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Team Agriculture -Working to Protect Water Resources

Conference Proceedings

VOLUME II: NUTRIENTS

March 5-8, 1995
Kansas City, Missouri

Sponsored by
Working Group on Water Quality - U.S. Department of Agriculture

Coordinated by
ASA E -The Society for engineering in agricultural, food, and biological systems

#72

Pesticide Leaching Under Different Irrigation Systems

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Summary

The effect of different irrigation management systems on pesticide transport toward groundwater was evaluated under field conditions. In Experiment 1, during a 2-year period, soil profile and shallow groundwater samples were analyzed for pesticides applied to cotton grown with four irrigation systems, i.e., subsurface drip (SSD), low-energy precision application (LEPA), conventional, and improved furrow. There was no apparent difference in soil distribution of pesticide residues below the 20-inch depth among the four irrigation treatments, although some shallow groundwater samples were found to contain pesticides with concentration somewhat higher in the existing and improved furrows than in LEPA or SSD fields. In Experiment 2 at Shafter, California, on a sandy loam soil, higher concentrations of pesticides were observed in the surface soil of SSD plots than in furrow irrigated ones, but no residues were found below 20-inch depth in either irrigation system. The effect of injecting polyacrylamide at 5-10 ppm in irrigation water on sediment and pesticide load in runoff water was evaluated. The polymer application significantly reduced the sediment load and kelthane concentrations in runoff from a furrow irrigated lima bean field.

Project Description

To develop better understanding of how water and pesticide applications can be controlled to reduce pesticide transport to groundwater, pesticide transport studies were coupled with water management practices to evaluate the effectiveness of water application methods in reducing pesticide transport in two large scale field experiments.

In Experiment 1, conducted on the Harris Ranch near Fresno, California during a 2-year period, soil profile and shallow groundwater samples were analyzed for pesticides applied with four irrigation systems, i.e., subsurface drip (SSD), low-energy precision application (LEPA), conventional furrow and improved furrow systems. Each irrigation system was 40 acres. Soils at the site were fine-textured silty clay loams with no tile drains and a shallow saline water table (70-85 inches). Groundwater wells were installed in the plots using 2-inch steel tubing, 10 feet long with slots in the lower 8 feet. This experiment was designed to investigate the pesticide behavior in fields that are managed using traditional agricultural practices. Soil was sampled to a depth of 80-120 inches two times during 1993 (before and after harvest of cotton). Water samples were obtained from the sampling wells on five dates during 1993. At each sampling time, water (1 qt) was drawn from four monitoring wells from each irrigation system, extracted into hexane by liquid-liquid partitioning, and analyzed by GC for trifluralin, chlorpyrifos, methamidophos, and pendimethalin.

In Experiment 2 at Shafter, California, pesticide movement was measured in a sandy loam soil as affected by furrow and subsurface drip irrigation systems. Cotton was planted in 30-inch rows with the subsurface drip tubing being 8-10 inches deep under the plant row. The plot design is a randomized block with five replications, each plot 140 feet long by 4 rows wide. The herbicides trifluralin and prometryn were applied pre-planting by spraying over the entire soil surface and incorporating to 4 inches with a cultimulcher. Before the first irrigation following cotton planting in 1993, three soil cores were obtained to the 20-inch depth from five replications of each irrigation system. Extensive soil profile sampling was conducted after harvest with samples obtained to the 120-inch depth with a heavy-duty drilling rig equipped with a 60-inch-long split-tube auger.

A third experiment was conducted near Patterson, California in which polyacrylamide was injected at 5 to 10 ppm into the irrigation water to evaluate its ability to reduce sediment load and pesticides in runoff water. Eight 300-foot-long rows were irrigated with or without polymer treatment. The runoff water was sampled at various times and analyzed for suspended sediment, total sediment and kelthane insecticide residues. Suspended solids were measured by spectrophotometer, total sediments by filtration, and kelthane residues by GC.

Results

Differences between irrigation systems on movement of the various pesticides are not readily apparent from the data of Experiment 1. Samples taken on March 9, 1993 (representing 1992 cotton harvest) indicated that pesticide concentrations were all very low or non-detectable except for small amounts of chlorpyrifos and pendimethalin in the surface 12 inches. The distribution of trifluralin, chlorpyrifos, and pendimethalin in soil samples taken on December 8, 1993, after the 1993 cotton harvest indicated slightly higher residues of trifluralin, chlorpyrifos, and pendimethalin in the surface 20 inches in furrow irrigated plots than in those receiving irrigation water through the LEPA or subsurface drip irrigation systems. There was essentially no difference between irrigation treatments at depths near 20 inches, and no measurable quantities of pesticides were detected below 20 inches. Shallow groundwater samples collected on five dates from different irrigation systems did not show great differences in their concentration levels, although the furrow irrigated plots appeared to have slightly higher concentrations of pendimethalin and chlorpyrifos. No trifluralin was detected in the groundwater samples.

