California Department of Food and Agriculture
Environmental Monitoring and Pest Management
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PROTOCOL TO DETERMINE THE EFFECT OF DELAYED IRRIGATION ON SOIL MOVEMENT OF PESTICIDES

I. INTRODUCTION

Effective modification of pesticide use for compliance with AB 2021 legislation requires an understanding of the influence of irrigation on pesticide movement in soil. The amount of pesticide available for leaching in drainage water produced by an irrigation or natural rainfall is a function of the reaction that occurs between pesticide residues and soils (Green and Khan, 1987). Adsorption of pesticides by soil is described by pesticide-soil adsorption isotherm coefficients which are usually derived from batch studies conducted in the laboratory. The coefficients are used in models of pesticide movement as determinants for the amount of pesticide available for leaching. Isotherm coefficients are also included in the calculation of less complex attenuation or retardation factors which could be used to compare the potential for pesticide movement between soil types or between pesticides within a soil type (Jury et al., 1987; Rao et al., 1985).

Adsorption isotherm coefficients are measured under conditions where local equilibrium is attained (Rao and Davidson, 1980). In local equilibrium, reversible reactions are in a state of local chemical equilibrium. Adsorption-desorption equilibrium in most studies has been shown to be attained under slurry conditions when flasks are shaken for a 24-hour time interval (Hance, 1967). The transfer of these results to field conditions, however, may not be appropriate because of uncertainty in the mathematical expression of the kinetics of adsorption which may be confounded by differences between laboratory and field conditions (Leistra and Dekkers, 1977; Boesten, 1987).

Appropriate measurement of the pesticide-soil reaction is important when considering the timing of major irrigation or rainfall events in relation to a pesticide application. One result of non-equilibrium adsorption may be that the reaction between pesticide and soil increases with time after initial application. Delaying irrigation could be effective in minimizing the amount of pesticide available for downward movement. This study is designed to test this hypothesis, providing field measurements of the amount of pesticide available for movement in irrigation drainage water as influenced by the time between pesticide application and an irrigation event. The data will be used: (1) to develop modified use recommendations with respect to timing of pesticide application and initial irrigation events; (2) to provide a data set for use in PCA training demonstrating the importance of timing a pesticide application in relation to an irrigation event; and (3) to use as a test data set for determining whether or not models of pesticide movement can be modified to include effects of delayed irrigation on pesticide leaching.

II. OBJECTIVE

The objective of this study is to describe the leaching potential of pesticides with respect to the time lapsed between a pesticide application and a subsequent irrigation event.

III. PERSONNEL

This project will be conducted by the Environmental Hazards Assessment Program. John Sanders, Program Supervisor, will be the overall supervisor. Other key personnel include:

Project leader - John Troiano

Senior Staff Scientist - Bruce Johnson

Study design/Data Analysis - John Troiano

Field Sampling - Cindy Garretson

Lab liaison/Quality control - Cindy Garretson

Agency and public contact - Madeline Ames - (916) 324-8916

IV. STUDY PLAN/EXPERIMENTAL DESIGN

This study will be conducted on the field station at the California State University at Fresno. A split-plot design will be used to determine the effect of 3 time intervals between pesticide and irrigation applications on the leaching of 3 pesticides, simazine, bromacil, and atrazine. Pesticides will be the whole plot factor. Each whole plot will be split into 3 subplots corresponding to the time interval between pesticide and irrigation applications. The whole experimental design will repeated three times giving a total of 9 whole plots and 27 subplots.

The pesticides were chosen because they represent a range in soil adsorption values and water solubility. Water solubilities are 5, 33, and 820 ppm and Koc values are 220, 180 and 60 cm^3/g, respectively for simazine, atrazine and bromacil (Johnson, 1988). Split-plot irrigations will occur at 1, 4 or 7 days after pesticide application. Based on a previous irrigation study conducted at the site, one 7-inch basin irrigation event moved atrazine to at least the 5-foot depth. Soil will be sampled in 6-inch segments down to the 10-foot depth. Samples from the first 5-feet of soil will be analyzed for pesticide content and the remaining will be stored in a freezer and analyzed incrementally with depth, if necessary.

Pesticides will be applied at 4 lbs/acre to each whole plot and immediately watered-in with 0.5 inches of sprinkler irrigation. At 1, 4 or 7 days after pesticide application, a single 8-inch basin-flooding irrigation will be made to each appropriate subplot. Soil cores will be taken 7 days after the irrigation event to allow for equal post-irrigation drainage time between the treatments.

