Eijkelkamp Laboratory Permeameter. The moisture content at 0, 1/3, 10and 15bar will be determined using a Soil Pressure Extractor. Soil texture will be analyzed using the hydrometer method following SOP METH004.00 (Dietrich, 2005).

Total number of samples for chemical analysis (estimates)

Tank mix: 1 sample for each chemical x 2 chemicals = 2
Foliar deposition: 2 blocks x 2 sheets/block x 2 applications = 8
Background soil: 2 blocks x 2 composited samples per block x 2 chemicals = 8
Background leaf: 2 blocks x 2 composited samples per block x 2 chemicals = 8
Soil: 2 blocks x 2 composited samples per block x 2 depth x 5 days x 2 chemicals= 80
Leaf: 2 blocks x 2 composited samples per block x 5 days x 2 chemicals = 40
Water whole water: 4 runoff event x 2 sets (one for each block) x 8 samples per event x 2 chemicals = 128 samples
Quality control: blind spikes and field blanks about 10% of total number of samples = 28
Total samples = 302

Estimated cost

Table 2: Number of samples and estimated cost for chemical analysis

| Matrix | Normal sample | QAQC (10%) | Method validation | Storage stability* | Total sample | Cost /sample | Total cost |
|---|---|---|---|---|---|---|---|
| Soil | 80 | 8 | 3 | 15 | 106 | $600 | $63,600 |
| Alfalfa | 40 | 4 | 3 | 15 | 62 | $600 | $37,200 |
| Kimbie sheet | 8 | 1 | 3 | 15 | 27 | $600 | $16,200 |
| Labor cost for method development: 15 days x $840 per day= $8,400 | | | | | | | $12,600 |
| | | | | | | Total | $129,600 |

* Storage stability study will be conducted on day 0, 2, 4, 18 and 32 with 3 replicates.

**Time Table**

| Tasks | Schedule |
|---|---|
| Site preparation and instrument testing | December, 2011 – March, 2012 |
| Soil properties sampling | February, 2012 – March, 2012 |
| Foliar deposition sampling | Before and after each pesticide application |
| Soil and leaf sampling for pesticide residue | After each application on day 0, 2, 4, 7, 30 |
| Flow measurement | During each runoff event |
| Water sampling for pesticide concentration | During each runoff event |
| Data analysis and report writing | After analytical data becomes available |

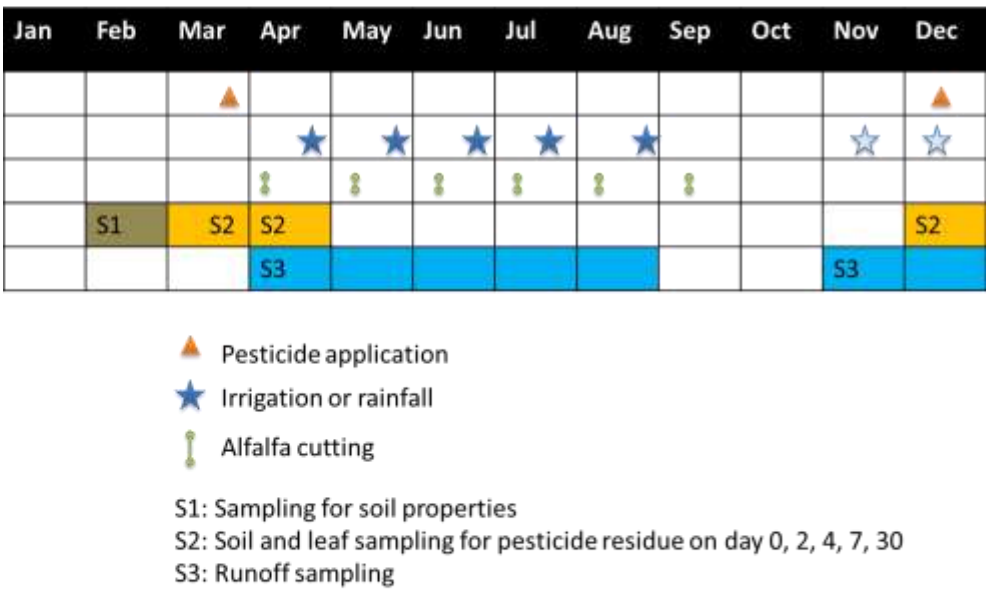


Fig 2: Important events in a year according to a normal-year practice.

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