California Department of Food and Agriculture
Environmental Monitoring and Pest Management
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106

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Protocol to Measure Leaching of Simazine in Furrow and Mini-Sprinkler Irrigation

I. BACKGROUND

Residues of herbicides used in citrus production have been found in ground water (Troiano and Segawa, 1986). Leaching of residues with deep percolating water produced from irrigations has been identified as one of the potential pathways for contamination. In a previous study conducted on bare soil at CSU-Fresno, leaching of an herbicide, atrazine, was related to the amount of water added in irrigations: the amount and depth of atrazine leached increased as the quantity of water added in an irrigation increased (Troiano et al., 1990). Additions of water were based on estimates of reference evapotranspiration which provided a quantitative measure that related deep percolation losses to the magnitude of leaching. Although employment of a water budgeting technique appeared to be a reasonable approach to minimize leaching of herbicides, the magnitude of leaching differed between irrigation method. Less water was lost to deep percolation in sprinkler irrigation and less pesticide was leached than in basin-flooding or furrow irrigation methods.

The differences in magnitude of leaching between irrigation methods requires confirmation under cropped conditions. Citrus is grown on the farm-site at CSU-Fresno. The planting is large enough to allow application of differential irrigation treatments. Application of a water budgeting technique to irrigation of this planting with subsequent measurement of effects on the

soil distribution of citrus herbicides would provide strong practical evidence for recommending the use of water budgeting methods as agricultural modifications.

II. OBJECTIVE

The objective of the study is to relate leaching of citrus herbicides to irrigation applied under cropped conditions. In the winter, effects of frost protection irrigation will be studied and in the summer, deep percolation of water and pesticide leaching will studied in furrow and in sprinkler irrigations.

III. PERSONNEL

Study design and analysis - John Troiano

Field sampling and laboratory liaison - Cindy Garretson

Senior scientist - Bruce Johnson

Cooperating scientist - Dr. Charles Krauter, CSU-Fresno

IV. STUDY PLAN

The citrus planting consists of 30 rows of trees that are furrow-irrigated. Each row has 24 trees. Seven of the rows would be assigned to this study. A treatment replicate would consist of a single tree located between border rows of trees (Figure 1). For studying the effects of graded levels of deep percolating water on leaching, three blocks would be positioned across the rows and three treatment levels randomly assigned within the blocks. The amount of water added would be the treatment factor with 3 levels of water addition that would produce graded levels of deep percolating water. The lowest level of water addition would supply the amount of water needed for crop growth as based on reference evapotranspiration (ETo) values obtained

from a local CIMIS weather station. ETo values are then adjusted for the appropriate crop coefficient values for citrus. The other two treatment levels would provide 40 and 80% greater amounts of water which should result in deep percolation.

Graded levels of water application in furrow treatments will be made by physically blocking off each treated area and then by supplying water in gated pipe which would control the flow. Water meters will be used to measure water delivery in each treatment. In addition, half of the study area would be equipped with mini-sprinkler irrigation. Owing to constraints on the design, it will not be possible to randomize furrow and sprinkler treatments. Mini-sprinkler treatments would be located adjacent to the furrow-irrigated treatments in the next set of 10 contiguous trees. The same treatment design will be used as in the set of trees used for the furrow irrigation (Figure 1). One mini-sprinkler head will be located between each tree effectively supplying 1/2 the water supply to a tree. Overlap between sprinklers will be insignificant.

Measurements of the redistribution of herbicide in soil would be made using soil-suction tensiometers. The tensiometers first would be tested for potential reaction with the pesticides applied. Preliminary data indicate that they could be used to collect residues of the citrus herbicides bromacil, simazine, or diuron (Bob Teso, personal communication). Each replicate tree would be instrumented with 4 sets of tensiometers, each set located at 0.5. 2.0, and 3.5 meter depths. Two of the sets would be used as soil-suction lysimeters to collect replicate soil solution samples, one set would be used to monitor soil water tension and the fourth set would act as a reserve to replace any failed tensiometers. Tensiometers in each set will

be located near each other but at the minimum distance where samples would be independent. They will be located in the furrow bottoms and situated on either side of the treated tree. Sampling would be timed to collect soil solution from the front of deep percolating water as it moves through the soil after each irrigation event. Dr. Charles Krauter, a cooperating scientist on the project, has had extensive experience on the installation and use of soil-suction tensiometers. They are currently used on a contract that he has with the CDFA to measure the amount of deep percolating water produced from irrigation events. Data from that study would be used to refine the sampling schedule for this study.

