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Fluridone Effects on Stressed Submersed Macrophytes

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INTRODUCTION

Herbicide efficacy may be affected by factors influencing plant growth and distribution. By definition, a plant is growing under stress if adequate conditions for unimpaired growth are not available. Barko and Smart (1983) suggested that submersed aquatic macrophytes may actually depend for growth more upon nutrient uptake by roots via sediments than on foliar absorption of nutrients from the water column. Moreover, substrate-induced growth stress was found to be caused by nutrient deficiency, inhibition by organic matter (Barko and Smart, 1983), or nutrient limitation based on sediment density rather than organic matter content (Barko and Smart, 1986). These research results suggest a significant role for sediment in regulating plant growth based on nutrient availability via sediment and physical properties of sediment; however, substrate effects on efficacy and mode of uptake and action of aquatic herbicides are not well understood.

The objective of this study was to determine if selected submersed aquatic macrophytes respond differently to fluridone when grown on a nutrient-rich and a nutrient-deficient substrate.

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MATERIALS AND METHODS

Detailed discussion of the diluter system experimental design is included in previous reports (Westerdahl, et al. 1983; Hall et al., 1984). Briefly, a simple randomized experimental design was used to assign fluridone concentrations of 10, 20, 40, 70 and 90 μg/l, respectively, to groups of four aquaria connected to a diluter system (Westerdahl and Hall, 1983) in an environment-controlled greenhouse. Supplemental lighting was provided to approximate a mean daily photosynthetically active radiation of 1600 $\mu E \cdot m^{-2} \cdot S^{-1}$, which corresponds to 75 percent of solar noon sunlight received at this latitude. A standardized reconstituted natural hard water (EPA, 1975) was used in the diluter system. Water temperature was maintained at 252C throughout the study.

Four 15-cm meristematic cuttings of watermilfoil and hydrilla were placed in 12 ea. 250-ml glass beakers, respectively, containing either sand:peat (3:1 by vol.) or natural sediment containing 20 percent sand, 75 percent silt, and 5 percent clay. Nutrient composition of the natural substrate was optimal for plant growth (Barko and Smart, 1981). A 2-cm layer of finely sieved, washed sand was placed over each of the beakers prior to placing 6 beakers containing milfoil and 6 containing hydrilla in each aquaria. Three beakers each of natural and sand-peat substrate, containing watermilfoil, were placed on one side of each aquaria and six beakers containing hydrilla were placed on the other side of each aquaria in similar manner. Water only flowed for 4 weeks preceeding treatment

through the aquaria to permit root development and initiation of plant growth prior to fluridone treatment.

Fluridone-treated water was passed continuously through each aquaria for 12 weeks to provide a hydraulic retention time of 24 hours. At the end of 12 weeks, the aquaria were dismantled and remaining plants were removed from each beaker and rinsed. Shoots and leaves of both species were subsampled for chlorophyll analyses. The remaining shoots and roots were dried at 70°C for 36 hours, and weighed for biomass determinations.

RESULTS

Pilot study results showed differences between hydrilla (*Hydrilla verticillata* Royle) and Eurasian watermilfoil (*Myriophyllum spicatum* L.) biomass grown on natural sediment from Brown's Lake, Vicksburg, MS, versus that grown on a sand-peat (75:25 by volume) mix (Table 1). After a 12-week posttreatment period both root and shoot biomass of those species grown on natural sediment were three times greater than those grown on the sand-peat mixture. By comparing hydrilla and watermilfoil shoot biomass with the root biomass produced throughout the study, it was found that the natural sediment produced twice as much root biomass than did the sand-peat mix for both species.

Based on the reduced root and shoot biomass values obtained when both species were grown on a sand-peat substrate, it was evident that the plants were growing under stress induced by the sand-peat substrate. Since sand is chemically inactive, its potential as a nutrient sink is essentially nil (Brady 1974). Substrate type was the only variable designated in the experimental design. Results from the Duncan's Multiple Range Test showed a consistent reduction of shoot and root biomass (compared with the reference plants) for both watermilfoil and hydrilla grown on natural substrate resulting from herbicide treatment. However, the statistical response of shoot and root biomass following fluridone treatment for both watermilfoil and hydrilla grown on sand-peat substrate was very inconsistent.

Since the mode of fluridone action involves interruption of chlorophyll synthesis, total chlorophyll, chlorophyll *a* and chlorophyll *b* were determined (see Table 1) for each of the species grown on the two substrates. Virtually no differences in chlorophyll concentration were found in reference watermilfoil grown on both substrates. Watermilfoil exposed to at least 20 µg/l fluridone showed a statistically significant reduction in total chlorophyll, chlorophyll *a*, and chlorophyll *b* while growing on natural and sand-peat substrates over the posttreatment period compared with the reference plants.

