Department of Pesticide Regulation
Environmental Monitoring and Pest Management
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Protocol to Determine the Influence of Irrigation Amount on Herbicide Efficacy

I. Background

The Pesticide Contamination Prevention Act (PCPA) authorizes the Department of Pesticide Regulation (DPR) to modify uses of pesticides in areas where they have leached through soil to ground water (Connelly, 1985). Leaching of agricultural chemicals occurs during recharge of ground water whereby water moves from the surface through the soil profile to a ground water aquifer (Whetje et al., 1984; Freeze and Cherry, 1979). Recharge may result from natural rainfall or from anthropogenic additions, such as from irrigation events (Bouwer, 1987). Since summertime climatic conditions are hot and dry in most of California's agricultural areas, irrigation is common and necessary in order to attain profitable yields.

To date, pesticide active ingredients that have been found in well water are predominately soil-applied herbicides. Since these pesticides are usually broadcast onto the soil surface, they require movement into the upper layers of soil where they contact actively germinating and growing weeds. Excess application of water causes movement of residues out of this active zone. Water budget techniques were derived to minimize deep percolation of water from irrigation events (Snyder et al., 1985). Recent studies conducted by DPR staff have investigated the use of water budgeting techniques as surrogate management techniques for use in restricting pesticide leaching (Troiano et al., 1990). The DPR study showed a close relationship between the amount of percolated water produced from irrigations and leaching of atrazine: residues of atrazine were moved deeper in the soil profile in direct proportion to the amount of deep percolating water produced from irrigations.

One other benefit obtained from linking water management techniques with pesticide management is a potential increase in efficiency through a decrease in rates of application that are efficacious. Although there is some indication in the literature that irrigation management is an important factor in the performance of pesticides, no data are available that directly link irrigation management practices to rates of herbicide application (Fisher et al., 1988; Jordan et al., 1963; Kempen, 1989). In order for water management options to be embraced by growers as an important factor in pesticide management, DPR must provide additional evidence that would persuade growers to adopt these measures. This study will be conducted to provide baseline evidence linking product performance with water management. The data will be important evidence in presentations given to PCA's, growers and others interested in controlling the leaching of pesticides because information on product performance is more persuasive than location of residues in the environment.

II. Objective

To determine the relationship between amount of water added by irrigation and efficacy of weed control by soil application of pre-emergence herbicide.

III. Personnel

Project Leader: John Troiano
Senior Scientist: Bruce Johnson
Pesticide Management Specialist: Sewell Simmons
Laboratory Liaison: Cindy Garretson
Cooperating Scientist: Charles Krauter, Irrigation Specialist and Gary Ritenour, Weed Specialist, USC,Fresno

IV. Study Design

Rationale for choice of treatments

The study is designed to investigate the effect of amount of water applied by irrigation on the performance of a pre-emergence herbicide in a young nectarine orchard. The study was originally intended to be conducted on bare soil. However, the plots were vandalized and the study re-initiated on a more secure site containing a 3-year-old nectarine orchard. Simazine, the herbicide used for this study, can be applied up to rate of 2 lbs per acre to young trees. In a previous study at the Fresno site, simazine had been applied at a 4 lb/acre rate which resulted in complete control of weed growth in both winter and summer seasons. Control lasted for at least a 4 month period even when soil was overwatered. In the proposed study, the 2 lb/acre rate will be used as a benchmark for control. Pesticide applications at this rate, at 1 lb/acre, and at 0 lb/acre will be made under either efficient or overwatered irrigation conditions to determine if a relationship exists between rate of herbicide application and amount of irrigation water applied. Under field conditions pesticide applications would occur under a variety of irrigation practices where irrigation efficiencies would range from very efficient to overwatered conditions.

Treatment allocations

Treatments will be applied to a 3-year-old nectarine orchard with dimensions of 11 x 20 rows of trees spaced on 20 foot centers. Simazine had not been applied in previous years because it is phytotoxic to young nectarine trees.

The experimental design is a 2 by 3 factorial with 3 blocks. Simazine will be applied at three rates. Two levels of irrigation management will be used to produce two levels of deep percolating water to simulate an efficient or an overwatered irrigation condition. A gradient in water infiltration was noted between the northern and southern ends of the site. Soil analyses indicated sandier conditions at the northern end of the plot. Based on these results the plot was blocked from north to south (Figure 1).

