

# Preliminary Evaluation of Hydrogen Peroxide as a Potential Herbicide for Aquatic Weeds<sup>1</sup>

P. C. QUIMBY, JR.

Plant Physiologist  
Southern Weed Science Laboratory,  
U.S. Department of Agriculture,  
Science and Education Administration,  
Agricultural Research, Stoneville, Mississippi 38776

## 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  $23 \pm 2$  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  $40 \mu\text{Em}^{-2}\text{s}^{-1}$  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

<sup>1</sup>Cooperative investigations of Agricultural Research, Science & Education Administration, United States Department of Agriculture, and Delta Branch, Mississippi Agricultural and Forestry 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<sub>2</sub>O<sub>2</sub> 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<sub>2</sub>O<sub>2</sub> residues were essentially non-existent (<.05 mM) after 4 days.

H<sub>2</sub>O<sub>2</sub> 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<sub>2</sub>O<sub>2</sub> 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<sub>2</sub>O<sub>2</sub> 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<sub>2</sub>O<sub>2</sub>. Concentrations of 3 and 4 mM H<sub>2</sub>O<sub>2</sub> 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<sub>2</sub>O<sub>2</sub> as a herbicide for aquatic weeds. These preliminary findings suggest that H<sub>2</sub>O<sub>2</sub> will provide at least temporary suppression of submerged weeds and is not toxic to guppies

TABLE 1. EFFECTS OF H<sub>2</sub>O<sub>2</sub> 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 <sub>2</sub> O <sub>2</sub>	Exposure time to H <sub>2</sub> O <sub>2</sub>	Elapsed time to evaluation	Injury to plants <sup>1</sup>	Remarks
	(mM)	(minutes)	(days)	(range)	
Coontail <sup>2</sup>	1.0	Continuous	5	9 to 10	Guppies included (6/jar), not injured.
Coontail <sup>3</sup>	1.0	1	7	0	
	4.0			0	
	1.0		14	0	
	4.0			1 to 2	
Coontail <sup>3</sup>	4.0	30	21	7 to 8	
Coontail <sup>3</sup>	4.0	60	4	8 to 9	
Coontail <sup>3</sup>	1.0	60	4	2 to 3	After 23 days, plants from 1 mM H <sub>2</sub> O <sub>2</sub> 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 <sup>3</sup>	2.0	60	4	1 to 4	
			13	6 to 8	
Hydrilla <sup>4</sup>	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 <sup>4</sup>	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

<sup>1</sup>In all experiments, the untreated controls were evaluated as showing no injury (score = 0).

<sup>2</sup>No supplemental light; tapwater in 3.8-liter jars; H<sub>2</sub>O<sub>2</sub> added in ice.

<sup>3</sup>14 hr photoperiod; 1/10 strength nutrient solution in 1-liter jars.

<sup>4</sup>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 emerged 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<sup>3</sup> (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.

#### LITERATURE CITED

1. Brennan, Thomas and Chaim Frenkel. 1977. Involvement of hydrogen peroxide in the regulation of senescence in pear. *Plant. Physiol.* 59:411-416.
2. Elstner, E. F. and A. Heupel. 1976. Formation of hydrogen peroxide by isolated cell walls from horseradish (*Armoracia lapathifolia* Gilib.). *Planta* 130:175-180.
3. Everett, R. L. and R. O. Meeuwig. 1975. Hydrogen peroxide and thiourea treatment of bitterbrush seed. USDA FS Research Note INT-196. 6 p.
4. Lee, D. V. 1979. Presidential address. *J. Aquat. Plant Manage.* 17:1-3.
5. Omram, R. G. 1977. The direct involvement of hydrogen peroxide in indoleacetic acid inactivation. *Biochem. and Biophys. Res. Commun.* 78:970-976.
6. Patterson, C. O. P. and J. Myers. 1978. Photosynthetic production of hydrogen peroxide by *Anacystis nidulans*. *Plant Physiol.* 51:104-109.
7. Quimby, P. C., Jr. and S. H. Kay. 1977. Hypoxic quiescence in alligatorweed. *Physiol. Plant.* 40:163-168.
8. Quimby, P. C., Jr., J. R. Potter, and S. O. Duke. 1978. Photosystem II and hypoxic quiescence in alligatorweed. *Physiol. Plant.* 44:246-250.
9. Roberts, E. H. 1964. The distribution of oxidation-reduction enzymes and the effects of respiratory inhibitors and oxidizing agents on dormancy in rice seed. *Physiol. Plant* 17:14-29.
10. Siegel, S. M. and R. L. Weintraub. 1952. Inactivation of 3-indoleacetic acid by peroxides. *Physiol. Plant.* 5:241-247.
11. Yasue, T. and Y. Kawase. 1975. Studies on the cultivation of Japanese millet (*Echinochloa utilis* Ohwi et Yobuno) as a soiling crop. 1. Seed germination and seedling growth under various environmental conditions. *J. Japan. Soc. of Grassland Sci.* 21:34-41.