In contrast, hydrilla did not exhibit a statistically significant reduction in chlorophyll concentration following fluridone treatment. However, the reference hydrilla grown in natural substrate possessed nearly twice the chlorophyll found in those plants growing in the sand-peat substrate, further supporting the premise that hydrilla was growing under stress in the sand-peat substrate. The hydrilla grown in the latter substrate did not respond consistently to fluridone treatments.

TABLE 1. ROOT (n=12) AND SHOOT (n=6) BIOMASS AND CHLOROPHYLL CONTENT (n=4) OF WATERMILFOIL AND HYDRILLA GROWN ON NATURAL AND SAND-PEAT SUBSTRATES FOLLOWING 12-WEED CONTINUOUS EXPOSURE TO FIVE FLURIDONE CONCENTRATIONS.[1]

Fluridone Concentration µg/l	Biomass, Dry Weight, mg			
	Natural		Sand-Peat	
	Shoots	Roots	Shoots	Roots
	Watermilfoil			
Reference	460.0a	370.0a	130.0ab	170.0a
10	140.0b	170.0b	50.0c	100.0b
20	140.0b	80.0c	170.0a	70.0b
40	110.0b	100.0bc	100.0abc	100.0b
70	110.0b	80.0c	140.0ab	100.0ab
90	70.0b	110.0bc	80.0b	120.0ab
	Hydrilla			
Reference	720.0a	270.0a	240.0a	90.0ab
10	190.0b	190.0c	60.0c	50.0c
20	160.0b	140.0c	90.0bc	70.0bc
40	170.0b	220.0ab	140.0b	50.0c
70	230.0b	150.0c	50.0c	80.0abc
90	210.0b	190.0bc	80.0bc	110.0a
	Chlorophyll, mg/g Fresh Tissue			
	Watermilfoil		Hydrilla	
	Natural	Sand-Peat	Natural	Sand-Peat
	Chlorophyll a			
Reference	1.23a	1.17a	0.74a	0.40a
10	0.74b	0.58b	0.28b	0.25ab
20	0.07c	0.03c	0.26b	0.21ab
40	0.03c	0.02c	0.22b	0.27ab
70	0.02c	0.02c	0.20b	0.23b
90	0.02c	0.02c	0.17b	0.19b
	Chlorophyll b			
Reference	0.40a	0.38a	0.19a	0.10a
10	0.34a	0.31a	0.13ab	0.11a
20	0.03b	0.005b	0.07ab	0.04a
40	0.01b	0.01b	0.007ab	0.11a
70	0.005b	0.003b	0.06b	0.05a
90	0.005b	0.01b	0.06b	0.06a
	Total Chlorophyll			
Reference	1.62a	1.54a	0.93a	0.48a
10	1.07b	0.88b	0.41ab	0.37a
20	0.09c	0.03c	0.33b	0.25a
40	0.03c	0.03c	0.29b	0.38a
70	0.02c	0.02c	0.26b	0.28a
90	0.02c	0.03c	0.22b	0.25a

[1]Values in a column followed by the same letter are not statistically different at the 10 percent level as determined by Duncan's multiple range test.

In summary, the differences in fluridone efficacy between hydrilla and watermilfoil on the two different substrates suggests a plant specie-by-specie susceptibility to this herbicide, caused by stressed plant growth on the sand-peat substrate. The response of root and shoot biomass to fluridone was inconsistent for both watermilfoil and hydrilla grown on the sand-peat substrate. No consistent reductions in total chlorophyll, chlorophyll *a*, and chlorophyll *b* content of hydrilla were observed in the hydrilla grown on the sand-peat substrate.

The stress imposed on watermilfoil and hydrilla by the sand-peat substrate may have mitigated the potential impact of the herbicide causing inconsistent responses of the hydrilla biomass and the associated lack of significant chlorophyll reduction. Perhaps sufficient fluridone levels

in plant cells to effect control were not achieved. Anderson (1981) reported that only very low levels of fluridone are actively absorbed by submersed macrophytes, requiring several days to achieve levels for control. Also, Hall and Westerdahl (1985) reported that a fluridone concentration of 15 μg/l for 12 to 20 days controlled (greater than 50 percent) watermilfoil grown on natural substrate; whereas, a fluridone concentration of 30 μg/l for 12 days also controlled watermilfoil. For hydrilla, Hall and Westerdahl (1985) reported a 20 to 40 day exposure to 15 μg/l or a 12-day exposure to 30 μg/l fluridone. The time required for lethal fluridone concentrations to be actively or passively absorbed into these submersed plants suggests that the sand-peat substrate may have reduced the capacity for fluridone uptake by the plants resulting in an inconsistent response.

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