Irrigations will be made through mini-sprinkler heads connected to driplines. Each plot will consist of 9 trees encompassing a portion of three adjacent tree-rows and two row centers (Figure 1). The most efficient irrigation treatment will be based on a water budget method where enough water will be added to replenish available water lost from the first 12 inches of soil and then water added to provide 10% deep percolation (Grant et al., 1986). Overwatered treatments will provide 175% of the crop water requirement, theoretically producing 75% deep percolating water. Irrigations will occur when tensiometers placed in the soil at the 12-inch depth indicate depletion of water to the wilting point. At that time, enough water will be added to replenish available water down to the 12-inch soil depth. Rates of simazine application will be 0, 1, and 2 lbs/acre. The 0 lb/acre rate of simazine application treatment will measure potential effects of irrigation treatments on weed growth.

Efficacy of simazine applications will be determined by measurements of growth and mass of field-grown plants. Seeds of plant species sensitive to simazine will be planted at each treated plot. Counts of the number of plants growing in each plot and changes in plant mass over time should be indicative of the amount of simazine present in the soil. The schedule for media sampling is given in Table 1. The number and mass of plants measured at each time interval will be variables entered into a repeated measures Aanalysis of Variance (ANOVA). Data will be analyzed according to the following ANOVA table:

Source of Variance	DF
Blocks	2
Pesticide Rate (P)	2
Linear (PL)	1
Quadratic (PQ)	1
Water Rate (W)	1
P x W	2
Error 1 [Plots (PB)]	10
Time	5
Time x P	10
Time x W	5
Time x P x W	14
Error II	60

In order to provide additional information on the concentration of simazine in soil core samples, the concentration of simazine will also be measured in soil samples and in soil water extracted from soil suction

suction lysimeters. At each sampling date, one soil sample from the 0-2 inch depth will be collected. Soil suction lysimeters will be placed at two depths, one at the 12-inch depth and another at the 36-inch depth. Analyses will be conducted using immuno-chemical assays with a portion of the samples analyzed by gas chromatography (Goh et al., in press).

V. References

Bouwer, H. 1987. Effect of irrigated agriculture on groundwater. Journal of Irrigation and Drainage Engineering, 113(1):4-15.

Connelly, L. 1985. AB2021-Pesticide Contamination Prevention Act. Article 15, Chapter 2, Revision 7, Food and Agricultural Code, California.

Fisher, B.B., D.A. Goldhammer, T. Babb, and R. Kjelgren. 1988. Preemergence herbicide performance under drip and low volume sprinkler irrigation. 40th Annual California Weed Conference, Proceedings. January, 1988, pp 486-490.

Freeze, R.A. and J.A. Cherry. 1979. Groundwater. Prentice-Hall, Inc., Englewood Cliffs, N.J. 604pp.

Goh, K.S., S.J. Richman, J. Troiano, C.L. Garretson, H. Hernandez, J. Hsu, J. White, T.A. Barry, M. Ray, D. Tran, and N.K. Miller. In Press. ELISA of simazine in soil: applications for a field leaching study.

Grant, J, D.A. Goldhamer, and M. Gagnon. 1986. The water budget method. Cooperative Extension, University of California, Leaflet 21419.

Jordan, L.S., B.E. Day, and W.A. Clerx. 1963. Effect of incorporation and method of irrigation on preemergence herbicides. Weeds, 11:157-160.

Kempen, H.M. 1989. Growers weed management guide. Thompson Publication, Fresno, Ca.

Milligan, G.A., and D.E. Johnson. 1984. Chapter 25. Strip-plot designs. In (G.A. Milliken and D.E. Johnson, eds) Analysis of Messy Data Volume I: Designed Experiments. Van Nostrand Reinhold, N.Y., NY, pp 315-321.

Snyder, R., D.W. Henderson, W.O. Pruitt and A. Dong. 1985. California Irrigation management information system final report June 1985. Ca. Department of Water Resources, Contract NO. B53812. Univ. Calif. Davis.

Troiano, J., C. Garretson, C. Krauter and J. Brownell. 1990. Atrazine leaching and its relation to percolation of water as influenced by three rates and four methods of irrigation water application. Environmental Hazards Assessment Program, California Department of Food and Agriculture, Sacramento, Ca. EH 90-7.

Wehtje, G., L.N. Mielke, J.R.C. Leavitt and J.S. Schepers. 1984. Leaching of atrazine in the root zone of an alluvial soil in Nebraska. J. Environ. Qual., 13(4):507-513.

