J. Aquat. Plant Manage. 19: 53-55

Preliminary Evaluation of Hydrogen Peroxide as a Potential Herbicide for Aquatic Weeds[1]

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INTRODUCTION

Only limited practices are currently available to managers of waterways for the control of undesirable aquatic weeds (4). Since water is often subject to multiple-use, the introduction of herbicides in aquatic systems is highly restricted. Potable water is classified as a commodity because of its ultimate use as a "food" or in food preparation. Because of overall concern about pesticides in the environment and the special status of water as a commodity, no new herbicides have been registered for aquatic weed control in recent years; in fact, labels of some existing herbicides have been cancelled or have become more restricted.

Thus, a need exists for new herbicides for aquatic plant management. Some important criteria for new herbicides are: 1) If possible, the active ingredient, degradation products, and their characteristics should be well-known. 2) The herbicide should be acutely toxic to the weeds and short-lived in the environment if the water is to be used for irrigation or domestic purposes. 3) The herbicide should be relatively inexpensive and provide acceptable control of aquatic weeds. 4) A technique should be available for identification and analysis of the herbicide in aquatic systems. 5) The herbicide should be relatively nontoxic to aquatic fauna and should be safe for irrigation of desirable plants.

Hydrogen peroxide (H_2O_2) appears to meet criteria 1, 2 and 4. It is a known constituent of some plant species (1, 2, 6) and interactions with indoleacetic acid have been reported (5, 10). H_2O_2 stimulates the growth of submerged alligatorweed, *Alternanthera philoxeroides* (Mart.) Griseb. in the dark (7), or when the plants are treated with inhibitors of photosystem II in the light (8). Stimulatory effects of H_2O_2 on seed germination have been noted (3, 9) and irrigation water containing H_2O_2 has been noted to have a beneficial effect on growth of Japanese barnyard millet [*Echinochloa crusgalli* var. *frumentacea* (Link) W.F. Wight] (11). However, the author observed that H_2O_2 appeared to be toxic to submersed weeds in laboratory experiments.

The purpose of this study was to determine whether H_2O_2 might have potential as a herbicide for control or suppression of submersed aquatic weeds. Specific objectives were to study the efficacy of H_2O_2 as an aquatic herbicide, to determine the degradation of H_2O_2, and to study the acute toxicity of H_2O_2 to fish.

MATERIALS AND METHODS

Coontail (*Ceratophyllum demersum* L.) and hydrilla [*Hydrilla verticillata* (L.f.) Royle] were selected as the test species. Coontail collected from Conservation Lake, Bolivar County, Mississippi and hydrilla from the University of Florida, Gainesville were maintained in 1/10 and 1/20 strength modified (7) Hoagland's solution, respectively, in aquaria in the laboratory at 23±2 C and illuminated with incandescent light. For testing the response of coontail to various treatments with or without added H_2O_2, each replicate of each treatment consisted of three plant shoots (10 to 14-cm long) loosely attached with a rubber band to a stoppered 50-ml vial filled with gravel (for weight) and submerged in tap water or in the diluted nutrient solution contained in either 1 or 3.8 liter jars. Each treatment was replicated at least three times in each experiment. H_2O_2 was added at concentrations ranging from 1 to 4 mM (34 mg/liter to 136 mg/liter), and plants were held in solution continuously or initially dipped for periods of 1 minute to 1 hour. Plants were held under a 14 hour photoperiod with photon flux density at 40 $\mu Em^{-2}s^{-1}$ as previously described (7, 8) until evaluated. Plants were evaluated by visual scoring (0 to 10, where 10 = dead) at various times ranging from 4 to 21 days after initiation of the treatment. In one experiment, "dead" and "live" tissues were separated on the basis of obvious necrosis, dried at 70 C to constant weight, weighed, and the percentages of each were calculated. The concentration of H_2O_2 was determined according to a method involving a peroxide-titanium complex as described by Brennan and Frenkel (1).

Guppies (*Lebistes reticulatus*) of various sizes and ages and of both sexes were exposed to H_2O_2. H_2O_2, in the form of cubed ice, 5 ml per cube and weighted with gravel, was added at the dose of 1 cube per jar to each of five 3.8 liter jars to produce 34 mg H_2O_2 per liter (1 *mM*). Five control containers were each treated with a cube of ice without H_2O_2. The weighted ice was used to release the H_2O_2 at the bottom of the container. The experimental

[1]Cooperative investigations of Agricultural Research, Science & Education Administration, United States Department of Agriculture, and Delta Branch, Mississippi Agricultural and Forrestry Experiment Station, Stoneville, MS 38776.

containers were placed on a laboratory bench at room temperature (about 25 C) with only room fluorescent light for 5 days, after which effects on plants and fish were evaluated.

RESULTS AND DISCUSSION

Concentrations of H_2O_2 ranging from 1 *mM* to 4 *mM* in continuous exposure provided 80% necrotic tissue of coontail after 1 week. At all concentrations tested (1, 2, 3, and 4 *mM*), H_2O_2 residues were essentially non-existent (<.05 *mM*) after 4 days.

