Persistence of Bensulfuron Methyl And Control of Hydrilla in Shallow Ponds[1]

K. A. LANGELAND AND F. B. LAROCHE[2]

ABSTRACT

Three shallow ponds near Welaka Florida were treated with 200 μg/l bensulfuron methyl to determine its effectiveness for control of hydrilla (*Hydrilla verticillata* (L.f.) Royle) and to determine its persistence in the ponds. Biomass of mature hydrilla in the ponds decreased following bensulfuron methyl application, but regrew within six months to pretreatment levels in two of the ponds. Newly sprouted hydrilla tubers placed in soil in plastic pans, which were submerged in the ponds immediately prior to treatment, were moribund one month following bensulfuron methyl application. Initial concentrations of bensulfuron methyl in the ponds, predicted by regression analysis, were 233, 183, and 209 ppb. Half-lives of the compound in the ponds were 5.9, 8.1, and 9.1 days.

Key words: Half-life, breakdown, sediments, hydrilla tubers, immature hydrilla, mature hydrilla, Florida.

INTRODUCTION

An aquatic plant's response to a herbicide is related to the length of time the plant is exposed and the concentration of the herbicide in the water (Netherland et al. 1991). The response will also be related to unique properties of individual herbicides and the sensitivity of the target species to each herbicide.

Bensulfuron methyl has shown promise for use as a herbicide or growth regulator in aquatic vegetation management (Anderson and Dechoretz 1988, Haller et al. 1992, Langeland and Laroche 1992, Van and Vandiver, 1992, Bowmer et al. 1992, Langeland 1993). Its effectiveness for hydrilla control under experimental conditions was dependent on the concentration and exposure time (Langeland and Laroche 1992). Bensulfuron methyl reduced hydrilla biomass to various levels in lakes, depending on the concentration applied to the water and the number of applications made (Langeland 1993). This again suggested that the amount of control was related to the concentration and exposure time, however, bensulfuron residue data was not available. Therefore, the ability to predict bensulfuron methyl persistence under various conditions will be useful for determining concentrations and application schedules for optimum hydrilla control. Additionally, determination of a pesticide's persistence in the environment is necessary as part of the risk assessment that must be completed for registration by the United States Environmental Protection Agency (EPA).

The purpose of this study was to determine the effectiveness of bensulfuron methyl for controlling hydrilla, and its persistence in the water and sediment of three shallow ponds.

MATERIALS AND METHODS

The study was conducted at the University of Florida Institute of Food and Agricultural Sciences' Welaka Research and Education Center (Putnam Co., Florida). Sufficient bensulfuron methyl 60 DF was applied on May 2, 1989 to three ponds (0.2 ha by 0.5 M deep) to result in a 200 ppb concentration. Three replicate water samples were collected from each pond prior to bensulfuron methyl application, and 3 hr, 1, 3, 5, 7, 10, 15, 20, 31, 50, and 75 days after application. Water samples were transported on ice and maintained frozen until they were analyzed for bensulfuron methyl. Bensulfuron methyl analysis was conducted by Morse Laboratories, Inc (1525 Fulton Avenue, Sacramento, CA) using the immunoassay method reported by Sharp[3] (1989). Half-lives of bensulfuron methyl in water were calculated as $t_{1/2}=-\ln 2/k$ where k is the slope coefficient from the best fit regression equation in the form $y=e^{a+kx}$, where y represents bensulfuron methyl concentration at x days after Mariner application and e is the base of the natural logarithm.

Sediment samples were collected with a 9.5 cm diameter stainless steel core sampler at the same time intervals as water samples. At each sample time, the upper 5 cm of 3 core samples were composited and stored frozen until they were analyzed for bensulfuron methyl. Morse Laboratories conducted bensulfuron methyl analysis using the methods reported by Johnston et al. (1987)[4]

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[2]Associate Professor, and Assistant in Aquatic Plant Research, respectively, University of Florida, Institute of Food and Agricultural Sciences, Department of Agronomy, Center for Aquatic Plants, 7922 NW 71st Street, Gainesville, FL.

[3]Sharp, J. K. 1989. A monoclonal antibody-based immunoassay method for the determination of residues of DPX-F5384 in water, Du Pont Report No. AMR-1422-89, Supplement No. 1, Agricultural Products Department, E. I. du Pont de Nemours & Co., Inc., Wilmington, DE.

[4]Johnston, E. F., R. V. Slates, and G. P. Griffith. 1987. Determination of rice herbicide candidate DPX-F5384 in rice paddy soil, "Du Pont Report No. AMR-295-84, Revision I, January 30 1987, Agricultural Products Department, E. I. du Pont de Nemours & Co., Inc. Wilmington, DE.

