Pesticide Movement & Water Management

by

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Abstract

Agricultural chemicals are essential components of agricultural production systems in the United States. Pesticides control weeds, insects, and have had an important role in increasing agricultural productivity in the last 50 years, despite diminishing crop land acreage. The benefits of chemicals use options in agriculture must be balanced against potential contamination of surface water and ground water resources. This study shows the effect of water management practices on pesticide movement and its potential pollution to ground water. It indicates that careful use of pesticides, water management practices and irrigation system design alternatives could cause a major reduction in ground water contamination potential.

Introduction

With increased attention on ground water issues, conflicts in regard to maintaining surface water and ground water quality have become apparent. Conservation practices that reduce surface run-off while enhancing of infiltration have been associated with increased potential for pesticide transport to ground water. Pesticides include organic and inorganic chemicals used as: insecticides, herbicides, fungicides, rodenticides, fumigants, disinfectants, plant growth regulators and other related substances. At the present, about 45,000 pesticides products are marketed in the US. The Environmental Protection Agency (EPA) estimates that about 70 percent of all pesticides used in the country are applied in agricultural production, 7 percent in home and garden settings, and the remaining 23 percent in forestry, industry and government programs (Figure 1).

In Utah, ground water is a valuable and necessary resource. About 63 percent of Utah's population depends on ground water for drinking supplies (Waddell, 1987). In rural areas ground water is often the only source of drinking water. However, in some of these same areas, ground water is close to the surface and, therefore, easily subject to contamination by agricultural chemicals. There are up to 50,000 wells statewide supplying water for various purposes. There is some degradation of ground water quality in several areas caused by urbanization (Figure 2). Ground water contamination is caused by agricultural use of pesticides, irrigation practices, leachate from mine and mill tailing and surface impoundments. Contamination from many organic compounds has been detected in the shallow zones of some of the basin-fill aquifers but has not been detected in the deeper zones.

Consideration of site specific conditions and the individual physical/chemical properties of potential pollutants is a prerequisite for prevention of water quality deterioration in an environment of intense agriculture. Design and development of pesticide management to protect both surface water and ground water requires use of a combination of management strategies.

The benefits of chemical and physical management options in agriculture must be balanced against potential contamination of surface water and ground water resources. All agricultural chemicals are soluble to some degree in water and therefore subject to transport within the hydrologic cycle. Concern over non point source pollution of water resources has intensified with increased reliance on use of chemicals and increased demand on water resources in agricultural systems. Links has been associated between surface and ground water quality and certain agricultural practices.

Farm managers are caught in the dilemma of maintaining a profitable operation while sharing public concern over health hazard to their water supply. Many farmers see limited options adopted on the recommendation of both university and industry scientists. The challenge is to develope management strategies that optimize the benefit of agricultural chemicals and minimize the risk of non point source pollution.

Results and Discussions

Design and recommendation of best management practices BMP's to protect both surface water and ground water quality may require use of combination of management strategies. A combination of BMP's may resolve the apparent conflict between protecting surface water and ground water quality. Preventing water quality deterioration in an environmental of intense chemical management in agriculture will also require consideration of site specific condition and individual physical/chemical properties of potential pollutant.

The use of pesticide is considered necessary for economically successful agriculture systems. Sound pesticide management involves use of practiced design to retain the applied chemical on site and within the rooting zone (Figure 3). This Figure shows interaction between use of alternative irrigation water management and pesticide movement beyond the root zone. It also shows reactions of pesticides in the vadose zone such as adsorption, volatilization, crop removal, chemical decompositions, and biological degradation. The ultimate goal of any BMP's should be consider such management practices that would keep pesticides in their target site, or in root zone.

Figure 4 is a geographical representation of counties in Utah and indicates those counties which are more vulnerable to ground water contamination as a result of agricultural practices (Eisele at el., 1989). These results are based on the survey done on 1988-1989 by extension agents of Utah State University. Figures 5 and 6 was developed as a result of this survey and consequent analyses done to screen the potential hazardous pesticides used in State of Utah. The information on water quality and agricultural management practices are obtained from recent state-of-the-art literature reviews, simulation modes, water quality monograghes, and symposium publications. These Figures are indicators of the extent of pesticide usage in Utah county and potential hazardous to the quality of ground water that can be posed by extensive use of these particular pesticides.

Managing the type, amount, formulation, placement, and timing of pesticide applications are a practice that will accomplish both pest control and water quality goals. Selection of the appropriate array of pest management practices will control organisms and minimize potential contamination of water resources and non-target organisms. Critical pesticide management practices to decrease the potential for surface and subsurface transport include: a. reduction of pesticide applied; b. timing of application relative to run-off events; and c. selection of appropriate chemical and formulation for site conditions.

Selection criteria for the type of pesticide should include consideration of 1. target species; 2. pesticide characteristics such as pesticide degradation, soil adsorption coefficient and solubility. Site characteristic such as soil texture and organic matter content, geology, depth to ground water, proximity to well heads, proximity to surface water, topography, and climate. Pesticides that minimize these pollution characteristic should be selected. Substitution of less toxic, less mobile, less persistent, and more selective chemicals to meet pest control objectives is an important management alternative. Figures 7 to 10 are indicating the importance of appropriate selection of pesticides. This Pesticides can be used as alternative to pesticide which is more leachable and consequently have more potential for ground water contamination. These pesticides have similar affect for pest control on the indicated crop. This selection of alternative pesticides to reduce species resistance, use of less persistent chemicals and consideration of chemical transport mode, will reduce chemical loading and potential for off-site transport and its pollution potential.

Timing and amount of pesticides application in relation to local environment conditions, temperature, and especially rainfall determines potential of surface and sub-surface pesticide transport and degradation characteristics. Timing of application by crop stage may reduce leaching losses depending on whether multiple post-emergence applications are required to a single pre-emergence application. Restriction of a single application prior to anticipated storm events may be more effective in reducing surface and deep leaching losses of pesticides than most soil and water conservation practices. Figure 11 shows the effect of different application date on pesticide mobility. It indicates importance of timing in relation to local environmental conditions such as heavy rainfall or irrigation after pesticide application.

Conservation practices and appropriate selection of irrigation systems could reduce also the potential of pesticide contamination for ground water. Figure 12 shows the reduction of pesticide leaching to ground water by almost %50 when a more selective system was considered. This reduction is caused by more uniform application of irrigation water and less leaching beyond the root zone. Application methods including aerial, ground, and chemigation all influence the partitioning and potential transport of pesticides. Proper application rates and careful application to target site insure effective use of the applied pesticide. Losses of pesticides transported exclusively by over irrigation and not proper design selection are reduced significantly by implementation of a educated design alternative. For pesticides lost primarily in the dissolved phase leaching beyond the target root zone, would decreases by improving the quality if the applied water, primarily increasing the surface water application efficiency. Figures 13 is indicating the decrease in potential of pesticides leaching to non target area (beyond the root zone) by improving the irrigation application efficiency.

