DEGRADATION AND DISTRIBUTION OF SIMAZINE UNDER DRIP IRRIGATION IN A GRAPE VINEYARD

F. Liu[1], Timothy S. Prather[1], and Cindy Garretson[2]

[1]Kearney Agricultural Center, Statewide IPM Project, UCCE
[2]California Department of Pesticide Regulation

Introduction

Contamination of groundwater from herbicides puts important weed control tools at risk and potentially increases risks to human health. Movement of simazine into groundwater has been documented by the California Department of Pesticide Regulation. Simazine has been found in over 30% wells sampled in Fresno and Tulare counties. Dating of water with CFC's indicates the contaminated groundwater is less than 10 years old (Frank Spurlock, California Department of Pesticide Regulation. personal communication). In California, simazine use is predominately in citrus and grapes within the area of concern. DPR statistical analyses of their data suggest grapes and citrus are primary sources of contamination from these herbicides.

One route of groundwater contamination by agricultural chemicals occurs through recharge of groundwater whereby water moves from the surface through the soil profile to a groundwater aquifer (Wehtje et al., 1984; Freeze and Cherry, 1979). Recharge may result from natural rainfall or irrigation events (Bouwer, 1987). Alternative ground-floor management is needed to prevent movement of herbicides into groundwater. Drip irrigation is an irrigation method that results in irrigation water moving through herbicide - treated soil. Difficulty in evaluating downward movement of herbicides under the drip irrigation is that water application is not uniform over the surface of the field and, as a result, both water and herbicide may move downward, laterally or both. In a previous study (Troiano et al., 1990), an attempt was made to evaluate atrazine leaching directly under the drip emitters. Very little solute or tracer was recovered in cores taken below the drip emitters, even at the lowest level of irrigation (irrigation depth $\approx$ 0.75 ET calculated over entire plot area). This study concluded that more frequent and detailed sampling of soil located from both beneath and between drip emitters is needed in order to adequately describe solute movement in low volume systems where horizontal movement to non-irrigated areas could occur. While drip is a low-volume irrigation method that should allow a high degree control over total water application and timing, it is possible that, relative to furrow irrigation, enhanced herbicide transport may occur under the drip emitters because water application is not spatially uniform and directly contacts treated soil. Therefore, field observations are needed to evaluate the downward and lateral movement of simazine. The objective of this study was to determine simazine dissipation and distribution in a soil profile under drip irrigation, while maintaining acceptable crop health and weed control.

Materials and Methods

The study was conducted in a vineyard near Sanger, Fresno. The soil at the site is mapped as Hanford fine sandy loam (SCS, 1971), with about 50% sand and 6% clay content throughout soil profile. Soil organic carbon content is 1.1% in 0 - 15 cm soil depth.

Experiment 1: The experimental design was a randomized complete block with four replications. The list of treatments for this experiment is summarized in Table 1. Under drip irrigation, three irrigation models - Growers standard, Historic ET, and Current ET, were used. Historic ET and Current ET models have been derived to relate the amount of water in ET irrigation according to crop requirements and climatic conditions (Synder et al, 1985). For growers standard, water was applied by the grower according to his experience. Data for daily ET_0 values were acquired from a CIMIS weather station located in Fresno, California for Current ET model. Yearly average ET_0 values were used for Historic ET model (Cooperative Extension, University of California, 1986). A water flow meter was installed for each irrigation model. Herbicides were broadcast over the soil surface with a sprayer on 2/18/97. Herbicides were applied in a 1.7 m swath down vine row on the soil surface. Irrigation began on 4/2/97 and usually irrigated once a week. Soil simazine concentration and distribution in soil profile was only determined for grower standard, and current ET model. Soil cores were taken directly under the emitter on 4/10/97, 1.0 m west between the vine row and the emitter on 4/17/97, and 1.0 m east between the vine row and the emitter on 5/1/97. The samples taken were immediately frozen on dry ice and kept at -4^0 C until submission to laboratory. Simazine in soil was analyzed using the ELISA immuno-assay method.

Table 1. Summary of treatment under drip irrigation.

Irrigation	ET model	Chemicals	Additive
Drip	Growers	2.0 lb ai simazine ac^{-1} + 2.0 lb ai diuron ac^{-1}	surfactant
	Historic	2.0 lb ai simazine ac^{-1} + 2.0 lb ai diuron ac^{-1}	surfactant
	Current	2.0 lb ai simazine ac^{-1} + 2.0 lb ai diuron ac^{-1}	surfactant

Experiment 2 - : Simazine was applied at a rate of 1.21 lb ai ac^{-1} on 09/18/97 in a 1.7 m swath down the vine row. The first irrigation was made three days later. Soil cores were taken under the emitter, 0.33 m west and east between the vine row and the emitter for simazine analysis one week (9/18/97), two weeks (9/24/97) and four weeks (10/8/97) after application.