Data will be analyzed to determine the effects of amount of water added on:

1. The concentration of solute measured at each tensiometer depth over time. Analysis would be conducted as a split-plot with level of water as the main plot and time as the subplot as follows:

Source of Variation	DF
Main plot	
Rep	2
Water added	2
Rep*Water added	4
Subplot	
Time	n
Time*Water added	n*2
Subplot error	n*2(Rep)

2. The slope as determined from the difference in concentration between the shallowest and deepest tensiometer will be determined for each sampling

interval. Derived slopes will also be analyzed as a split-plot ANOVA to determine the effect of added water over time. Graphical presentation will aid in interpreting these results to indicate whether or not leaching occurred.

3. The integration of the area under the curves produced in #2 will be determined for each time interval. The resultant mass will be summed over all sampling intervals and the total cumulative mass subjected to ANOVA.

This data will first be used to determine if use of a water budget technique is effective at mitigating leaching of pesticides. If successful, the data could be used to illustrate the practical use of water budgeting in providing adequate water to a crop while controlling the leaching of a pesticide. The level of watering that produces leaching will also be determined to indicate the practical limits of this approach to a cropped situation, i.e. some amount of overwatering may be appropriate because leaching does not occur until y amount of water is added. This acceptable level will be compared between the two irrigation methods to compare how similar these values are.

For studying frost protection, 4 of the trees within each irrigation method will be randomly chosen. Samples from the soil suction lysimeters will be taken from these trees and used to determine the depth of leaching within each irrigation method. Simazine and bromide will be applied to the soil in mid-November prior to frost protection irrigations. Bromide will be used as an inorganic tracer to measure efficiency of sample collections. The number

of samples taken at each interval to measure effects of frost protection would be:

2 methods x 4 trees x 3 depths x 2 subsamples/tree = 48 samples.

Samples will be taken: 1) for background at an irrigation that occurs prior to simazine application; 2) post-irrigation after the first one which would occur in December; and 3) then after a second frost protection irrigation. The total number of samples will be 144.