Irrigation and water management are critical factors in pesticide leaching. Areas with significant irrigation and heavy levels of pesticides have experienced significant increases in pesticide contamination of ground water. Leaching losses are increased with irrigation of shallow rooted crops on sandy soils. Accumulated pesticides in irrigated soils will be leached past the rooting zone when excess irrigation water is applied to reduce salt accumulation in the surface soil. On sandy soils excess pesticides will accumulate in the soil during cropping season with a low moisture input. These excess pesticide may be available for leaching with a heavy rain or repeated irrigation.

Assessing of potential off-site transport of chemicals by run-off or leaching losses prior to application will provide essential information on selection of pesticide appropriate for a specific site. Computer models have used for representing the current figures shown in this paper. Figures 14 and 15 was developed to demonstrate the importance of selection of a proper design criteria for a particular site. It indicates that by choosing a proper inflow to the head of a furrow or by having a appropriate length of run, pesticide leaching would be reduced by %45. This could be an important factor for reducing the ground water contamination potential when there is a limited choise of different management practices such as use of alternative pesticides.

Prevention of surface water and ground water contamination by implementation of rational pesticide practices is a cost effective measure to protect a limited water resources. Soil and agricultural managers should also be aware of the economic benefits of management practices that keep agricultural chemical within the root zone.

Run-off, leaching and volatile losses of applied chemicals degrade water quality and also represent production input losses. Pesticides beyond crop growth and yield requirements and excessive application of pesticides would result in sub surface and surface leaching, and volatile losses of applied chemicals. These practices are cost ineffective. Chemicals removed by run-off and leaching are not available for plant growth and pest control. Use of pesticide conservation practices will have both short term and long term economic benefits. Voluntary adoption and cost sharing and selection of sound chemical management are superior alternative to regulatory mandates. Implementation of sound pesticide management practices has water quality, crop production and economic return benefits.

Conclusions

It was demonstrated that a proper pesticide selection or a appropriate management alternative in irrigation systems could reduce the potential pesticide contamination of ground water. The relative risk posed by alternative use of pesticides for particular crops presented graphically. This is helpful to farmers and pesticide users showing a frame of reference for voluntary reducing the potential for non-point source pollution. Chose of alternative irrigation management and selection of proper irrigation design parameters was demonstrated. It could be an alternative approach for reducing pollution potential to our water resources. A appropriate water management selection could reduce pesticide movement and its leaching effect out of root zone. These practices could consequently decease potential of ground water contamination caused by use of pesticides.

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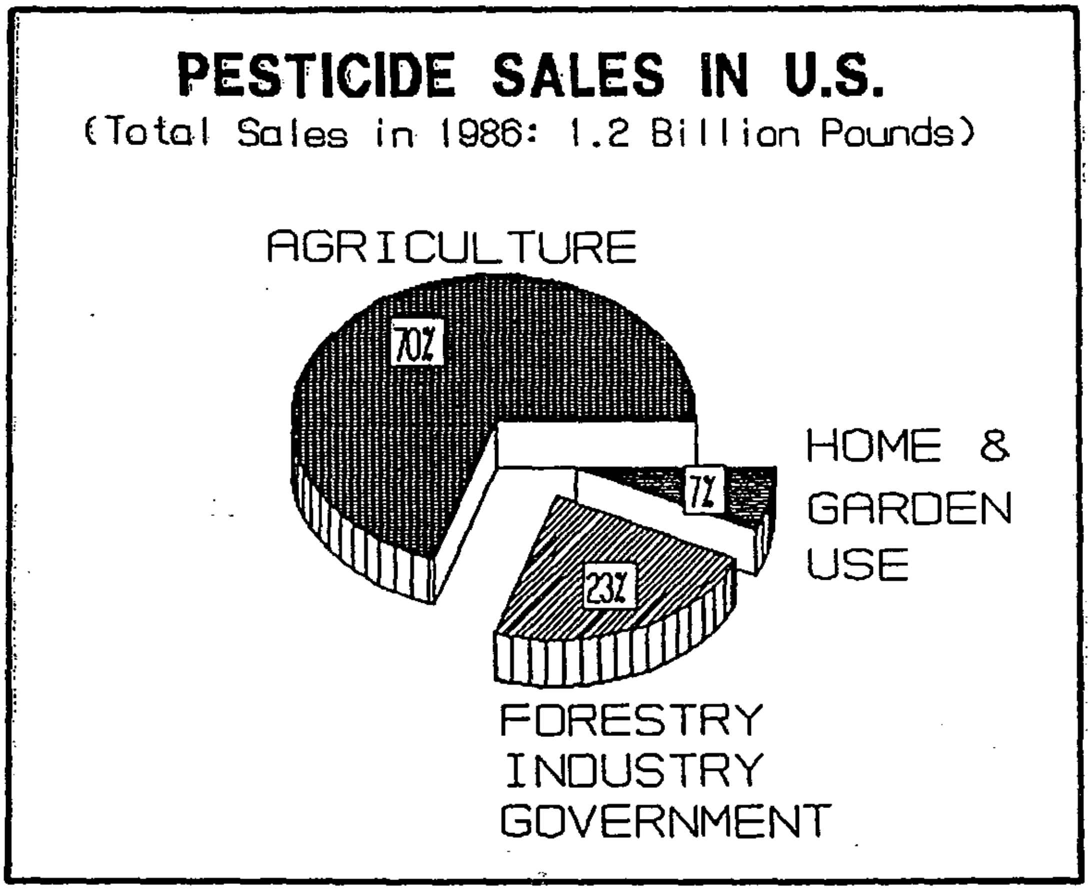


Figure . Pesticide Sales in United State.

