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Influence of Acetic Acid on Regrowth of Dioecious Hydrilla from Root Crowns

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ABSTRACT

Sediments may contain numerous compounds resulting from anaerobic degradation of organic matter, including acetic acid which has been shown to reduce viability of vegetative propagules. Root crowns of hydrilla *(Hydrilla verticillata* (L.f.) Royle) were exposed to acetic acid concentrations of 0, 17, 44, 87, 174, and 348 mmol/L for 24 h. Acetic acid concentrations which produced a 50% reduction in growth (measured by dry weight, shoot length, or number of new shoots) ranged from 9 to 26 mmol/L. It may be possible to use a dilute acetic acid solutions to treat exposed hydrilla plants during drawdown.

Key words: sediment, phytotoxin, drawdown.

INTRODUCTION

Hydrilla is a non-native submersed aquatic plant introduced into the U. S. around 1960 (Blackburn et al. 1969). Under some conditions it grows abundantly and has become a serious aquatic weed, interfering with water flow and clogging pumps in irrigation and drainage canals and utility cooling reservoirs, impeding navigation in rivers and lakes, and reducing recreational uses (Anderson and Dechoretz 1982, Swarbrick et al. 1982, Langeland 1990). Hydrilla may be managed using herbicides, biological control agents, mechanical removal, and physical habitat manipulations, but it remains a serious aquatic weed (Langeland 1990). Most widely used aquatic weed management techniques are aimed at reducing the abundance of above ground biomass. Hydrilla's persistence in the face of management efforts is partly due to its ability to produce both above and below ground reproductive structures, and its ability to regrow from small stem fragments and root crowns that may remain viable following application of some management techniques. Spencer and Ksander (in press) have demonstrated that viability of underground tubers is reduced by brief exposure to dilute concentrations of the natural microbial metabolite acetic acid which is often produced during anaerobic decomposition of organic matter in sediments. The purpose of this paper is to report experimental results demonstrating the sensitivity of hydrilla root crowns to dilute solutions of acetic acid which may lead to novel control measures.

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MATERIALS AND METHODS

Shoots with attached roots were harvested from dioecious hydrilla cultures grown outdoors at the USDA Aquatic Weed Laboratory, Davis, California. Each root crown was prepared by trimming a shoot to 6 cm length. Thus a root crown consisted of roots attached to a 6-cm long shoot. Ten root crowns were randomly selected to determine starting dry weights (mean and standard deviation were 0.27 ± 0.19 g for Experiment 1 and 0.18 ± 0.09 g for Experiment 2). The root crowns were planted on October 15, 1993 (designated as Experiment 1) in individual plastic containers (60 mm by 64 mm) filled with pond sediment, and placed in 90 L tubs filled with water in a greenhouse. The plants were allowed to equili-

TABLE 1. PARAMETERS FOR BEST FIT OF EXPONENTIAL DECAY FUNCTIONS ($Y = A * E^{B * MMOL/L}$) FOR RESPONSE VARIABLE CHANGES OVER ACETIC ACID CONCENTRATION FOR HYDRILLA ROOT CROWNS. A IS THE INITIAL ESTIMATE (I.E., CONTROL) WHICH DECLINED EXPONENTIALLY WITH EXPOSURE TO INCREASING CONCENTRATIONS OF ACETIC ACID. THE ACETIC ACID CONCENTRATION (MMOL/L) ASSOCIATED WITH A 50% REDUCTION IS GIVEN IN THE COLUMN LABELED I_{50}.

				Asymptotic 95% C.I.		
Experiment	Characteristic	Parameter	Estimate	Lower	Upper	I_{50} (mmol/L)
1	Shoot Length	b	0.0493	0.0328	0.0658	14.06
		A	19.88	17.19	22.57	
2	Shoot Length	b	0.0263	0.0128	0.0398	26.36
		A	15.03	11.79	18.26	
1	New Shoots	b	0.0621	0.0443	0.08	11.16
		A	5.78	5.14	6.42	
2	New Shoots	b	0.0429	0.0248	0.0611	16.15
		A	3.73	3.08	4.38	
1	Dry Weight	b	0.0763	0.0216	0.1312	9.08
		A	270.3	261.48	279.12	
2	Dry Weight	b	0.0549	0.0273	0.0824	12.63
		A	302.1	274.72	329.47	

brate for 5 days prior to treatment. To avoid contamination among treatments each group of 10 plants was placed in separate tubs. The treatments were: 0, 17, 44, 87, 174, and 348 mmol/L acetic acid. Treatments were applied by removing all water from the tubs, and filling them with enough acetic acid (at the appropriate concentration) so that the liquid level was just above the pot rims. This completely saturated the sediment. Plants were maintained in this condition (6-cm shoots exposed to air) for the 24 hour exposure period. After 24 hours, the tubs were drained and any excess acetic acid poured from the pots. The tubs were filled with well water and fresh water was continuously flushed through the tubs for 48 hours. Plants were allowed to grow in the greenhouse and harvested three weeks later. At harvest, we recorded the number of new shoots per pot, measured the longest new shoot, then dried (80 C for 48 h) and weighed the total biomass per pot. The entire experiment was repeated starting on May 19, 1994 (designated as Experiment 2).

