Chemical Control Of Hydrilla[1]

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ABSTRACT

Growth pool and large scale field tests prove that hydrilla (*Hydrilla verticillata* Royle) can be controlled by application of 6,7-dihydrodipyrido (1,2-α:2',1'-*c*) pyrazinediium ion (diquat) in combination with copper. Residues of diquat and copper in the water were found negligible 14 days after treatment. Multiple regression analysis of the data showed statistically significant effects of diquat on alkalinity, ammonia nitrogen (NH_3), and nitrate nitrogen (NO_3-N). The level of diquat residue in the water was zero, 14 days after chemical treatment. Hydrilla was controlled for 9 months.

INTRODUCTION

Hydrilla has become a serious aquatic plant problem in Florida, Louisiana, and Texas (3). During the past 10 years, several different herbicides have been studied in the laboratory and the field for control of hydrilla (2, 4). These studies indicated that 7-oxabicyclo (2.2.1) heptane-2,3-dicarboxylic acid (endothall) and diquat in combination with copper provide varying degrees of control of hydrilla (5, 6, 7, 8, 9).

METHODS AND MATERIAL

Growth Pool Studies. A soil mixture (50% peat and 50% sand) was spread uniformly to a depth of 15 cm over the bottom of plastic lined swimming pools. These pools were 0.9 m in depth and 3.4 m in diameter. Terminal cuttings of hydrilla about 20 cm long were placed with the basal 8 to 10-cm portions in the soil. Various herbicides were applied to the pools at concentrations which were shown to give good control in jar evaluations (1). Liquid herbicides were dissolved in water prior to uniform distribution over the pool surface. Each concentration of each treatment was applied to three pools, and three untreated pools served as controls. Herbicide effect was evaluated weekly for 4 weeks after application.

For fish toxicity analysis, growth pools were stocked with six bluegills (*Lepomis macrochirus* Rafinesque), three largemouth bass (*Micropterus salmoides* Lacapede), and three channel catfish (*Ictalurus punctatus* Rafinesque). Evaluations were made as percent mortality 2, 4, and 8 weeks after treatment.

Large Scale Field Tests. Results from pool studies were further examined in large scale field tests in Inglis Reservoir in west Florida. The depths of water varied between 1 and 1.3 m. The area had a heavy infestation of hydrilla and other submersed aquatic weeds. Test Area 1 was approximately 28 ha and Test Area 2 was 32 ha.

The herbicides were premixed in a 9:1 water-herbicide in a 2000-liter constant agitation tank. The premixed herbicide was then pumped into 400-liter tanks mounted in airboats. Test Area 1 was treated with 1 ppmw of diquat plus 0.14 ppmw of copper as the triethanolamine complex of copper sulfate (Cutrine). Test Area 2 was treated with 1 ppmw of diquat and 0.86 ppmw of copper as copper sulfate. The herbicides were injected approximately 1.0 m below the water surface from the stern of an airboat through three flexible hoses. Treatment of Test Area 1 was accomplished on 19 August 1969 in about 14 hr and Test Area 2 was treated on 21 August 1969 in about 11 hr.

Evaluation stations were established at eight locations in the treated area. These stations were marked before the herbicides were applied. Two divers using self contained underwater breathing apparatus (SCUBA) made independent visual estimates of the density of aquatic vegetation at each station before and at 3, 4, 14, 28, 48, 82, and 128 days after treatment.

Copper concentrations in water samples collected 0, 3, 14, 28, 82, and 128 days after treatment were determined with a Beckman DBG Spectrophotometer with an atomic absorption attachment. Water samples were kept in a refrigerator until analyzed. Samples which contained less than 0.1 ppmw of copper were concentrated by evaporating 200

[1]Cooperative investigations of the U.S. Department of Agriculture, Agricultural Research Service, Southern Region—Florida/Antilles Area; Central and Southern Florida Flood Control District; the Florida Agricultural Experiment Station, Fort Lauderdale, Florida; and U.S. Army Office of the Chief of Engineers, Washington, D.C.

ml to 50 ml. Prior to heating, perchloric acid was added at the rate of 0.5 ml per 200 ml of water to keep the copper in solution.

Also, copper and diquat were added to some water samples at the time of treatment to serve as an internal standard.

Diquat concentrations in water samples were determined according to a colorimetric method. The limit of detection with this method is 0.01 ppmw diquat. Determination was accomplished by adding 10 ml of a 0.2% sodium dithionite in 0.3 N NaOH to 10 ml of a water sample. An intense green color was formed in the presence of diquat and immediately read at 390 to 379 millimicrons with a Beckman DBG Spectrophotometer (5).

A field laboratory was set up using a Hach colorimeter for determining tannin, lignin, NO_3–N, NH_3, and ortho phosphate. Field tests also included pH, alkalinity, dissolved oxygen, temperature, and hardness. Duplicate samples were sent to the Florida Department of Air and Water Pollution Control Laboratory at Winter Haven, Florida for analysis.

RESULTS AND DISCUSSION

Growth Pools. These tests (Table 1) showed that diquat and copper sulfate are non-toxic to fish at the levels used for weed control.

Field Test. The effectiveness of the treatments in Inglis Reservoir is shown in Table 2. The combination of diquat plus copper sulfate resulted in a more rapid kill of hydrilla than the diquat plus Cutrine; however, both of the treatments gave 70% to 95% control of hydrilla 82 days after treatment. Regrowth was apparent at 128 days after treatment. Satisfactory control persisted about 9 months.