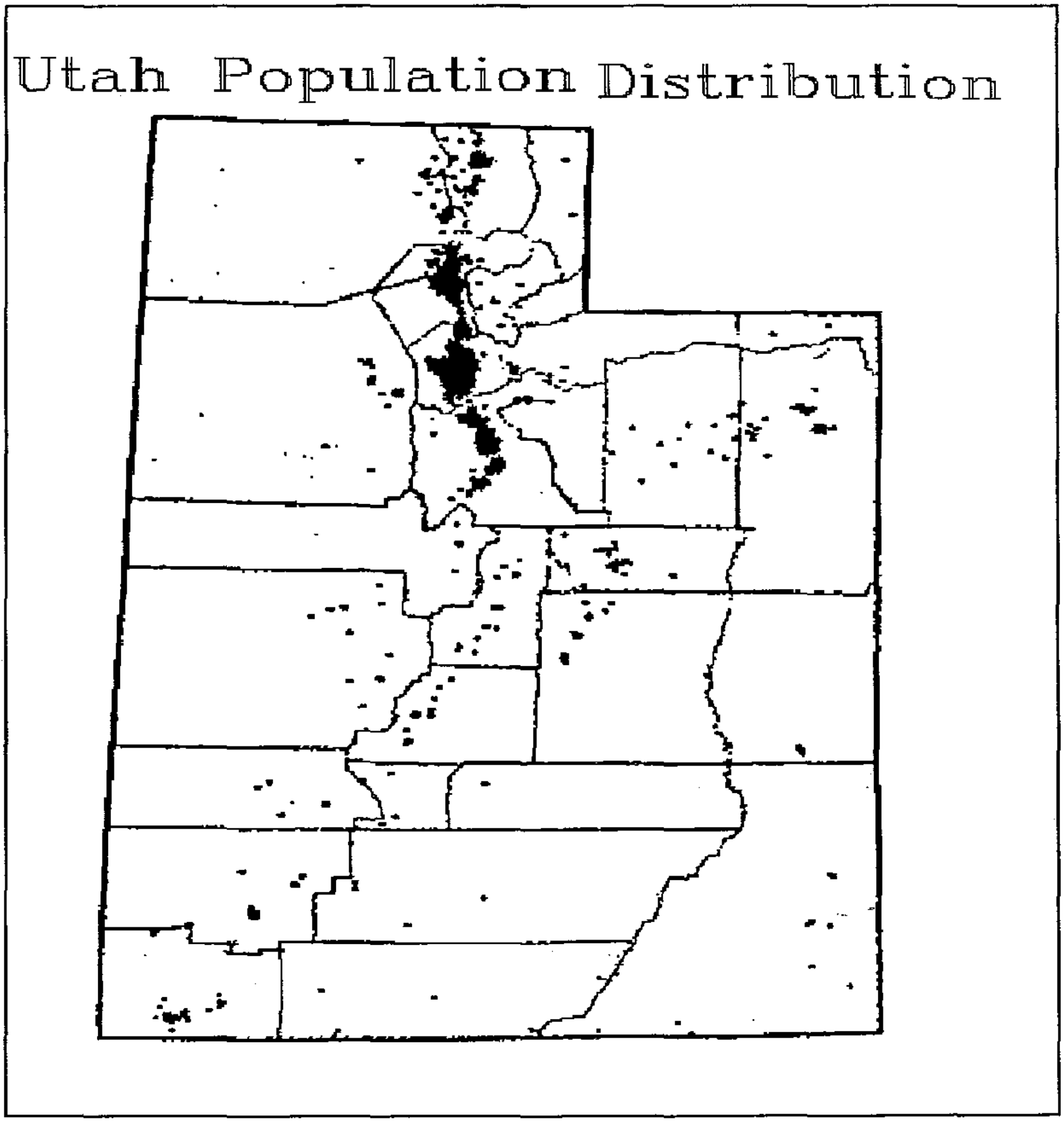


Figure . Population Distribution, 1985; each Dot on the Map Represent 1,000 People. (Source: 1985 U.S. Bureau of the Census Data for County Population.)

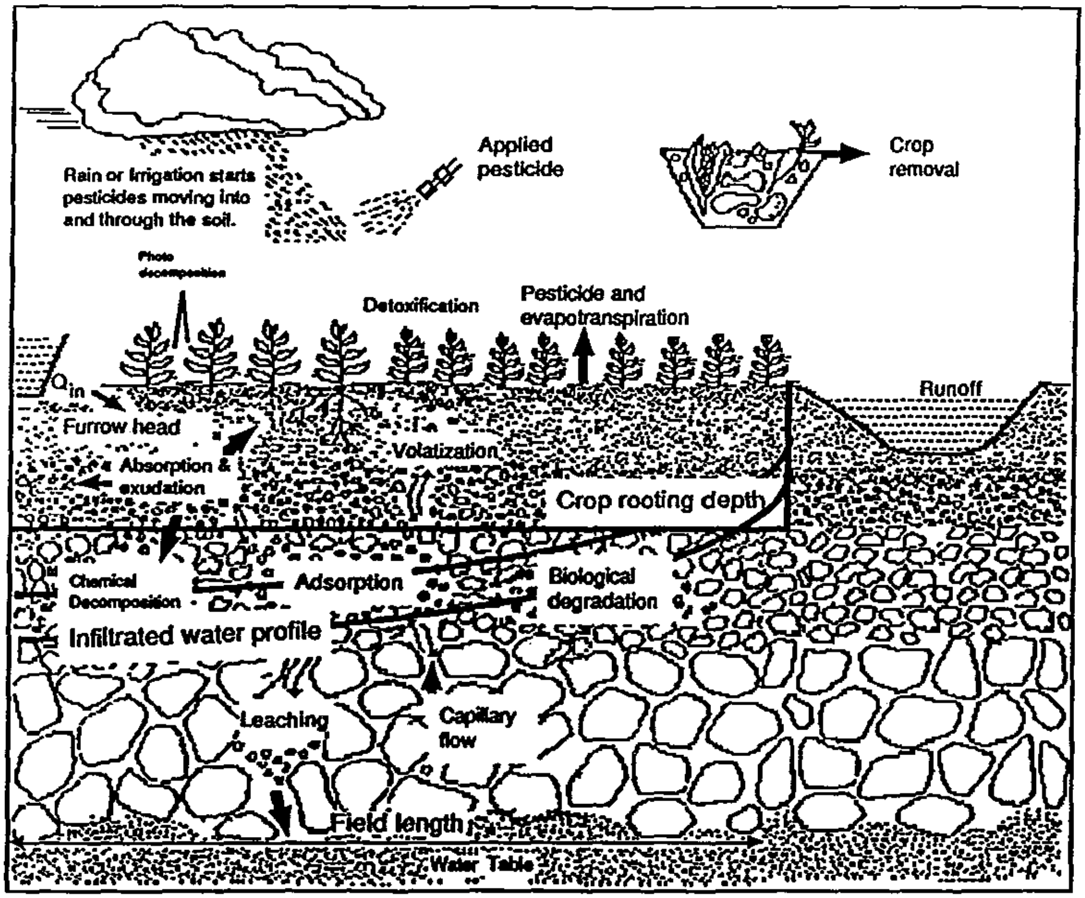


Figure . Schematic Representation of Reaction Between Pesticide Movement and Surface Irrigation Water Management Practice and Design.