Prior to the use of this site by CDFA, background cores had been taken for previous studies and analyzed for the presence of simazine or atrazine residues. No residues were detected at minimum detection limits of at least 2 ppb. Atrazine had been applied to the plots that will be used in the proposed study in the summer of 1987. Also, during past 3 years no bromacil applications were made at the site. Thus, it is anticipated that no detectable residues will be present because of no known applications of simazine or bromacil and because of the length of time between atrazine applications. Three background cores will be taken from plots to confirm this hypothesis. Soil from each 6-inch segment will be composited and analyzed for each pesticide. Analyses will be conducted on samples down to 5-feet with the 5.5-10 foot samples stored.

The amount of pesticide recovered in each treatment and the depth to which 50 and 90% of the recovered pesticide is measured will be analyzed according to the following ANOVA table.

Source of Variation	DF
Whole Plot Analysis:	
Trial	2
Pesticide	2
Error I	4
Subplot analysis:	
Irrigation	2
Irrigation x Pesticide	4
Error II	12

V. SAMPLING METHODS

Soil cores will be taken with a hand bucket auger. Prior to coring, a 12-inch long plastic sleeve will be inserted 6 inches into the soil. The surface 6-inch sample will be taken, then the remaining soil will be removed from inside the sleeve. Continuous 6-inch sampling will then occur to the 5-foot depth. The auger will be washed with soapy water, well water, de-ionized water and isopropyl alcohol before each re-insertion into the borehole. Soil samples will be immediately mixed in a plastic bag and divided into two subsamples. One subsample will be frozen in a glass mason jar until subsequent pesticide and water content analyses and the other subsample will be air-dried for subsequent organic carbon analyses.

Three soil cores will be taken in each subplot with the samples composited from each depth. A total of 540 samples will be produced of which 270 will be analyzed. Samples greater than 5 feet may be analyzed if necessary. This would occur if the bulk of the pesticide residue was not captured in the first 5 feet.

VI. CHEMISTRY METHODS/QUALITY CONTROL

Samples will be preferentially analyzed by immuno-chemical techniques when available. It is possible that immuno-chemical soil analyses will be available to analyze for simazine and atrazine. Bromacil will be analyzed by APPL laboratories, Fresno. However, if immuno-chemical techniques are not available, standard laboratory analyses will also need to be conducted for simazine, and atrazine. APPL has previously analyzed the irrigation soil samples for atrazine. They are proficient at these analyses. However, some methods development may be necessary for bromacil and simazine, if they lack previous experience. Quality control procedures will be similar to those used for the study 65 analyses.

VII. TIMETABLE

Pesticide and irrigation applications ....June 1 - 10

Soil sampling ....June 8 - 17

Chemical analyses ....July-January

Data analyses ....February

Report preparation ....March

VIII. REFERENCES

Boesten, J.J.T.I. 1987. Modelling pesticide transport with a three-site sorption sub-model: a field test. Netherlands Journal of Agricultural Science 35:315-324.

Green, R.E. and M.A. Khan. 1987. Pesticide movement in soil: mass flow and molecular diffusion. In J.W. Biggar and J.N. Seiber (ed.) Fate of Pesticides in the Environment. p 87-92. Agricultural Experiment Station, Division of Agricultural and Natural Resources, University of California. Publication 3320.

Hance, R.J. 1967. The speed of attainment of sorption equilibria in some systems involving herbicides. Weed Res. 7:29-36.

Johnson, B. 1988. Setting revised specific numerical values November, 1988. Environmental Hazards Assessment Program, California Department of Food and Agriculture, Sacramento, California. EH 88-12.

Jury, W.A., D.D. Focht, and W.J. Farmer. 1987. Evaluation of pesticide groundwater pollution potential from standard indices of soil-chemical adsorption and biodegradation. J. Environ. Qual. 16(4):422-428.

IX. BUDGET

With no immuno-chemical assays

300 analyses - simazine, bromacil and atrazine (@$125)....	$ 37,500
10% QA/QC	4,000
Total..	41,500

With immuno-chemical assay for atrazine

200 analyses - simazine and bromacil (@125)	$ 25,000
90 analyses - atrazine (@10)............................	900
10% QA/QC..	2,500
Total..	28,400

With immuno-chemical assays for atrazine and simazine

100 analyses - bromacil (@$125).........................	12,500
180 - atrazine and simazine (@$10)........................	1,800
10% QA/QC..	1,500
Total..	15,800