J. Aquat. Plant Manage. 21: 38-40 (Notes)

Control of Coontail With Hydrogen Peroxide And Copper[1]

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INTRODUCTION

For years, the major emphasis of research on noxious aquatic vegetation has been the development of new formulations and combinations of currently-existing herbicides and advances in application technology. More recently, allelopathy has been investigated as an alternative method for the biological suppression of aquatic weeds (6, 16, 19), and several allelopathic compounds have been isolated and characterized (4).

Although not yet classified as an allelochemical, a readily-synthesized, naturally-occurring, phytotoxic substance is hydrogen peroxide (H_2O_2). Hydrogen peroxide was suggested as a treatment for the control of slimes and algae in cooling towers (15) and as a noncorrosive algicide for use in systems constructed of aluminum alloys (18). Recently, Kay *et al.* reported a possible use for H_2O_2 as an algicide in commercial aquaculture (10). Quimby (13) first provided evidence that H_2O_2 might be useful as a herbicide for the control of submersed aquatic weeds. Quimby found that H_2O_2 (1 to 4 mM) was toxic to hydrilla (*Hydrilla verticillata* (L.F.) Royle) and to coontail (*Ceratophyllum demersum* L.), but did not significantly damage either emersed or floating aquatic vegetation at similar levels of exposure. He indicated further that guppies (*Lebistes reticulatus*), exposed to H_2O_2 in the presence of coontail were apparently unharmed at concentrations that were toxic to the plants; in the presence of coontail, H_2O_2 was no longer detectable in solution after four days, suggesting rapid degradation in the environment into water and oxygen. A recent report (12) also has demonstrated larvicidal activity of H_2O_2 against mosquitos (*Aedes aegypti* L.), suggesting a possible beneficial side effect of submersed weed control using H_2O_2 as an herbicide. The results of these studies, the commercial availability of food–grade H_2O_2 and of H_2O_2–handling equipment,[3] and current commercial use of H_2O_2 in pre-treatment of drinking water supplies (17) and in wastewater treatment plants (3, 5, 11, 14) suggest that H_2O_2 may be suitable for use in the control of submersed aquatic vegetation with minimal adverse environmental effects.

Copper compounds are commonly used both alone and in combination with other herbicides in aquatic systems (2). Our objective was to evaluate the effect of short-term exposure of coontail to combinations of H_2O_2 with low levels of Cu.

METHODS AND MATERIALS

Coontail for these experiments was collected at Lake Bolivar County, Mississippi, during October and November 1980. At this time the plants were forming the compact, terminal winter buds, or hibernacula, that are characteristic of coontail during the winter months. Plants were held in the greenhouse in polyethylene tanks prior to experimentation. At the outset of an experiment, approximately 10-g cuttings of healthy plants with intact hibernacula were washed and weighed for each experimental unit.

A modified (7) Hoagland's No. 1 nutrient solution (8) was diluted to 1% strength with distilled water and supplemented with 100 mg/liter $NaHCO_3$ to provide a carbon source. A 30% H_2O_2 solution was diluted to provide a 1 M stock from which dilutions were made with the nutrient solution to provide H_2O_2 concentrations of 0, 34, or 68 mg/

[1]Portions of this paper were previously published in abstract form: Kay, S. H. and P. C. Quimby, Jr. 1981. Response of coontail to H_2O_2 ± Cu. J. Miss. Aca. Sci., Suppl. 24:18.

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[3]A bulletin entitled "Hydrogen Peroxide Solutions, Storage and Handling" describing commercially-available H_2O_2 solutions, their properties, and the proper storage and handling equipment and procedures, is available from E.I. duPont de Nemours & Co.

liter. Cu was added to the treatment solutions in the form of copper triethanolamine complex (Cutrine Plus)[4] at concentrations of 0, 0.1, or 0.5 mg/liter. All possible combinations of the above H_2O_2 and Cu solutions were prepared for a total of nine treatments.