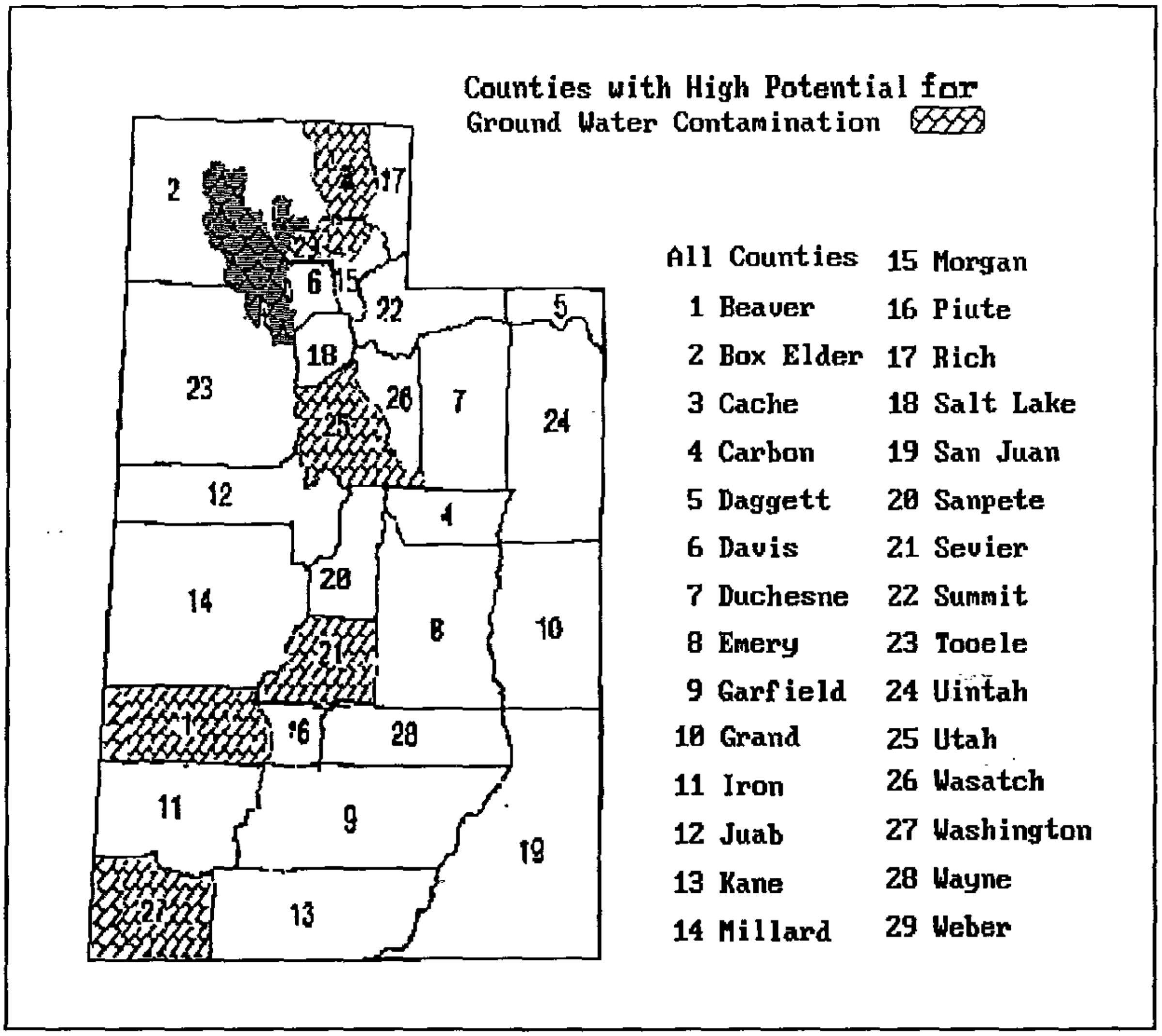
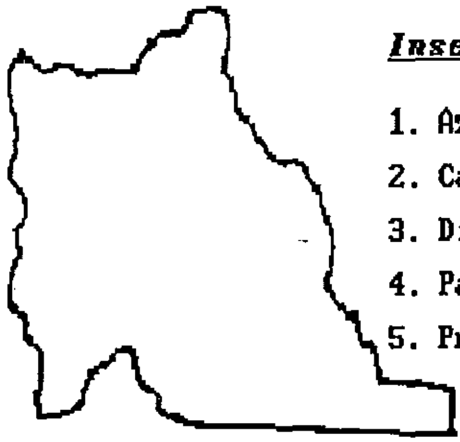


Figure . Geographical Representation of Counties with High Potential for Ground Water Contamination.

Utah County Pesticides Use



Insecticides

1. Azinphos-Methyl
2. Carbofuran
3. Diazinon
4. Parathion
5. Propagite

Herbicides

1. 2,4-D
2. Atrazine
3. Chlorsulfuron
4. Dicamba
5. Difenzoquat
6. Glyphosate
7. Hexazinone

Figure . Pesticide Use in Utah County, Insecticides and Herbicides.

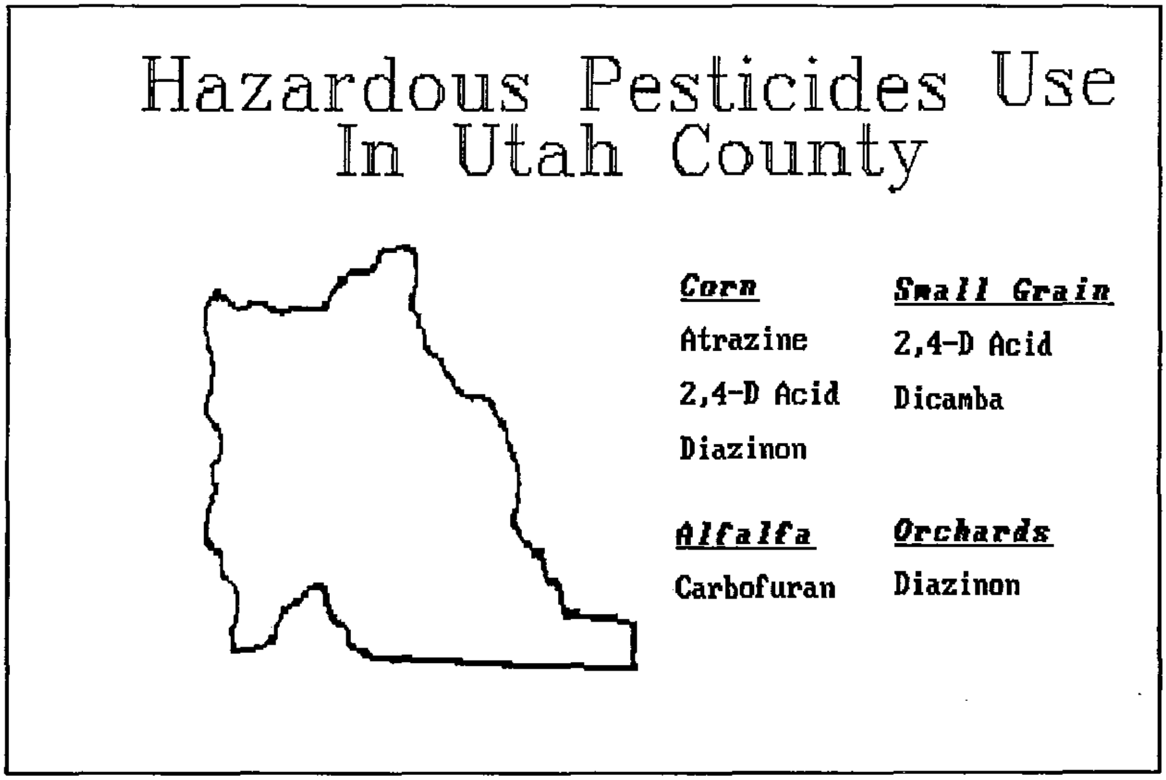


Figure . Hazardous Pesticide Use in Utah County for Different Crops.

