Aquatic Weed Control Trials, Gatun Lake, Panama Canal

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ABSTRACT

For three successive years, field trials have been conducted in Gatun Lake during the dry season (January through June) to determine the effect of $CuSO_4$ (copper sulphate), 6, 7 dihydrodipyrido [1,2-a:2',1'-c], pyrazinediium salts (diquat), diquat-copper sulphate combinations, Mono (N, N-dimethylalkylamine) salt of endothall (Hydrothol 191) liquid and granular formulation, and 3-(3,4-dichlorophenyl)-1-methyl-1-methylures (Karmex) on hydrilla (*Hydrilla verticillata* (L. F.) Casp.). Copper sulphate crystals at rates of 5, 10, and 15 ppmw controlled hydrilla effectively for 12 weeks and at 20 ppmw for over 16 weeks. Fish toxicity occurred after all copper sulphate treatments. Diquat and diquat-copper sulphate combination at rates above 0.5 ppmw showed excellent control of hydrilla up to 14 weeks after treatment. No fish kill occurred with these treatments. Hydrothol 191 (liquid) at rates above 1 ppmw gave effective control for 12 weeks, light fish kill was observed in these treatments. Hydrothol 191 (granular) showed a slow herbicidal action and did not give a satisfactory control. Karmex never controlled more than 45 percent of hydrilla.

INTRODUCTION

The aquatic weed problem of the Panama Canal did not become generally known until a relatively short time ago.

Prior to 1958, the Panama Canal appeared to have small populations of floating waterhyacinth *(Eichhornia crassipes* (Mart.) Solms). and anchored waterhyacinth (Eichhornia azurea (Sw) Kunth), plus some aquatic grasses; all of which were under control. In 1958 our troubles began with the advent and dissemination of numerous other types of aquatic vegetation, but did not become alarming until eight years ago. During a very short period, many acres became choked off with hydrilla and other submersed weeds. A concerted effort was made to control these aquatic weeds; various mechanical means were tried with relative success, but proved to be effective for only short periods of time. We soon realized that we would have to rely on other means and methods of control.

In 1963 the Panama Canal Company joined the Hyacinth Control Society thus joining the ranks of all those so vitally concerned with the menace of aquatic weeds.

In 1964 experiments with $CuSO_4$ (copper sulphate) resulted in good control of hydrilla (1). All essential areas were cleared; but it has been quite expensive. Therefore, we have continued trying to find other and better means of control which would be more efficient and less expensive.

In May of 1966, an experiment was initiated in Miraflores Lake to evaluate the herbicidal properties of three chemicals, copper sulphate, diquat and, Hydrothol 191 on hydrilla. The results obtained from these tests were encouraging from a standpoint of initial control, however, their effects were not lasting.

Even though Miraflores Lake is considered a fresh-water lake, it is affected by the mixing of ocean waters due to the lifting of ships from the Pacific Ocean through the Miraflores Locks into the lake. Water quality in this lake is affected by increasing amounts of salinity; therefore, it was determined to repeat these tests in a fresh body of water.

METHODS AND MATERIALS

The area selected for the fresh-water trials is located in Darien, Gatun Lake, five miles north from Gamboa to the east side of the main traffic channel. This area is affected by surges from passing ships up to as much as 1 foot from the larger vessels and diminishes due to the size and speed of the passing crafts. Prevalent vegetation of the area is principally hydrilla, some coontail (*Ceratophyllum demersum L.*), floating water hyacinth, and marginal grasses.

Thirty plots, each 0.1 of an acre in size and infested with hydrilla, were established to evaluate the effects of copper sulphate crystals, diquat, diquat-copper sulphate combination, Hydrothol 191 liquid and granular formulation, and Karmex on hydrilla.

All plots were separated by buffer zones to prevent mixing of herbicides. Water depth in the test area averaged 10 feet. Water temperature at time of application varied from 82 to 85 F. Copper sulphate crystals and granular Hydrothol 191 were broadcast by hand from a row boat. The other materials, diquat, diquat-copper sulphate combination, Hydrothol 191 (liquid) and Karmex were sprayed uniformly over the surface. The herbicide for each plot was applied in 30 gal. of water and sprayed by a 5 gal/min John Bean pump. Control of hydrilla was considered effective when reduction of original weed population was maintained 70%.

These trials were conducted during the dry seasons (January through June) of three consecutive years. Results are expressed as a mean average of the three consecutive years. A value of 100 indicates complete removal of the aquatic weeds while a value of 0 means that the weeds were not affected by the herbicides.