In Experiment 2 at Shafter, soil samples taken before irrigation in 1993 indicated uniform distribution of trifluralin, MITC, chlorpyrifos, and methamidophos with no difference between the furrow and subsurface drip irrigation systems. The residues were rapidly dissipated during the cotton growing season and soil samples taken after harvest on December 6, 1993, showed very low residue concentrations (Fig. 1).

None of the four pesticides moved deeper than 20 inches under either irrigation system. In the surface 4 to 6-inch layer, trifluralin, chlorpyrifos, MITC, and methamidophos residues were higher in the subsurface drip than in furrow irrigated plots. The surface layers were probably dryer under the subsurface drip system, and residues may dissipate more slowly than under the furrow irrigation system. This may also indicate that the pesticides are less mobile under subsurface than furrow irrigation systems, although this will require further study.

In Experiment 3, application of polyacrylamide in irrigation water at 5-10 ppm was very effective in reducing overall sediment load and greatly decreased kelthane concentrations in the runoff water (Fig. 2).

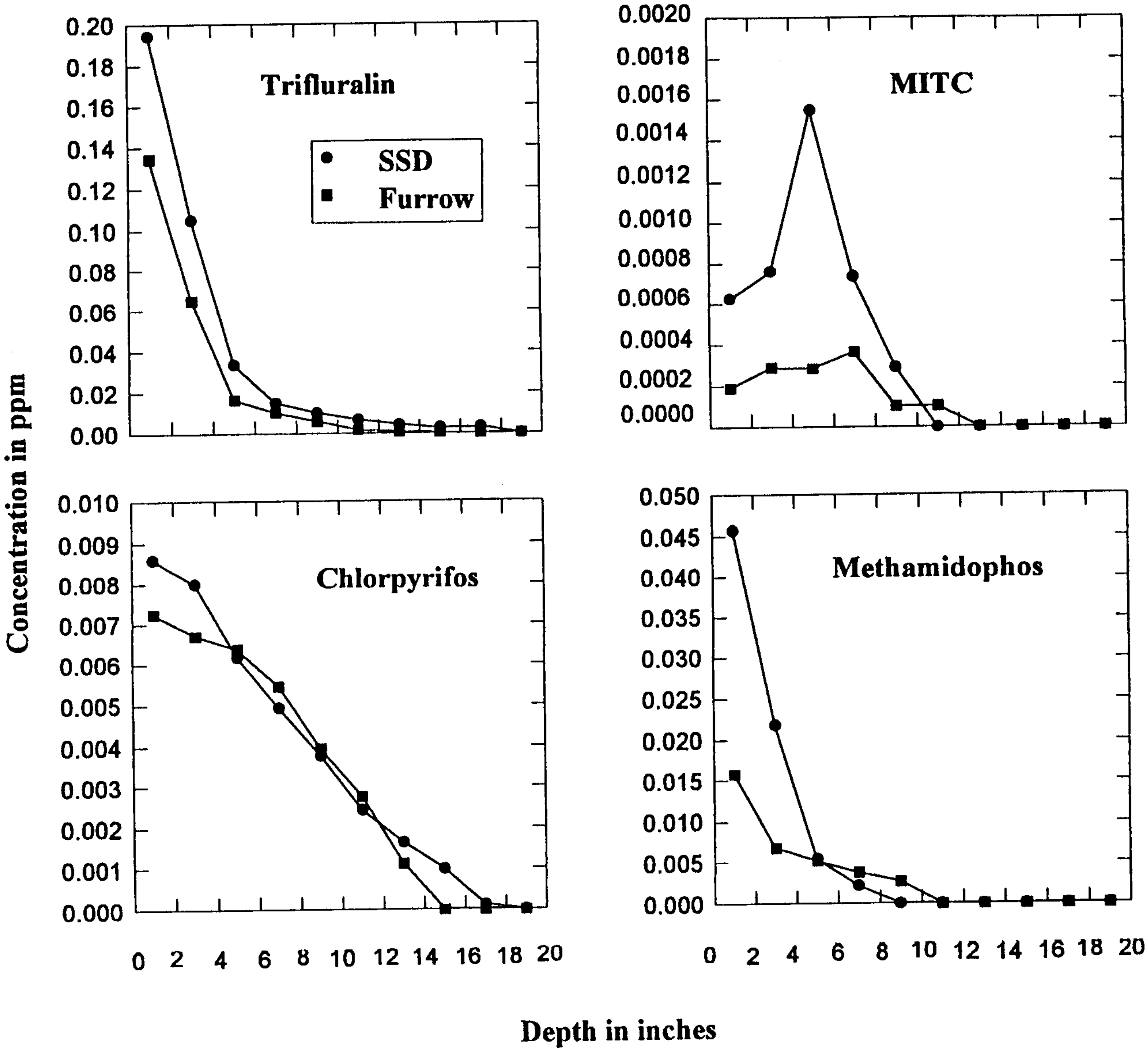

Figure 1. Pesticide distribution in sandy loam soil after cotton harvest as affected by irrigation management (SSD = Subsurface drip).