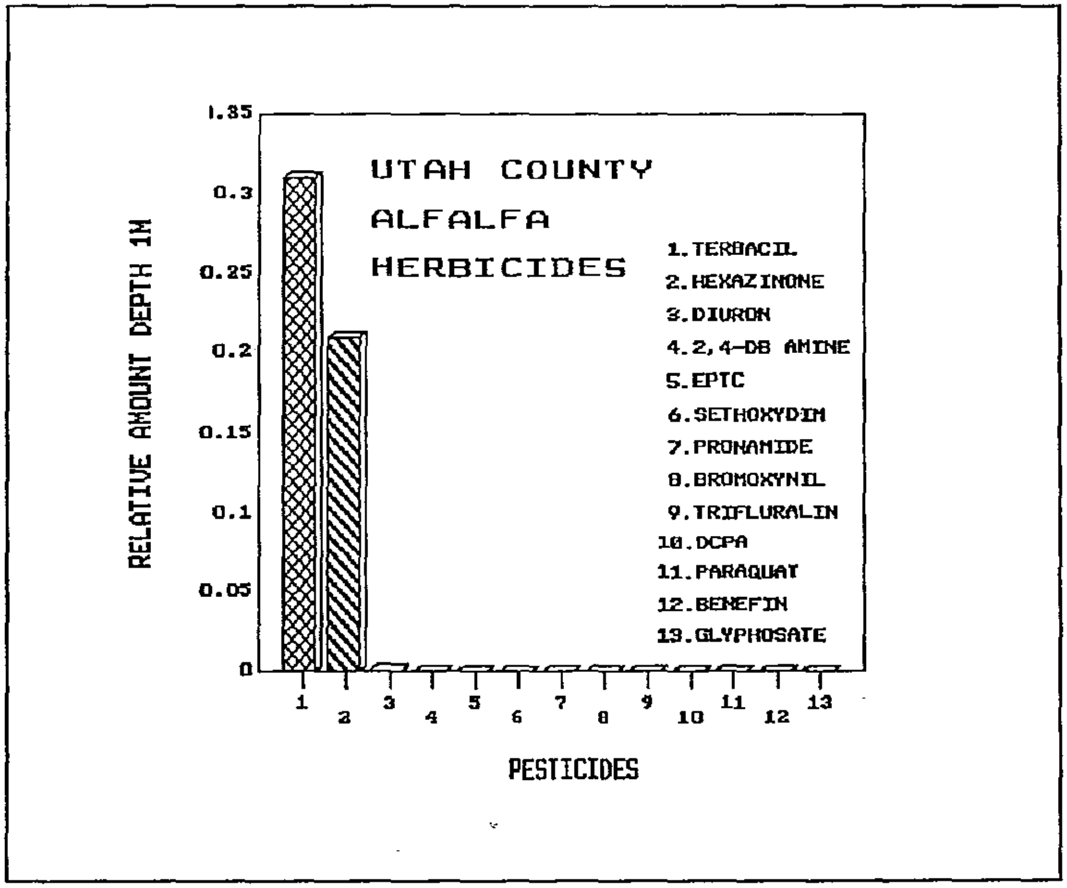


Figure . Alternative Use of Herbicides Suitable for Alfalfa in Utah County and their Relative Amount in 1 Meter Depth.

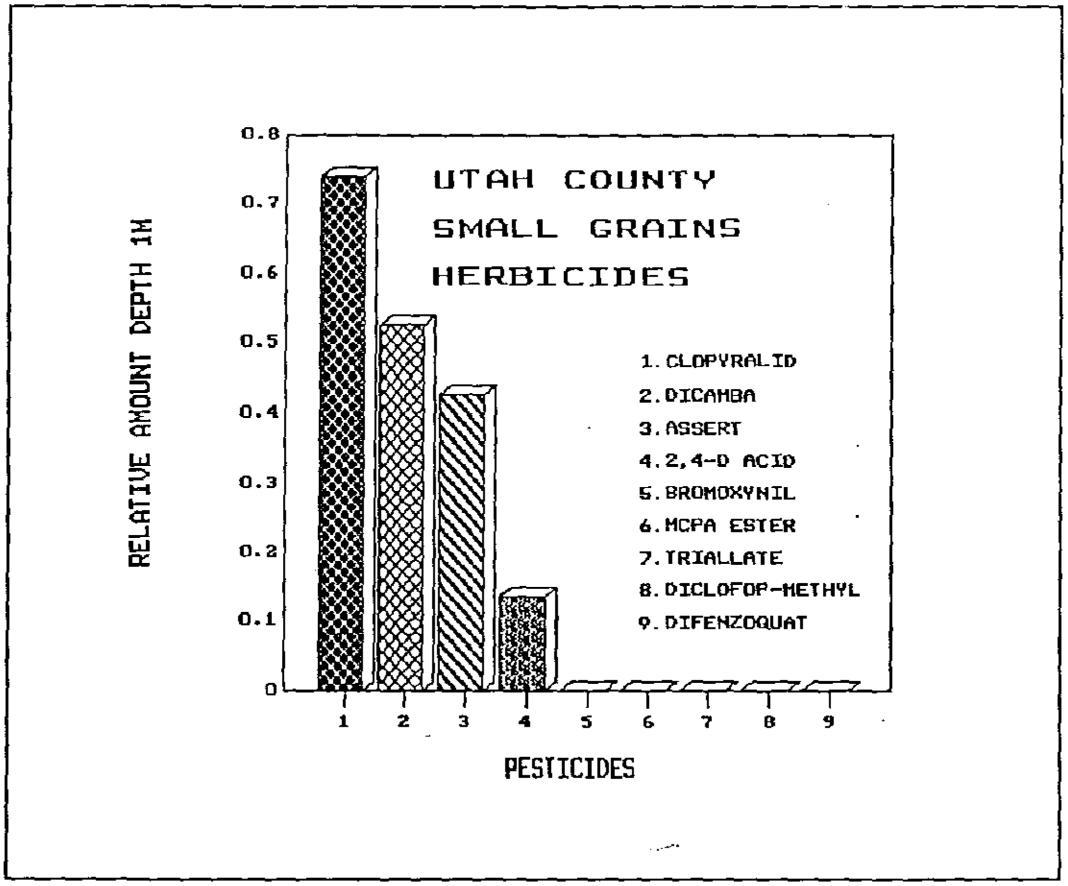


Figure . Alternative Use of Herbicides for Small Grains in Utah County and their Relative Amount in 1 Meter Depth.