Residue Levels. The recovery of copper and diquat in control (spiked) water samples was 100%. Apparently no loss of these chemicals occurred during transit from the treatment area to the laboratory. Data of the study are presented in Table 3. The pretreatment water samples contained 0.001 to 0.011 ppmw of copper. Water samples from stations 3, 5, 7, and 8 contained concentrations of copper greater than 0.1 ppmw 1 day after treatment. In general, more copper was in the top sample (0.3 m below the surface) than in the bottom sample (0.3 above the hydrosoil). The area treated with copper sulfate pentahydrate (CSP) plus diquat contained 0.129 to 0.102 ppmw of copper 1 day after treatment as compared to 0.035 to 0.036 ppmw for the copper triethanolamine complex (Cutrine) treated area. A rapid dissipation of copper from both areas occurred. The level of diquat in water samples was not detectable 14 days after treatment.

TABLE 1. HERBICIDE ACTIVITY AND FISH TOXICITY OF SELECTED HERBICIDES ON HYDRILLA IN GROWTH POOL STUDIES.[1]

Herbicide	Rate (ppmw)	Weeks After Treatment 2	4	8	Fish Toxicity[2]
Diquat	0.5	53	60	80	0
	1.0	65	85	93	0
Diquat + CSP	0.5 + 0.5	72	100	100	0
	1.0 + 1.0	90	100	100	0
Copper sulfate	1.0	57	48	37	0
Copper sulfate encapsulated[3]	1.0	10	28	35	0

[1] Each value is the average of three replications expressed as percent control.
[2] Percent mortality 8 weeks after treatment.
[3] Encapsulated slow release experimental herbicide.

TABLE 2. COMPARISON OF DIQUAT PLUS COPPER COMPLEX AND DIQUAT PLUS COPPER SULFATE FOR PERCENT CONTROL OF HYDRILLA IN INGLIS RESERVOIR.[1]

Treatment Means	Days after treatment 3	7	14	28	48	82	128
Diquat + Copper[2] 1.0 + 0.46	3	43	60	48	70	76	44
Diquat + Copper[3] 1.0 + 0.86	12	43	60	78	90	93	74

[1] Hydrilla control expressed as average of visual observation at 8 sampling stations.
[2] Copper in form of triethanolamine copper complex (Cutrine).
[3] Copper in form of inorganic copper sulfate pentahydrate (CSP).

TABLE 3. COPPER AND DIQUAT IN SOLUTION (PPMW) AFTER TREATMENT FOR CONTROL OF HYDRILLA IN INGLIS RESERVOIR.[1]

Water Sample	Days after treatment 1	3	7	14
		Copper content		
Diquat + Cutrine copper 1.0 + 0.46				
Top	0.040	0.015	0.009	0.006
Bottom	0.032	0.015	0.011	0.006
Diquat + CSP 1.0 + 0.86				
Top	0.168*	0.064	0.011	0.009
Bottom	0.092	0.040	0.026	0.023
		Diquat content		
Diquat + copper 1.0 + 0.46				
Top	0.90	0.26	ND	ND
Bottom	0.45	0.29	ND	ND
Diquat + CSP 1.0 + 0.86				
Top	1.69*	0.92*	0.02	ND
Bottom	0.66	0.11	0.02	ND

[1] Top and bottom water samples were collected at 8 stations, 0.3 m below the surface and 0.3 m above the hydrosoil, respectively. Asterisk denotes significance at 95% of the significance level.

Water Quality. The results of water quality studies are summarized in Table 4. These observations indicated that ammonia nitrogen increased shortly after spraying and was high during the first month. Nitrate nitrogen dropped slowly. It is assumed that since the dissolved oxygen was low, the nitrate was reduced, yielding oxygen, causing a decrease in nitrate and increase in ammonia. Dissolved oxygen at the surface was not affected to any great extent by the treatment.

TABLE 4. WATER QUALITY DATA OF DIQUAT PLUS COPPER SULFATE AND DIQUAT PLUS COPPER COMPLEX TREATED PLOTS IN INGLIS RESERVOIR FOR CONTROL OF HYDRILLA, FOR PRETREATMENT (8-1) AND POST TREATMENT SAMPLING, 30 DAYS (9-17) AND 60 DAYS (10-14) AFTER TREATMENT.

Date and treatment	Dissolved oxygen (ppm)	Calcium Carbonate Alkalinity (ppm)	Nitrogen NH_3 (ppm)	Nitrogen NO_3–N (ppm)
	Diquat plus copper sulfate			
8-1	6.8	94	0.47	0.06
9-17	6.8	119*	0.26*	0.10*
10-14	5.7	116*	0.15*	0.06*
	Diquat plus copper complex			
8-1	8.0	85	0.40	0.06
9-17	7.3	110*	0.26*	0.10*
10-14	5.7	117*	0.18*	0.06*
	Dates after treatment means			
8-1	7.4	90	0.44	0.06
9-17	7.1	115	0.26*	0.10*
10-14	5.7	117	0.17*	0.06
	Copper treatment means			
Sulfate	6.4	108	0.29	0.73
Complex	7.0	104	0.28	0.73

* Significant effect associated with diquat treatment.

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