Changes in the response variables over acetic acid treatments were analyzed by fitting the exponential decay model ($y = A\ e^{-b * mmol/L}$). In this equation, *A* is the estimated value for the control; it declines exponentially with increasing levels of acetic acid at a rate *b*. The acetic acid concentration associated with a 50% decrease in the initial value of the response variable was calculated as 0.69315/*b*, following Batschelet (1973). Exponential decay equations were fitted to the data using PROC NLIN in SAS (SAS Institute 1989). Regression analysis is appropriate when the treatment variable (i.e., acetic acid concentration) is continuous (Chew 1976).

RESULTS AND DISCUSSION

Regrowth from individual hydrilla root crowns after three weeks produced plants which weighed an average of 270 mg dry weight in Experiment 1 (95% confidence limits were 204 to 336 mg) and 302 mg dry weight in Experiment 2 (95% confidence limits were 206 to 398 mg). Exposure of hydrilla root crowns to dilute solutions of acetic acid greatly reduced regrowth (Figure 1). Plants exposed to dilute solutions of acetic acid were shorter and produced fewer new shoots than controls (Figure 1). The response of hydrilla root crowns to acetic acid was adequately described by exponential decay functions (Table 1). Confidence intervals for equation coefficients overlapped, indicating that responses were similar in both experiments. The acetic acid concentration which inhibited regrowth by 50% ranged from 9 to 26 mmol/L. This suggests that acetic acid solutions (more dilute than commercially available vinegar) may be useful in managing regrowth of hydrilla from root crowns. This information may be useful in developing novel weed management strategies which attack weed propagule banks by altering the sediment environment (Gunnison and Barko 1989) by the application of microbially produced phytotoxins such as acetic acid (Kremer 1993). This approach may be especially useful when applied in conjunction with water level drawdowns such as proposed by Haller et al. (1976). Treatment during drawdown would allow direct treatment of only the areas of the sediment inhabited by hydrilla. This would reduce the amount of acetic acid used (since the water column would not be treated) and also reduce direct impacts on water column biota.

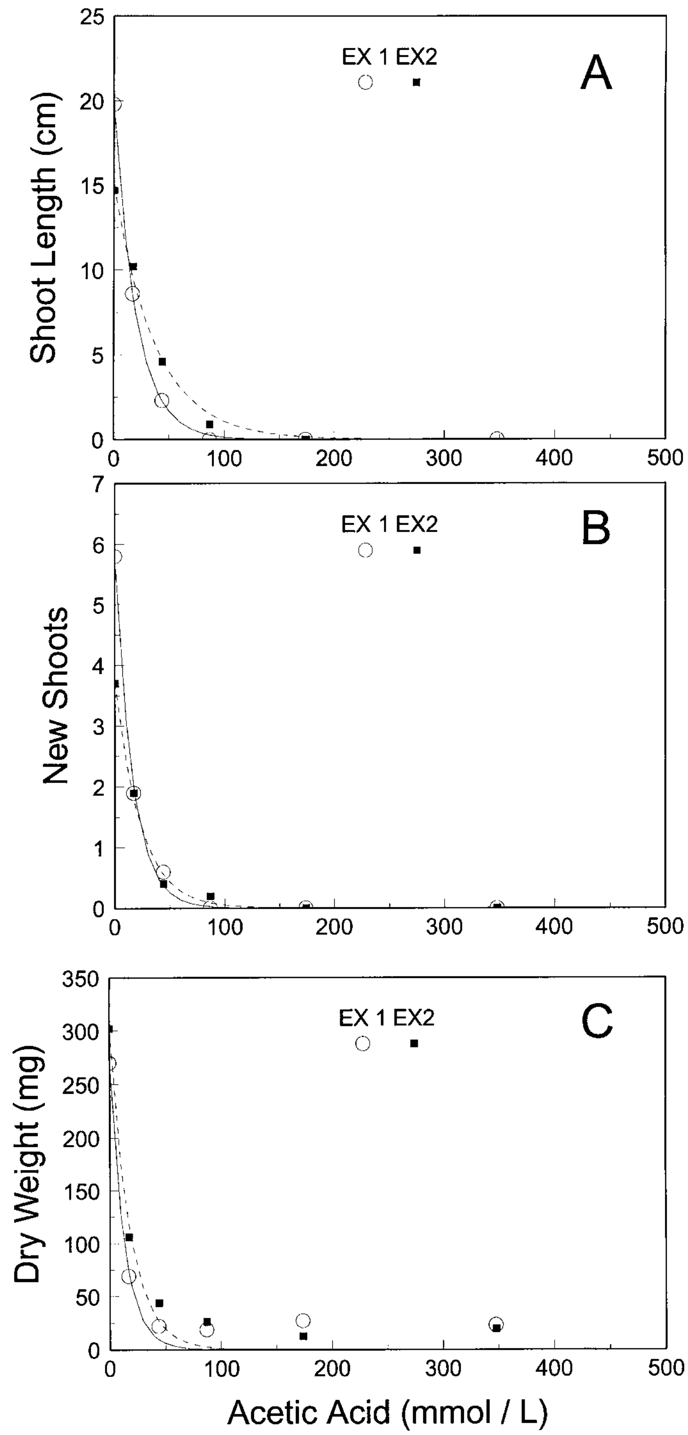

Figure 1. Regrowth of hydrilla root crowns following a 24 hour exposure to various concentrations of acetic acid in two separate experiments (EX 1 and EX 2). Plotted values are the means of ten plants. Lines represent the exponential decay equations ($y = A * e^{-b * mmol/L}$) whose parameters are listed in Table 1.

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