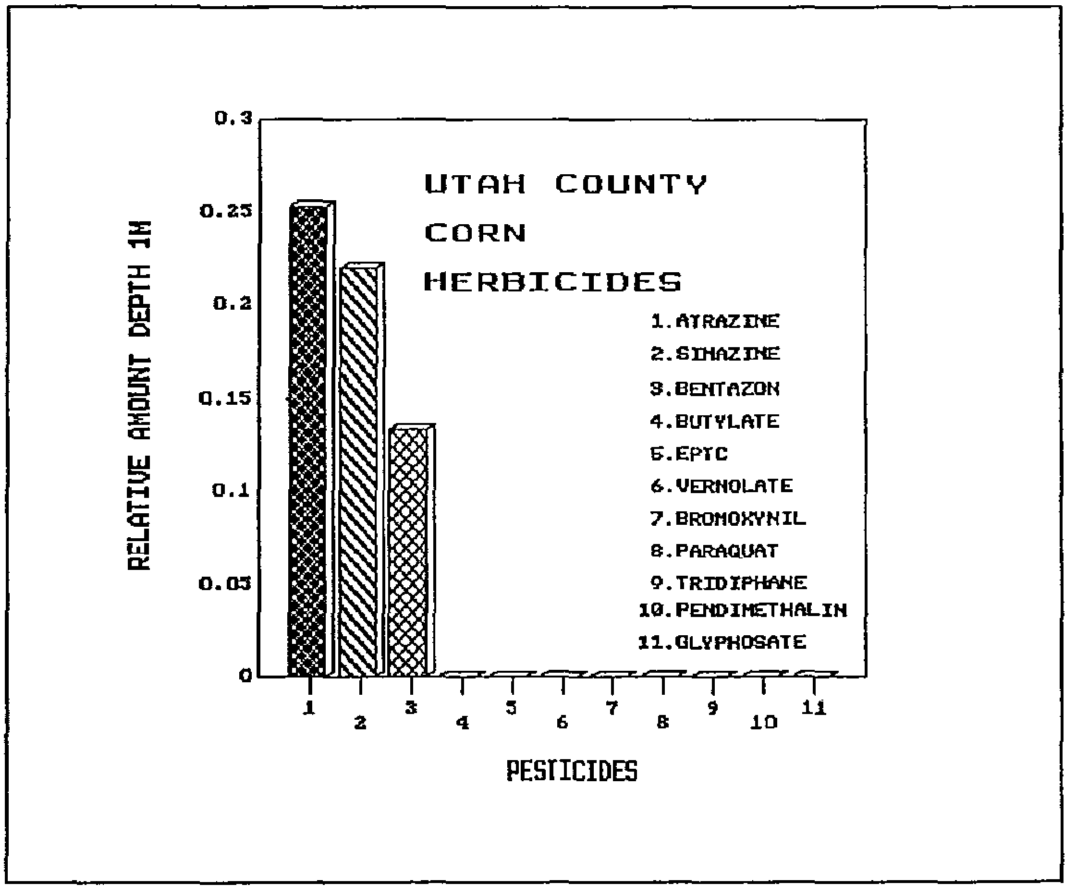


Figure . Alternative Use of Herbicides for Corn in Utah County and their Relative Amount in 1 Meter Depth.

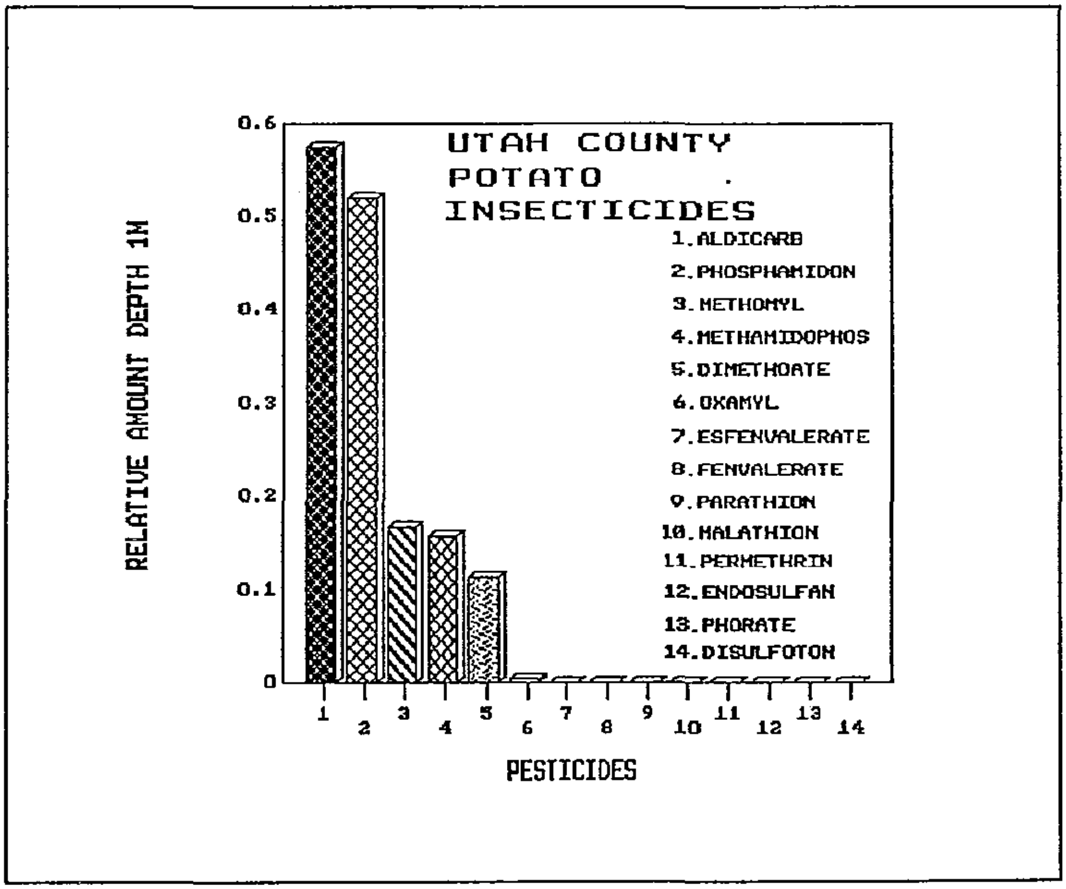


Figure . Alternative Use of Insecticides for Potato in Utah County and their Relative Amount in 1 Meter Depth.

EFFECT OF FORROW LENGTH

ON PESTICIDE MOVEMENT

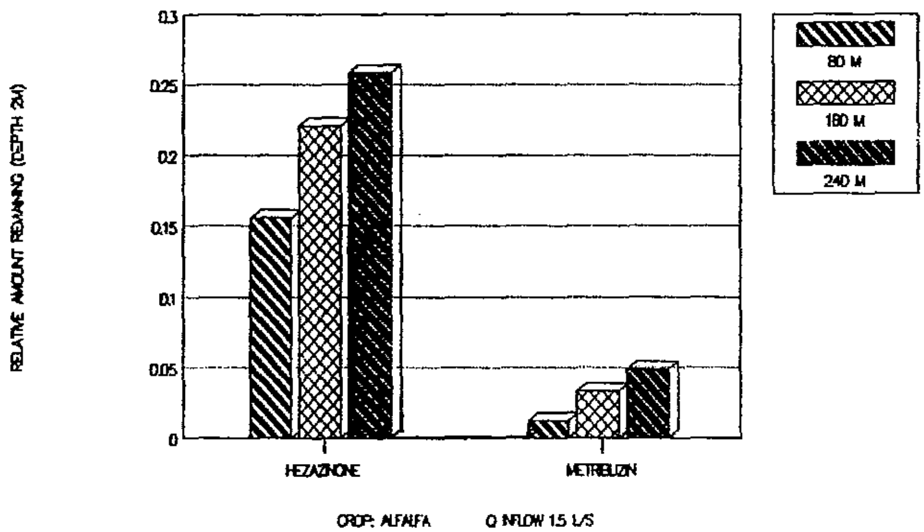


Figure . Effect of Various Furrow Length on Pesticide Movement.