Water temperature, dissolved oxygen, pH, turbidity, and conductivity were measured in a pond (part of a different study) adjacent and similar to the study ponds on the same days that samples were collected for this study. The upper 5 cm of sediment in the adjacent pond was characterized, according to standard methods, by Harris Laboratories, Inc., Lincoln Nebraska.

To determine the effect of bensulfuron methyl on mature hydrilla in the ponds, biomass was measured in each of the treated ponds prior to application and each month for 6 months after application, by hand removal from four 0.5 m^2 quadrats, drying, and weighing. To determine the effect of bensulfuron methyl on newly sprouted hydrilla, six plastic containers that contained fifteen sprouted hydrilla tubers planted in sand and fertilized with slow release fertilizer (Osmocote® 8-6-12) were placed in each treated pond and an untreated pond. Hydrilla biomass was determined in 3 pans from each pond 1 month and 6 months after Mariner application.

RESULTS AND DISCUSSION

Biomass of mature hydrilla decreased in all three treated ponds following bensulfuron methyl application (Table 1). However, substantial biomass remained in all ponds and hydrilla regrew to pretreatment levels in two of the ponds by six months after application. In contrast, all newly sprouted tubers appeared moribund one month following application and no biomass could be measured in the pans six months following application, compared to over 25 g dry wt in pans from the untreated pond.

Initial bensulfuron methyl concentrations, predicted from regression equations, were 233 (SE=44) μg/l in pond 1, 183 (SE=22) μg/l in pond 2, and 209 (SE=23) μg/l in pond 3 (Figure 1). Bensulfuron methyl disappeared rapidly from the water of all three ponds (Figure 1) with half-lives of 5.9 (SE=.45) in pond 1, 8.1 (SE=0.36) in pond 2, and 9.1 (SE=0.43) days in pond 3. Bensulfuron methyl was below detection limits (0.20 μg/l) in pond 1 and less than 1.0 ppb in the other two ponds 75 days after application. The half-lives observed in the shallow ponds of this study are similar to those observed in rice paddies of Louisiana and California, where bensulfuron methyl half-lives averaged 4.6 days and ranged from 1.8 days to 11.0 days[5]. In contrast, half-lives averaging 26 days and ranging from 8 to 54 days have been observed in California ponds, which varied in depth between 2 and 4 meters[6].

Greater persistence of bensulfuron methyl observed in California ponds compared to this study can probably be explained by the greater depths of the California ponds.

[5]Ackerson, R. C. undated. Modeling environmental fate of bensulfuron methyl (Londax®, Mariner®) in aquatic ecosystems with exams II. Du Pont Study No. RCA-EXAMS. E. I. du Pont de Nemours & Co., Inc., Agricultural Products Department Barley Mill Plaza, WM6-126, Wilmington, Delaware, 19880-0038. 138 pp.

[6]Anderson, L. W. J. 1992. Dissipation of bensulfuron methyl in aquatic sites. USDA/ARS Annual Report of Aquatic Weed Control Investigations, USDA/ARS Aquatic Weed Control Research Laboratory, Davis, CA. pp. 12-13.

Table 1. Biomass of mature hydrilla in three ponds near Welaka Florida, which were treated with 200 μg/l bensulfuron methyl.

	Biomass (g dry wt/m^2)		
Days after application	477 (118)[1]	69 (37.0)	150 (33)
31	267 (55)	17 (10.0)	29 (29)
65	102 (49)	31 (16.8)	53 (25)
92	340 (55)	51 (20.4)	80 (28)
150	206 (28)	68 (21.8)	140 (24)

[1]Numbers in parentheses are standard errors of means (n=4).

Bensulfuron methyl partitions rapidly and extensively into the bottom sediments of rice paddies where benthic bacteria are important in the fate of the compound[5]. In deeper waters, bensulfuron methyl remains in the water column longer and longer half-lives are observed compared to the shallower waters[5]. Longer half-lives in deeper water may occur because partitioning into bottom sediments is slower where the amount of water sediment interface is small compared to the water volume. In rice paddies and in the ponds of this study, the sediment water interface would be greater compared to the water volume, which would allow for more rapid segregation into bottom sediments and result in the shorter half-lives observed.

Bensulfuron methyl is bound to soil organic matter (OM). Increasing OM from 0.1% to 10.0% caused more rapid disappearance of the compound from water[5]. The organic content of the ponds in this study were relatively low (0.8% in the nearby pond) but high enough to have some binding capacity for bensulfuron methyl. Accumulation of the compound was not observed in the sediments (Table 2). Although 44 ppb were observed three hours after application in the sediment sample collected from pond 2, bensulfuron methyl was not detectable or slightly above detection limits in all other samples collected through 50 days after application. Bensulfuron methyl was not detectable in any samples collected 75 days after application. Therefore, microbial breakdown apparently occurred rapidly in the sediments.