VI. Budget

Soil Core samples (400 samples ELISA)..........................16000
QC (40 samples)..6000
Total 32000

CSUFresno Nectarine Plot
Spring 93

FIGURE 1

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W + E
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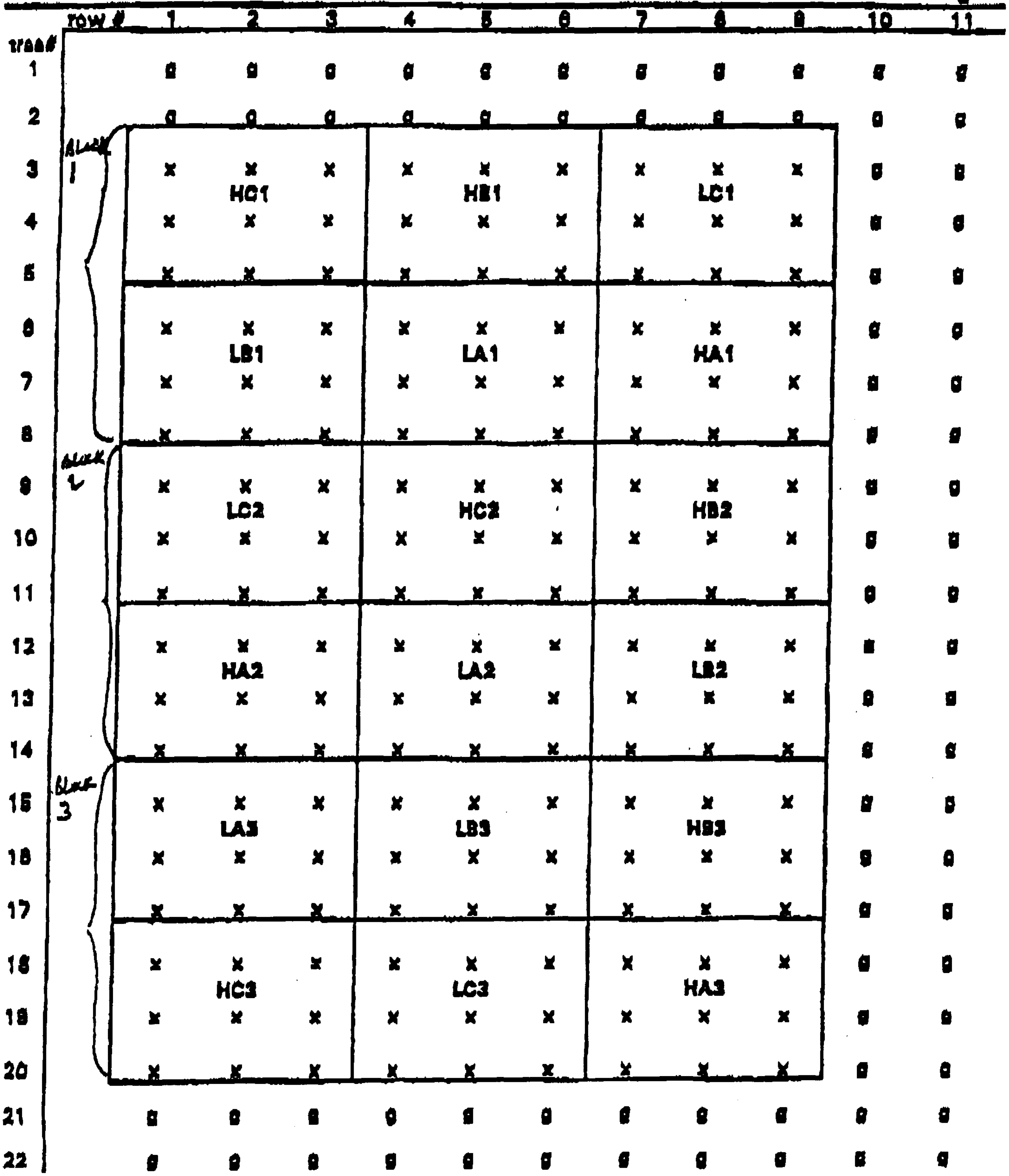

LEGEND:

L,H = Irrigation Rate:	A,B,C = Herbicide Rate:	Replicate #:
L = low (110%Et)	A = 0lb/acre	1
H = high (175%Et)	B = 1lb/acre ai	2
	C = 2lb/acre ai	3

x = tree
g = guard row tree, butterfly emitter at 100% Et

Study 112N - 1993 Nectarine Sampling Schedule April 1 thru Sept 1, 1993

1) **Backgrounds**
Soils - 9 cores, 0 to 3', at 6 " intervals — Sites: HC1, LC2, LA3, LA1, LA2, LB3, LC3, HA1, & HB2.
9 x 6 = 54 soils
Lysimeters - 18 sites, 2 depths per site (1' and 3')
18 x 2 x 3 = 108 soil water samples

2) **Application Day (Mass Deposition)**
Application Jars w/ 25g soil - 2 Irrigation Rates, 3 Herbicide Rates, 3 Reps
2 x 3 x 3 = 18 application jar samples w/ 25g of soil

3) **2 Weeks Post Application Day Samples**
Bioassay - 2 Irrig Rates, 3 Herb Rates, 3 Reps = 18 sites, 3 reps per bioassay sample
18 sites x 3 reps per site = 54 bioassay samples (allow for 14 sampling intervals)
Soils - 1 per bioassay site from 0 to 2"
54 sites x 1 = 54 soil samples
Lysimeter - 2 Irrig Rates, 3 Herb Rates, 3 Reps = 18 sites, 3 reps per depth
18 sites x 3 reps per depth x 2 depths = 108 soil water samples

4) **4 Weeks Post Application Day Samples**
Bioassay - 2 Irrig Rates, 3 Herb Rates, 3 Reps = 18 sites, 3 reps per bioassay sample
18 sites x 3 reps per site = 54 bioassay samples (allow for 14 sampling intervals)
Soils - 1 per bioassay site from 0 to 2"
54 sites x 1 = 54 soil samples
Lysimeter - 2 Irrig Rates, 3 Herb Rates, 3 Reps = 18 sites, 3 reps per depth
18 sites x 3 reps per depth x 2 depths = 108 soil water samples

5) **8 Weeks Post Application Day Samples**
Bioassay - 2 Irrig Rates, 3 Herb Rates, 3 Reps = 18 sites, 3 reps per bioassay sample
18 sites x 3 reps per site = 54 bioassay samples (allow for 14 sampling intervals)
Soils - 1 per bioassay site from 0 to 2"
54 sites x 1 = 54 soil samples
Lysimeter - 2 Irrig Rates, 3 Herb Rates, 3 Reps = 18 sites, 3 reps per depth
18 sites x 3 reps per depth x 2 depths = 108 soil water samples

6) **12 Weeks Post Application Day Samples**
Bioassay - 2 Irrig Rates, 3 Herb Rates, 3 Reps = 18 sites, 3 reps per bioassay sample
18 sites x 3 reps per site = 54 bioassay samples (allow for 14 sampling intervals)
Soils - 1 per bioassay site from 0 to 2"
54 sites x 1 = 54 soil samples
Lysimeter - 2 Irrig Rates, 3 Herb Rates, 3 Reps = 18 sites, 3 reps per depth
18 sites x 3 reps per depth x 2 depths = 108 soil water samples

7) **16 Weeks Post Application Day Samples**
Bioassay - 2 Irrig Rates, 3 Herb Rates, 3 Reps = 18 sites, 3 reps per bioassay sample
18 sites x 3 reps per site = 54 bioassay samples (allow for 14 sampling intervals)
Soils - 1 per bioassay site from 0 to 2"
54 sites x 1 = 54 soil samples
Lysimeter - 2 Irrig Rates, 3 Herb Rates, 3 Reps = 18 sites, 3 reps per depth
18 sites x 3 reps per depth x 2 depths = 108 soil water samples

8) **20 Weeks Post Application Day Samples**
Bioassay - 2 Irrig Rates, 3 Herb Rates, 3 Reps = 18 sites, 3 reps per bioassay sample
18 sites x 3 reps per site = 54 bioassay samples (allow for 14 sampling intervals)
Soils - 1 per bioassay site from 0 to 2"
54 sites x 1 = 54 soil samples
Lysimeter - 2 Irrig Rates, 3 Herb Rates, 3 Reps = 18 sites, 3 reps per depth
18 sites x 3 reps per depth x 2 depths = 108 soil water samples

Total Soils = 398 Lysimeter = 848 Bioassay = 324