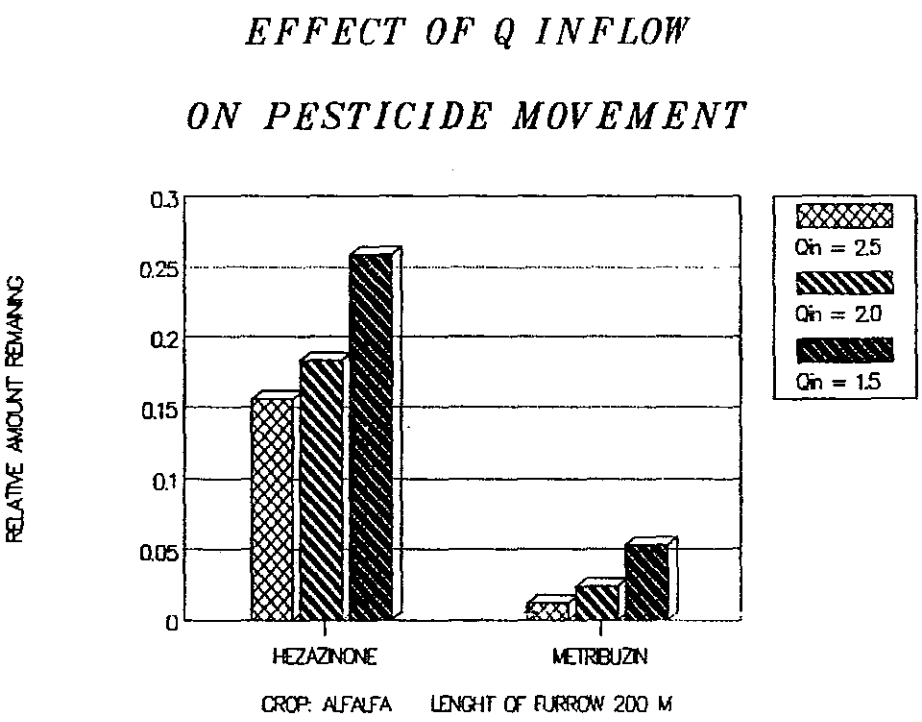


Figure . Effect of Various Q Inflow to the Furrow Head on Pesticide Movement.

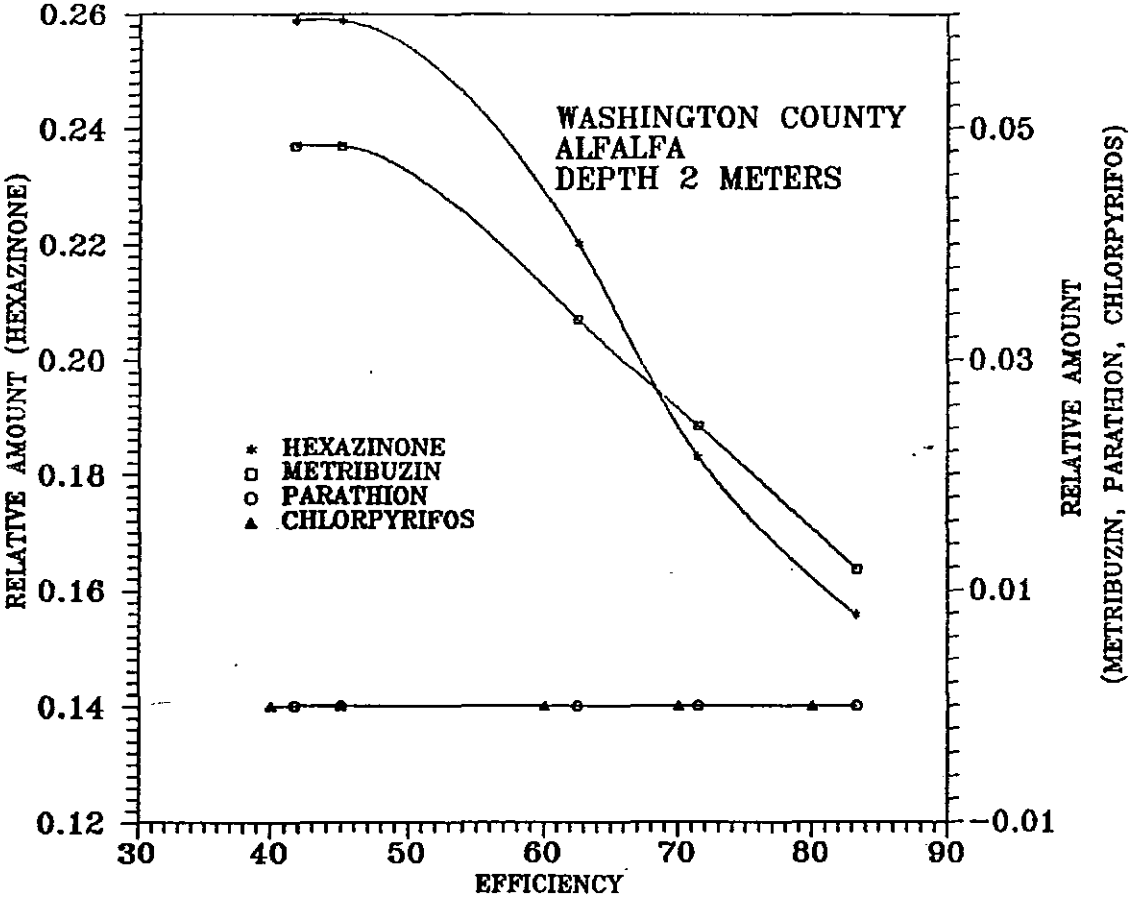


Figure . Effect of Various Surface Irrigation Efficiencies on Pesticide Movement at 2 Meter Depths.