A pre-weighed plant was placed for 1 h into each 3.79 liter jar with 3 liters of treated nutrient solution. Previous work by Quimby (13) had established a 1-h exposure as the minimal contact period required for control of coontail with H_2O_2. Plants were then washed in distilled water, transferred to jars containing 3 liters each of untreated nutrient solution, and covered with clear plastic film to retard evaporation. Plants were placed in controlled-environment chambers with a 14-h photoperiod and 25/20 C day/night temperatures. Photon flux densities were either 420 (1 test) or 450 (2 tests) $\mu E\ m^{-2}\ s^{-1}$. Light levels were measured with a Lambda Model LI-185 quantum meter.[5]

Each study was established in a completely random design having nine treatments and three replications per treatment. Plant responses were evaluated after 4, 7, 10, and 14 days using a visual rating scale of 0 to 10, where 0 represented no damage and 10 represented 100% kill. Qualitative factors used in visual evaluations included browning and necrosis of tissues, leaf abscission, and general disintegration of the plant stems. For practical application, a visual rating of seven was established as an acceptable level of control. At the termination of each study, the remaining intact plant material was dried for 48 h at 70 C and weighed. All data were subjected to an analysis of variance, and treatment means were compared using the Duncan's Multiple Range procedure. Initial data analyses indicated that there were no significant differences in response among the three experiments. The data, therefore, were combined and statistically analyzed together.

RESULTS AND DISCUSSION

The effects of all treatments with H_2O_2 and Cu, alone or in combination, increased with time after the 1-h exposure period (Table 1). Maximum damage ratings for 34 and 68 mg H_2O_2/liter alone were six and eight, respectively, and were not achieved until the 14- and 10-day rating periods, respectively. Injury ratings in the 34 mg H_2O_2/liter treatment increased almost linearly up to the 14-day rating period and possibly would have given acceptable control if the study had continued beyond 14 days. Treatment with 0.5 mg Cu/liter alone gave a damage rating of eight after seven days, with little further increase in damage thereafter. Fourteen-day ratings for the 0.1 and 0.5 mg Cu/liter treatments were three and eight, respectively. Effective control was not obtained after 14 days with 0.1 mg Cu/liter alone.

Combinations of 34 mg H_2O_2/liter with 0.5 mg Cu/liter or 68 mg H_2O_2/liter with either 0.1 or 0.5 mg Cu/liter produced injury ratings ≥ eight by seven days after exposure. The combination of 34 mg H_2O_2/ liter with 0.1 mg Cu/liter gave a mean damage rating of eight at the 14-day rating period, which was not significantly different from the injury produced by the 68 mg H_2O_2/liter plus 0.5 mg Cu/liter treatments ($\bar{x}$ = nine). After 14 days, treatment with either 68 mg H_2O_2/liter or 0.5 mg Cu/liter gave dry weight reductions that were statistically similar ($p = .05$) to those produced by treatment with 34 mg H_2O_2/liter plus 0.5 mg Cu/liter or 68 mg H_2O_2/liter with either 0.1 or 0.5 mg Cu/liter.

TABLE 1. THE RESPONSE OF COONTAIL TO TREATMENT WITH COMBINATIONS OF HYDROGEN PEROXIDE AND COPPER. RATINGS (ROUNDED TO NEAREST WHOLE NUMBER) ARE REPORTED ON A 0 TO 10 SCALE, WHERE 0 REPRESENTS NO DAMAGE AND 10 REPRESENTS 100% MORTALITY. DRY WEIGHTS WERE DETERMINED 14 DAYS AFTER EXPOSURE.

H_2O_2 mg/liter	Cu mg/liter	Time After Exposure (days)[a]				Dry Weight[a] (g)
		4	7	10	14	
0	0.0	0a	0a	0a	0a	0.93a
34	0.0	3b	4c	5c	6c	0.63b
68	0.0	4c	7d	8d	8de	0.30a
0	0.1	2b	2b	2b	3b	0.86a
0	0.5	7de	8de	8de	8de	0.31c
34	0.1	6d	7d	7d	8d	0.47b
34	0.5	7e	8e	9e	9e	0.19c
68	0.1	7e	9e	9e	9e	0.17c
68	0.5	8e	9e	9e	9de	0.19c

[a]Values in a column followed by the same letter are not significantly different at the 5% level as determined by the Duncan's Multiple Range procedure. Each value is the mean of nine replications.

The data indicate that the presence of Cu reduced the time needed to achieve acceptable control. Injury ratings ≥ seven were observed after four days in the combination treatments of 34 mg H_2O_2/liter plus 0.5 mg Cu/liter or 68 mg H_2O_2/liter plus either 0.1 or 0.5 mg Cu/liter. After seven days, injury ratings of ≥ seven were also observed for the 0.5 mg Cu/liter, 68 mg H_2O_2/liter, and 34 mg H_2O_2/ liter plus 0.1 mg Cu/ liter treatments. The combination of 34 mg H_2O_2/liter with 0.1 mg Cu/liter produced injury ratings that suggested synergism. With other combination treatments, however, the observed effects of H_2O_2 and Cu were ≤ additive. With time of one week or more, similar damage was produced by either 68 mg H_2O_2/liter or 0.5 mg Cu/liter alone. Combining H_2O_2 with 0.1 mg Cu/liter accelerated the control of coontail. The use of H_2O_2 alone could provide control while circumventing potential buildup of Cu in the aquatic environment and provide an alternative to the use of Cu in aquacultural systems in which direct Cu toxicity is sometimes a problem (1, 9).