Results and Discussion

Herbicide Concentration and Distribution as affected by irrigation model

Simazine concentration profiles for two ET models- Growers standard and Current ET, are listed in Table 2. Simazine distribution in soil profile under the emitter was influenced by both irrigated water and rainfall. The amounts of recorded rainfall events were 0.13 cm on 2/23, 0.33 cm on 2/27, 0.03 cm on 3/10, 1.04 cm on 3/22, and 0.18 cm on 3/23. The total amounts of irrigated water were 2.4 cm and 2.0 cm (calculation based on entire area) for growers standard and current ET, respectively. Simazine was only detected on the soil surface (0 - 15 cm). Irrigation levels did not significantly affect simazine distribution. The recoveries of simazine were very low (Table 2), indicating either a rapid dissipation of simazine, or that much of the simazine had passed beyond the depth sampled. However, simazine has not been detected under 15 cm soil depth. Under the normal climatic conditions, loss of simazine from soil by photodecomposition and/or volatilization is considered insignificant (Humburg et al., 1989). The low recovery could be attributed to microbial degradation. Organic carbon content was 1.1% in 0 - 15 cm soil depth and 0.6% in 15 - 30 cm soil depth. A positive correlation between organic carbon content of soil and biological degradation has been found (Morrill, et al., 1982).

Table 2. Simazine concentration with soil depth as affected by irrigation model.

			Concentration		
ET Models	Soil depth	Total rainfall and irri. water	Under emitter	1 m west of emitter	1 m east of emitter
	-------------- cm	-----------------	--------------------- ug kg^{-1}		-----------------
----					
Growers	0 - 15	4.11	30 (2.3%)†	5	9
standard	> 15		nd‡	nd	nd
Current	0 - 15	3.71	6 (0.4%)	4	nd
ET	> 15		nd	nd	nd

† Recovery of applied simazine. ‡ Not detected.

According to organic carbon content of the soil at the site, higher rate of degradation would be have been expected in the first 0 - 15 cm. The soil was predominantly sand with value near 50% and 6% clay throughout the profile. Lateral movement of simazine was also studied under drip irrigation. Soil core samples were taken 1 m west between vine row and emitter (55 days) and 1 m east between the vine row and the emitter (73 days) after simazine application. These areas received no simazine application and were out of the wetting edge of the emitter. There were trace or nondetectable amounts of simazine throughout soil profile (Table 2). The detected trace amounts of simazine on the soil surface may have resulted from previous simazine application.

Simazine degradation and distribution as affected by sampling time

Soil samples were collected 7, 14, and 28 days after application (Table 3). The

Table 3. Simazine concentration with soil depth related to sampling time

		Concentration		
Sampling time	Soil depth	Under emitter	West of emitter	East of emitter
---- day ------	----- cm -----	---------------------------------- ug kg^{-1}	-------------------------	
7	0 - 15	105	461	359
	15 - 45	22	17	30
	45 - 76	8	0	0
	> 76	0	0	0
		(23.7%)†	**(68.7%)**	**(58.5%)**
14	0 - 15	26	476	464
	15 - 45	0	8	19
	> 45	0	0	0
		(3.7%)	**(68.4%)**	**(69.9%)**
28	0 - 15	0	166	175
	15 - 45	0	0	6
	> 45	0	0	0
		(0)	**(23.0%)**	**(25.9%)**

† Recovery of applied simazine (0 - 152 cm soil depth)

corresponding cumulative water input were 0.97, 2.14, and 3.05 cm. For the first sampling date, core depth was taken to 152 cm. Analysis of the soil core data reveals that only 23.7 % of the simazine under the emitter and 68.7 % at 0.33 m between the vine row and the emitter were recovered. On the second sampling time, simazine recovery in the soil profile was 3.7 % under the emitter and remain about 68 % at 0.33 m between the vine row and the emitter. On the third sampling time, simazine remarkably decreased in the soil profile at 0.33 m between the vine row and the emitter. Even under the emitter, the soil sample data do not indicate that a large amount of applied simazine was displaced depth into the soil by matrix water flow. As a result, the field-scale degradation would be the mechanism responsible for simazine loss. The rapid degradation of simazine minimized the potential for its presence at lower soil depths.

Conclusion

In conclusion, a few generalizations can be made that are critical to determining the environmental fate of herbicide under drip irrigation.

1. Recovery of simazine was very low under drip irrigation The most important processes accounting for simazine disappearance from this field study could be microbial degradation. The rapid degradation of simazine minimized the potential for it to move to lower soil depths.
2. Percolation of simazine to groundwater in grapes under drip irrigation was not a factor.
3. Distribution of simazine with the soil profile differed markedly depending on the uniformity of water application.

References

Bouwer, H. 1987. Effect of irrigated agriculture on groundwater. J. of Irri. and Drain. Eng. 113:4-15

Cooperative Extension, University of California. 1986. The water budget method - Irrigation scheduling for southern San Joaquin Valley deciduous orchards. Leaflet 21419.

Freeze, R.A., and J.A. Cherry. 1979. Groundwater. Prentice-Hall, Inc. Englewood

Humburg, N.E., et al. 1989. Simazine. *In* Herbicide handbook of the Weed Science Society of America (6th ed). Weed Science Society of America, Champaign, Illinois 61820

Morrill, L.G., B.C. Mahilum, and S.H. Mohiuddin. 1982. Organic compounds in soil: sorption, degradation and persistence. Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan. p.170-172.

Soil Conservation Service. 1971. Soil survey: Eastern Fresno Area, California. United State of Department of Agriculture in Cooperation California Agricultural Experiment Station, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C.

Synder, 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. University of California, Davis.

Troiano, J., and C. Garreson, C. krauter, and J. Brownell. 1990. Atrazine leaching and it's relation to percolation of water as influenced by three rates and four methods of irrigation water application. Pub. EH 90-7. Environmental Hazards Assessment Program, California Dep. of Food and Ag. State of California.

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. 13:507-513.