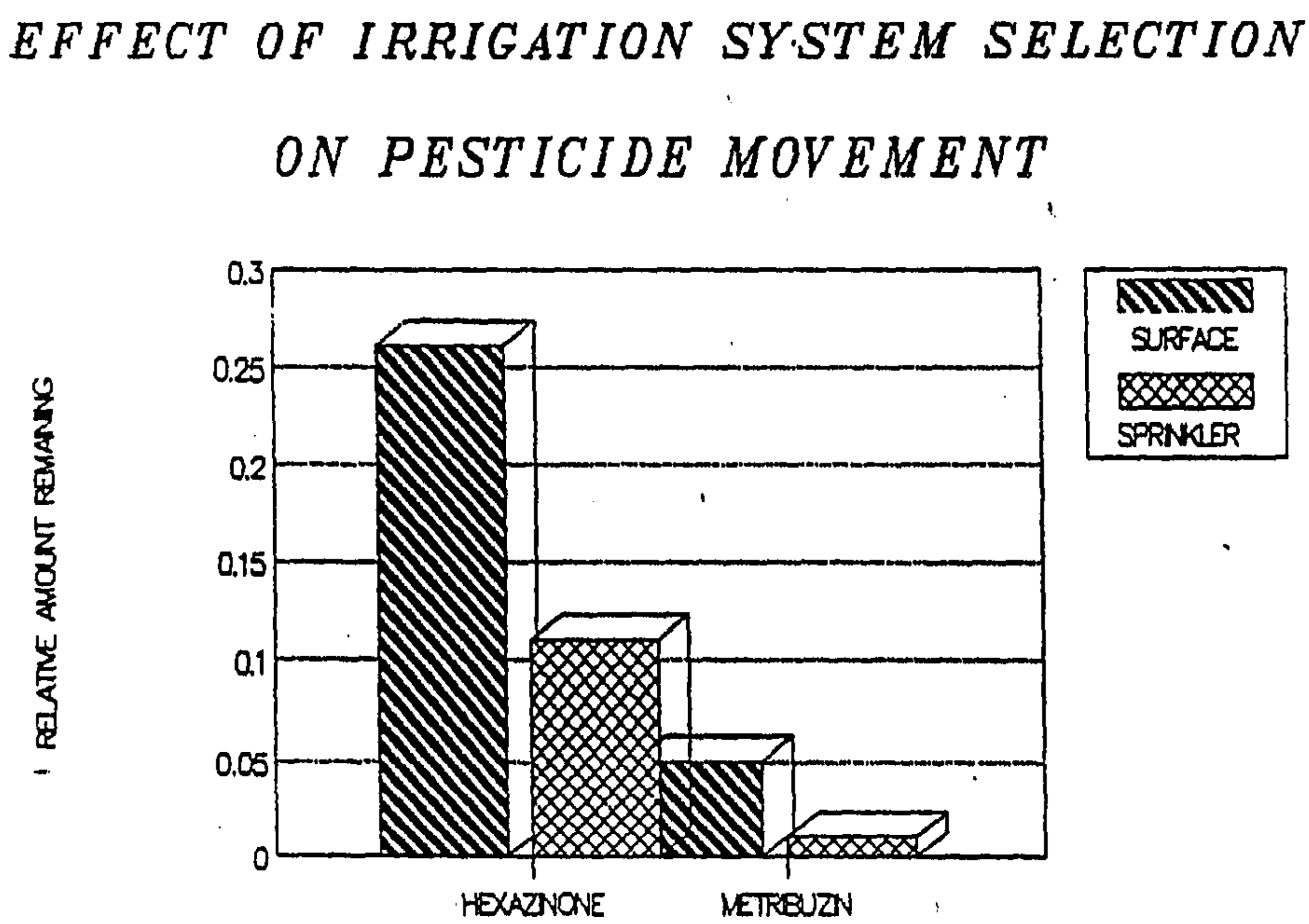


Figure . Effect of Different Irrigation Systems Selection on Pesticide Movement.

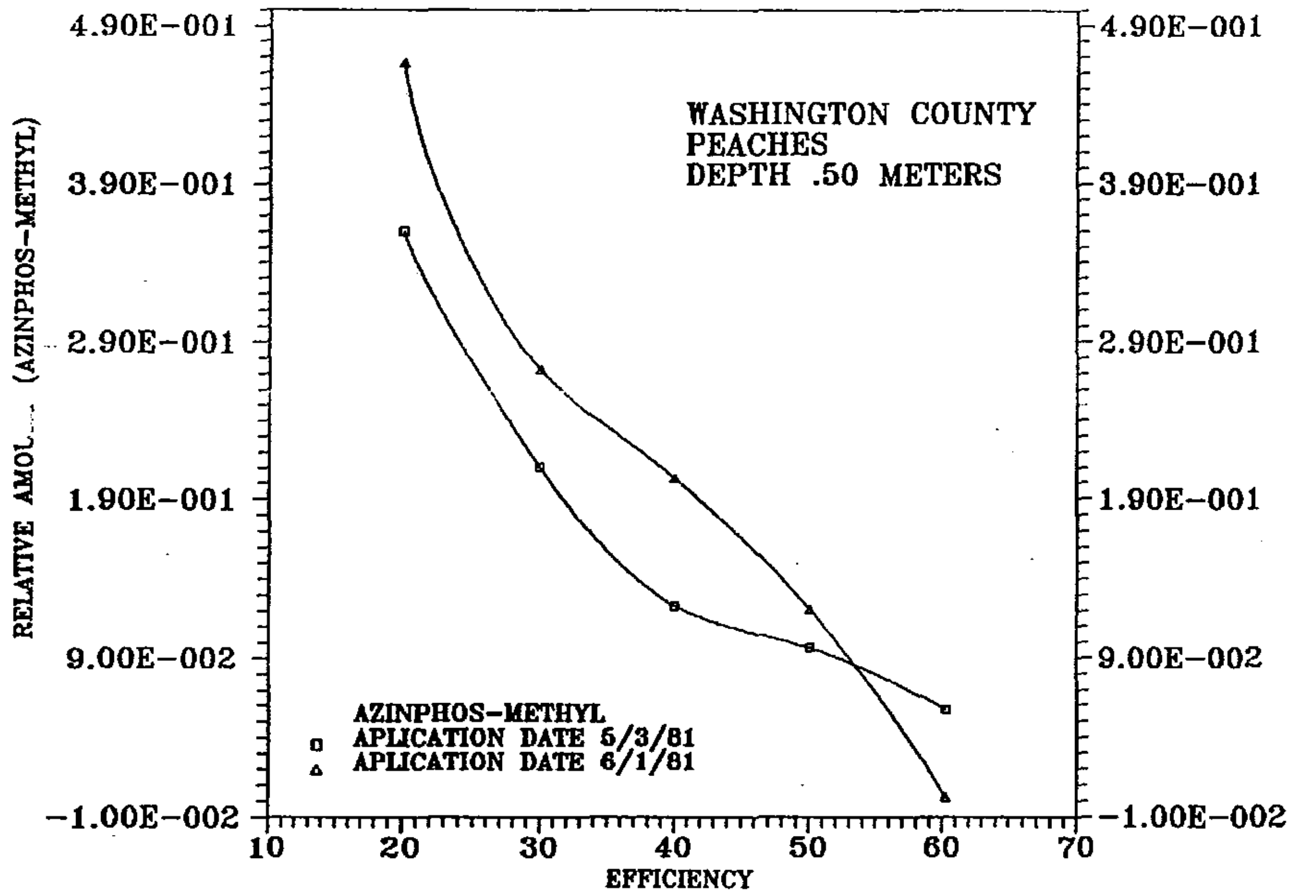


Figure . Effect of Various Surface Irrigation Efficiencies and Different Pesticide Application Date on Pesticide Movement at .5 Meter Depths.