ACKNOWLEDGMENTS

The authors are grateful for the excellent technical assistance of Ms. Kathy P. Bachman. We thank Ms. Bernandine Ward for typing of the manuscript.

LITERATURE CITED

1. Boyd, C. E. 1979. Water quality in warmwater fish ponds. Agric. Exp. Sta., Auburn Univ., Auburn, AL, 359 p.
2. Bureau of Aquatic Plant Research and Control. (No date) Aquatic Weed Identification and Control Manual. Fla. Dept. of Natural Resour., Tallahassee, FL, 100 p.

[4]Mention of a trademark, proprietary product, or vendor does not constitute a guarantee or warranty of the product by the U.S. Dept. Agric. or Delta State University and does not imply its approval to the exclusion of other products or vendors that may also be suitable.

[5]Other studies with coontail indicated reduced activity of H_2O_2 at lower light intensities (70 to 100 $\mu E\ m^{-2}\ s^{-1}$). Further investigations on the effect of light are in progress.

3. Chin, C., G. Hicks, and C. A. Geisler. 1973. Bio-oxygen stabilization using hydrogen peroxide. J. Water Pollut. Contr. Fed. 45:283-291.
4. Clark, L. R. 1980. Characterization of naturally occurring algal inhibitors. Dissertation, Univ. of Southern Miss., 182 p.
5. Cole, C. A., L. D. Ochs, and F. C. Funnell. 1974. Hydrogen peroxide as a supplemental oxygen source. J. Water Pollut. Contr. Fed. 46:2579-2592.
6. Frank, P .A. and N. Dechoretz. 1980. Allelopathy in dwarf spikerush (*Eleocharis coloradoensis*). Weed Sci. 28:499-505.
7. Frick, K. E. and P. C. Quimby, Jr. 1977. Biocontrol of purple nutsedge by *Bactra verutana* Zeller in a green house. Weed Sci. 25: 13-17.
8. Hoagland, D. R. and D. I. Arnon. 1950. The water-culture method for growing plants without soil. Calif. Agric. Exp. Sta. Circ. No. 347, 32 p.
9. Jackson, G. A. 1974. A review of the literature on the use of copper sulfate in fisheries. U.S. Fish Wildl. Serv., Rept. No. FWS-LR-74-06, 88 p.
10. Kay, S. H., P. C. Quimby, Jr., and J. D. Ouzts. 1982. H_2O_2: A potential algicide for aquaculture. Proc. 35th Ann. Meet., So. Weed Sci. Soc., 19-21 Jan., 1982, Atlanta, GA., pp. 275-289.
11. Keller, P. J. and C. A. Cole. 1973. H_2O_2 controls bulking. Water and Wastes Eng. 10(9):E4, E6-7.
12. Ouzts, J. D., S. H. Kay, and P. C. Quimby, Jr. 1981. Susceptibility of *Aedes aegypti* to various levels of hydrogen peroxide. Mosquito News 41:375-376.
13. Quimby, P. C., Jr. 1981. Preliminary evaluation of hydrogen peroxide as a potential herbicide for aquatic weeds. J. Aquat. Plant Manage. 19:53-55.
14. Sims, A. F. E. 1980. Odour control with hydrogen peroxide. Progress in Water Technol. 12:609-620.
15. Sladekova, A. 1969. Control of slimes and algae in cooling systems. Verh. Int. Verein. Limnol. 17:532-538.
16. Szczepanski, A. J. 1977. Allelopathy as a means of biological control of water weeds. Aquat. Bot. 3:193-197.
17. Voss, K., T. Votapka, and C. Bricker. 1980. Prechlorination treatment of water to reduce chloroform levels. Water Res. 14:921-926.
18. Wilde, E. W. and B. D. McLaughlin. 1981. Selecting an algicide for use with aluminum alloys. Water Res. 15:1117-1124.
19. Wolfe, J. M. and E. L. Rice. 1979. Allelopathic interactions among algae. J. Chem. Ecol. 5:533-542.