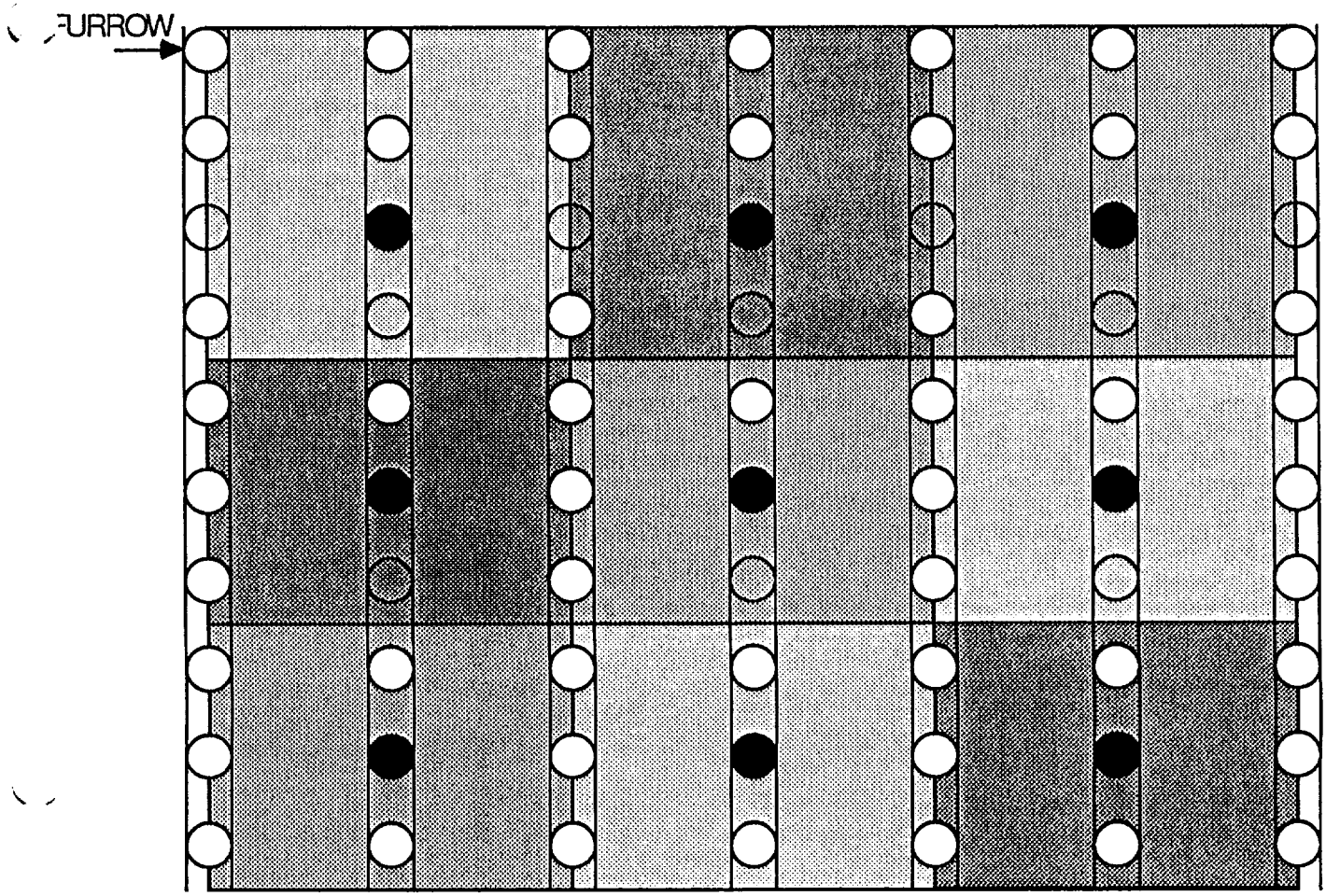
For studying deep percolation produced from crop irrigations, simazine and bromide would be applied in March. The number of samples taken at each sampling interval would be:

2 methods x 3 ETo levels x 3 reps x 3 depths x 2 rep/tree = 108.

Sampling would occur after application of each irrigation treatment. Use of permanently installed tensiometers would allow flexibility in the sampling schedule. Water samples would be stored and analyzed by immuno-chemical. Treatment effects between irrigations will be compared graphically. Measurements of soil texture and infiltration rate will be made to determine the similarity of the sites with respect to soil hydraulic properties.

It is anticipated that the preparation of the site would be completed by the fall of 1990. Once the lysimeters are installed and shown to be in working condition, the sampling methodology could be used to study effects of wintertime frost protection irrigation on herbicide leaching. The irrigation modification study would then commence in the spring of 1990.

FIGURE 1A. FIELD DESIGN FOR APPLYING 3 LEVELS OF WATER APPLICATION TO A PORTION OF A FURROW-IRRIGATED CITRUS GROVE.