H_2O_2 at 1 *mM* provided acceptable suppression (injury score of 9 to 10) of coontail when the weed was continuously exposed and fish were not harmed by this treatment (Table 1).

H_2O_2 at 2 *mM* provided greater than 60% suppression (injury) of coontail when the weed was initially exposed for 1 hour (Table 1) and evaluated after 13 days. Concentrations of 3 and 4 *mM* H_2O_2 provided even greater suppression (70 to 100%), and this effect was evident as early as 4 days after the initial exposure. A slight increase in injury was observed 10 days after initial exposure. A concentration of 4 *mM* provided 70 to 80% suppression when plants were initially exposed for 30 minutes and evaluated 3 weeks later. An exposure time of 1 minute provided inadequate suppression, even at the highest concentration of 4 *mM* H_2O_2. Concentrations of 3 and 4 *mM* H_2O_2 suppressed hydrilla 60 to 80% after 4 days and 80 to 90% after 15 days. Regrowth from shoot tips was present after 14 days.

Further testing appears to be warranted on the potential of H_2O_2 as a herbicide for aquatic weeds. These preliminary findings suggest that H_2O_2 will provide at least temporary suppression of submerged weeds and is not toxic to guppies

TABLE 1. EFFECTS OF H_2O_2 AT VARIOUS CONCENTRATIONS AND EXPOSURE TIMES ON COONTAIL AND HYDRILLA AFTER VARIOUS ELAPSED TIMES FROM TREATMENT TO EVALUATION OF INJURY [INJURY SCALE: 0 (NO INJURY) TO 10 (DEAD)].

Species	Concentration of H_2O_2	Exposure time to H_2O_2	Elapsed time to evaluation	Injury to plants[1]	Remarks
	(mM)	(minutes)	(days)	(range)	
Coontail[2]	1.0	Continuous	5	9 to 10	Guppies included (6/jar), not injured.
Coontail[3]	1.0	1	7	0	
	4.0			0	
	1.0		14	0	
	4.0			1 to 2	
Coontail[3]	4.0	30	21	7 to 8	
Coontail[3]	4.0	60	4	8 to 9	
Coontail[3]	1.0	60	4	2 to 3	After 23 days, plants from 1 mM H_2O_2 recovered.
	2.0			3	
	3.0			7 to 10	
	4.0			8 to 9	
	1.0		10	2 to 5	
	2.0			5 to 7	
	3.0			8 to 10	
	4.0			9 to 10	
Coontail[3]	2.0	60	4	1 to 4	
			13	6 to 8	
Hydrilla[4]	1.0	60	4	2 to 3	
	2.0			4 to 5	
	3.0			6 to 7	
	4.0			7 to 8	
	1.0		14	6 to 7	Regrowth (5 to 10 mm) present from tips
	2.0			6 to 7	
	3.0			8 to 9	
	4.0			9	
Hydrilla[4]	1.0	60	4	2 to 3	
	2.0			4 to 5	
	3.0			7 to 8	
	4.0			7 to 8	
	1.0		14	7 to 9	Regrowth (3 to 15 mm) present from tips
	2.0			8 to 10	
	3.0			9 to 10	
	4.0			9 to 10	Regrowth (10 mm) from 1 node

[1]In all experiments, the untreated controls were evaluated as showing no injury (score = 0).
[2]No supplemental light; tapwater in 3.8-liter jars; H_2O_2 added in ice.
[3]14 hr photoperiod; 1/10 strength nutrient solution in 1-liter jars.
[4]14 hr photoperiod; 1/20 strength nutrient solution in 1-liter jars.

at treatment rates required to suppress plants. H_2O_2 degraded very rapidly in the presence of plants under laboratory conditions.

In preliminary tests (author's unpublished data), H_2O_2 at the levels tested herein had neither inhibited nor stimulated growth of illuminated emersed alligatorweed or of floating waterhyacinth [*Eichhornia crassipes* (Mart.) Solms] when evaluated 1 week after treatment. Thus, H_2O_2 exhibits selectivity and appears to be much more damaging to submersed weeds.

The economics of using H_2O_2 for aquatic weed control remains to be defined because effective operational treatment rates have not been established. However, H_2O_2 (35% active ingredient) can be purchased in bulk and as of November, 1979 the retail price was about \$150/208.2 liters (55 gal), i.e., for a 226.8 kg (500 lb) drum. This would mean about \$300 to provide 130 mg H_2O_2/liter in 1233.5 m^3 (1 acre-foot) of water or \$244 for the same dose in 1 hectare-decimeter of water. If the above-cited advantages of using H_2O_2 are consistent after further investigations, this cost might allow its consideration as an aquatic herbicide for cases where it would meet a specific need such as timed injections into irrigation ditches.

ACKNOWLEDGMENTS

The author thanks D. G. McMinn, Laurie Turfitt, Michelle Hurst, and George Abide for technical assistance, Susan Walker for typing the manuscript, Dr. R. D. Wauchope for helpful discussions and assistance with computer analysis of the H_2O_2 determinations, and S. H. Kay, University of Florida, Gainesville, FL, for propagules of hydrilla.

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