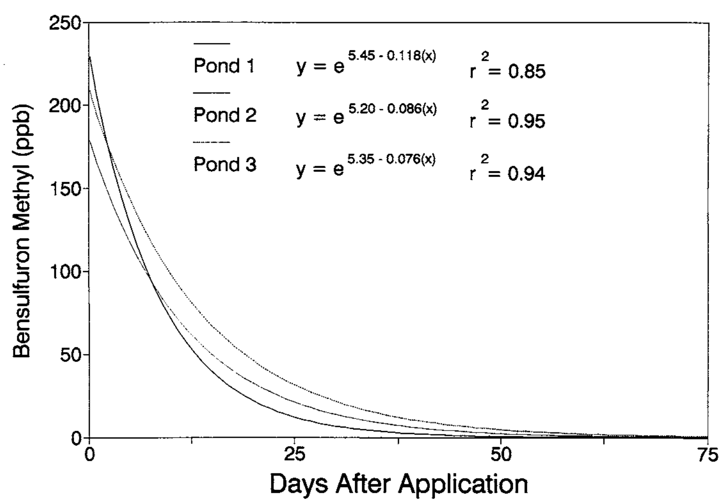

Figure 1. Concentration of bensulfuron methyl in three ponds near Welaka, Florida at various times after application.

TABLE 2. BENSULFURON METHYL RESIDUE (μg/l) IN THE SEDIMENT OF THREE PONDS FOLLOWING INITIAL CONCENTRATION OF THE COMPOUND AT 200 μg/l IN THE WATER.

Time After Application	Pond 1	Pond 2	Pond 3
3 hr	1.4	44.0	2.1
3 days	1.5	1.5	4.3
7 days	<1.0	1.7	<1.0
15 days	1.7	1.4	3.5
31 days	1.2	<1.0	1.1
50 days	1.0	<1.0	<1.0
75 days	<1.0	<1.0	<1.0

Absorption of bensulfuron methyl by hydrilla probably influenced persistence and distribution of the compound in the ponds. Pond 1 had the greatest biomass (Table 1) and the shortest bensulfuron methyl half-life, which suggests that persistence was related to hydrilla biomass. Pond 2 had the lowest hydrilla biomass and the greatest initial segregation of bensulfuron methyl into the sediments, which suggests that the importance of partitioning of bensulfuron methyl between water and sediments may be inversely related to plant biomass.

Chemical hydrolysis and microbial degradation can be important factors in the breakdown of bensulfuron methyl (Romesser and O'Keefe 1986)[7,8,9]. Chemical hydrolysis was not considered important in the three ponds of this study because bensulfuron methyl, which is a weak acid (pka 5.2), would be relatively stable at the high observed pHs (Table 3).

Bensulfuron methyl has been effective for control of hydrilla in lakes (Langeland 1993) where bensulfuron methyl persistence would be greater than in shallow ponds because of less partitioning to bottom sediments. The data from this study suggest that bensulfuron methyl does not adequately control mature hydrilla in shallow ponds even at an initial concentration of approximately twice the maximum concentration allowed by the experimental use label (100 ppb). This may result from rapid disappearance of the compound under these conditions. However, newly sprouted, actively growing, hydrilla is much more sensitive to bensulfuron methyl than mature hydrilla.

[7]Hunt, O. R. 1986. Aerobic Aquatic Metabolism of [phenyl(u)-[14]C] DPX-F5384 and [pyrimidine-2-[14]C] DPX-F5384. Du Pont Document AMR-475-86. as cited in footnote 3.

[8]Cadwgan, G. E. and T. W Ryan. 1986. Anaerobic aquatic metabolism of [pyrimidine-2-[14]C] DPX-F5384 and [phenyl(u)-[14]C] DPX-F5384 in water. Du Pont Document AMR-606-86. as cited in footnote 3.

[9]Friedman, P. L. 1984. Aerobic soil metabolism of [14]C-DPX-F5384. Du Pont Document AMR-216-84. as cited in footnote 3.

TABLE 3. SEDIMENT AND WATER CHARACTERISTICS OF A POND SIMILAR TO THREE TREATED WITH BENSULFURON METHYL NEAR WELAKA, FLORIDA (SEDIMENT CHARACTERISTICS MEASURED ONCE PRIOR TO APPLICATION, WATER CHARACTERISTICS MEASURED CONCURRENT WITH WATER SAMPLE COLLECTION FOR BENSULFURON METHYL ANALYSIS).

	Sediment
Sand (%)	96.0
Clay (%)	2.4
Silt (%)	1.6
Texture	Sand
Organic matter (%)	0.8
Cation exchange capacity (MEQ/100g)	11.1
pH	6.9

	Water	
	Average	Range
Temperature (C)	28.1	22.7- 31.0
Dissolved oxygen (ppm)	7.0	5.2- 8.4
pH	7.7	6.9- 8.2
Turbidity (ntu)	4.4	2.2- 7.5
Conductivity (μmhos/cm)	209.0	177.0-328.0

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