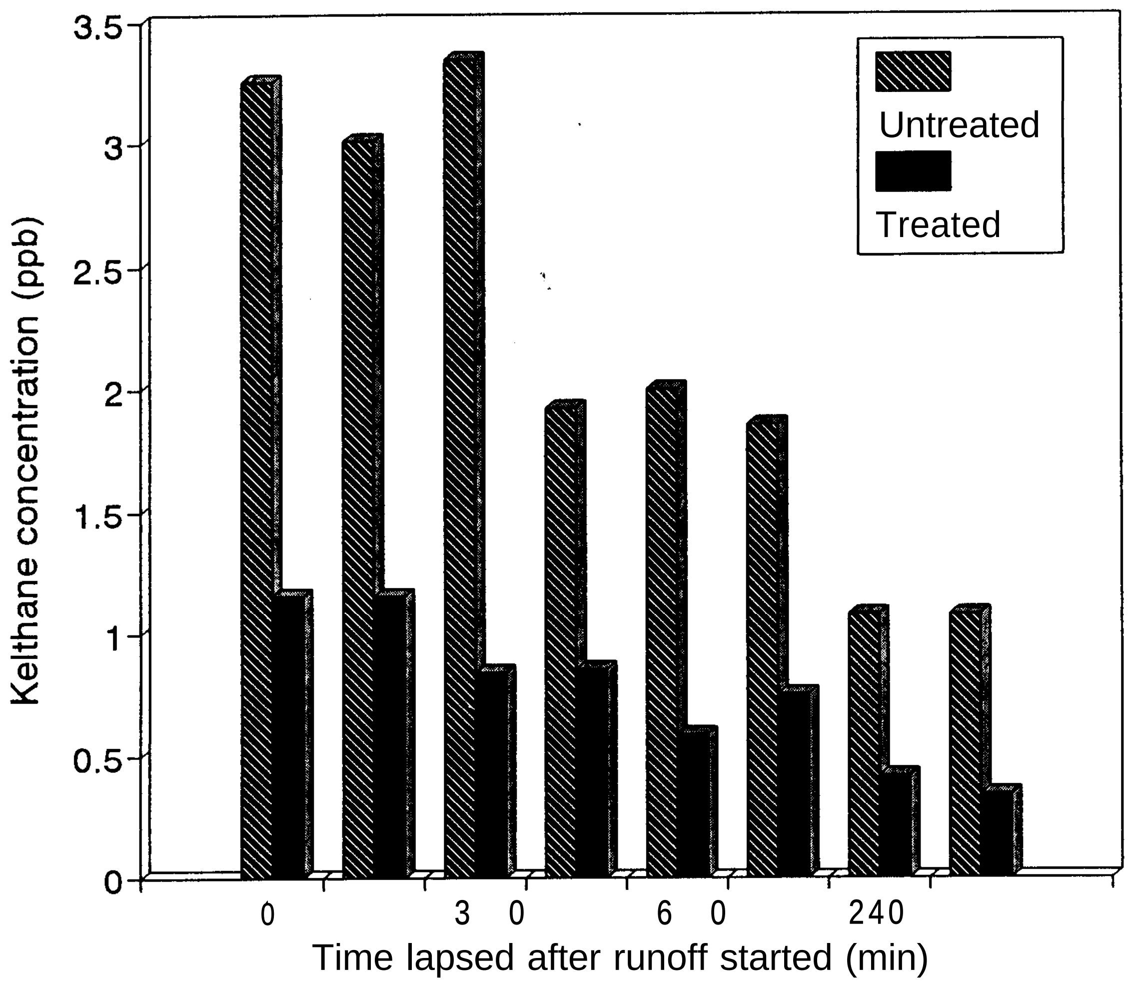

Figure 2. Kelthane residues in runoff water from polymer treated and untreated furrows.

Technology Transfer

The effect of the various irrigation systems on transport of pesticides is not sufficiently conclusive to make recommendations at this time. Hopefully further research will lead to developing the best combination of water and pesticide management practices to reduce pesticide transport below the root zone and for improving water and pesticide use efficiency in irrigated agriculture. Expected users of these results include: scientists, researchers, modelers, regulators, agricultural advisors, and farmers. This information could be transmitted to the agricultural and environmental users through publications, presentations at meetings, workshops, and field days.

Public Affairs Activities

Preliminary results of this project were reported at the American Society of Agronomy, Soil Science Society of America Meeting in Seattle, Washington, November 13-18, 1994.