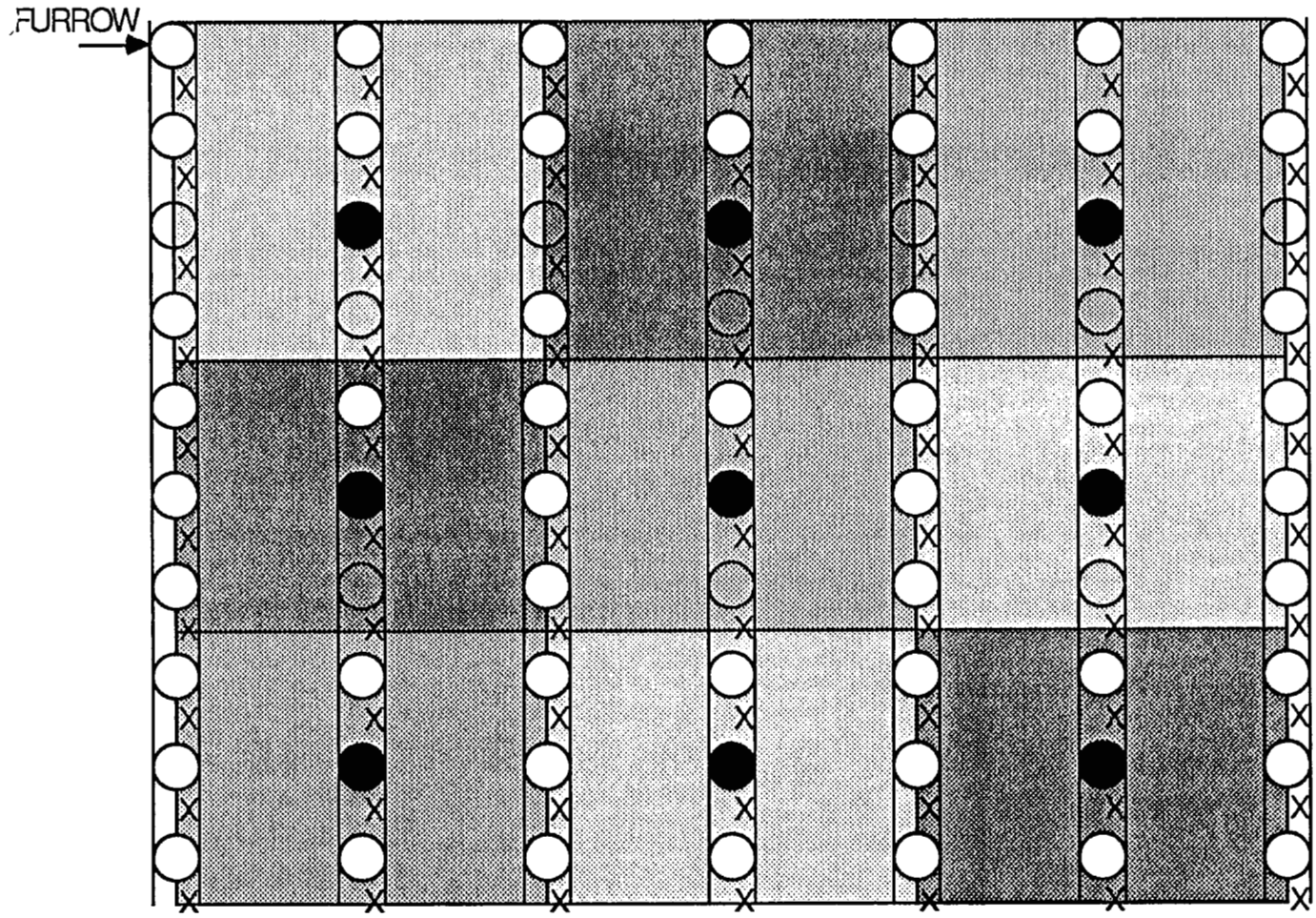


○ CITRUS TREE ● TREATMENT TREE

3 GRADED LEVELS OF WATER APPLICATION

• NOTE THAT THE SPRINKLER PLOTS ARE LOCATED DIRECTLY ADJACENT TO THE FURROW TREATMENTS

FIGURE 1B. FIELD DESIGN FOR APPLYING 3 LEVELS OF WATER APPLICATION TO A PORTION OF A SPRINKLER-IRRIGATED CITRUS GROVE.



○ CITRUS TREE ● TREATMENT TREE X SPRINKLER

3 GRADED LEVELS OF WATER APPLICATION

* NOTE THIS PLOT IS ADJACENT TO FURROW IRRIGATED PLOT

V. BUDGET

1. Frost protection irrigation-144 samples.....$2880

   QC (10%)-15 samples.....$2250

2. Efficient irrigation-(2/month for 6 months + background)1404 $28,080

   QC (10)-150 samples.....$22,500

VI. REFERENCES

Troiano, J.T. and R.T. Segawa. 1987. Survey for herbicides in well water in Tulare county. Environmental Monitoring Branch of the California Department of Food and Agriculture. January, 1987.

Troiano, J.T., 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 Monitoring Branch of the California Department of Food and Agriculture. July, 1990.