RESULTS AND DISCUSSION

Applications of copper sulphate crystals at 3 and 4 ppmw rates resulted in a gradual fragmentation of hydrilla, which turned brown and decomposed (Table 1). After 4 weeks a large number of plants were found in these plots. New shoots sprouted from bottom plants and floating fragments. Rates above 5 ppmw resulted in faster fragmentation and decomposition of hydrilla. Within 3 weeks plots treated at these rates were clear to the bottom. The 5, 10 and 15 ppmw rates controlled hydrilla effectively for 12 weeks, after which regrowth from turions occurred in each plot. At 20 ppmw control was maintained for over 16

TABLE 1. PERCENT REDUCTION OF HYDRILLA POPULATIONS IN DARIEN, GATUN LAKE AFTER APPLICATIONS OF VARIOUS CONCENTRATIONS OF COPPER SULFATE CRYSTALS

Plot No.	Conc. (ppmw)	Percent Reduction Weeks After Treatment 1	2	4	6	8	10	14	16
XI	3	25	35	50	40	33	31	18	—	—
XII	4	35	48	73	71	61	43	31	25	20
XIII	5	79	85	93	95	86	78	73	43	40
XIV	10	81	91	96	96	96	86	75	70	63
XV	15	66	73	90	100	91	75	70	56	56
XVI	20	86	95	100	100	100	100	96	83	83

weeks. Fish toxicity was observed at all copper sulphate treatments.

Diquat at rates above 0.5 ppmw resulted in excellent control of hydrilla up to 14 weeks after treatment (Table 2). Decomposition of hydrilla progressed slowly as indicated by the change in color of the plants from dark green to brown. Plots 1 week after treatment had a white appearance due to decomposition of all growing tips. At 2 weeks the plants were brown and at 3 weeks they were breaking apart, dropping their leaves, and sinking to the bottom. Reinfestation of the plots occurred from plants growing from the bottom. Underwater examination revealed plants growing from existing turions in lake bottom.

TABLE 2. PERCENT REDUCTION OF HYDRILLA POPULATIONS IN DARIEN, GATUN LAKE AFTER APPLICATIONS OF VARIOUS CONCENTRATIONS OF DIQUAT.

No. Plot	Conc. (ppmw)	Percent Reduction Weeks After Treatment 1	2	4	6	8	10	12	14	16
XXVII	0.5	30	50	71	71	71	57	50	40	31
XXVIII	1.0	45	55	80	85	81	75	70	70	50
XXIX	1.5	55	65	86	90	90	86	81	78	55
XXX	2.0	65	75	90	95	96	90	86	80	58

Diquat-copper sulphate combination had a rapid effect upon hydrilla (Table 3). The color of the plants changed from green to brown very soon after treatment, the leaves dropped from the stems, the plants fragmented and fell to the bottom leaving a few shoelace-like strands attached to the substratum. After 3 weeks the mud bottom could be seen.

Rates above 0.5 ppmw each of diquat-copper sulphate combination resulted in effective control of hydrilla up to 14 weeks after treatment. Regrowth of plants were traced to development of existing turions in mud bottom. No fish toxicity was observed in these plots.

TABLE 3. PERCENT REDUCTION OF HYDRILLA POPULATIONS IN DARIEN, GATUN LAKE AFTER APPLICATIONS OF VARIOUS CONCENTRATIONS OF DIQUAT-COPPER SULFATE COMBINATION

Plot No.	Conc. (ppmw)	Percent Reduction Weeks After Treatment 1	2	4	6	8	10	12	14	16
XIII	0.5+0.5	35	45	56	55	51	48	36	23	16
XIV	1.0+1.0	60	75	83	90	90	78	75	70	40
XV	1.5+1.5	68	86	92	91	93	83	80	75	46
XVI	2.0+2.0	71	83	86	96	96	86	80	75	50

Plots treated with Hydrothol 191 (liquid) revealed a rapid herbicidal action within 3 days after treatment. Hydrilla was sinking to the bottom 1 week after treatment. Rates above 1.0 ppmw resulted in a remarkable disintegration of vegetation after 2 weeks, with most of it lying on the bottom (Table 4). Plots treated at these rates, were virtually free of all vegetation after 3 weeks. At rates above 1.0 ppmw effective control of hydrilla was maintained for 12 weeks. Regrowth of hydrilla in plots treated with Hydrothol 191 (liquid) was observed to grow faster and denser than at any of the other treatments. Examination of plants taken from lake bottom revealed growth developing from underground turions. Light fish toxicity was observed in these treatments.

TABLE 4. PERCENT REDUCTION OF HYDRILLA POPULATIONS IN DARIEN, GATUN LAKE AFTER APPLICATIONS OF VARIOUS CONCENTRATIONS OF HYDROTHOL 191 (LIQUID)

Plot No.	Conc. (ppmw)	Percent Reduction Weeks After Treatment 1	2	4	6	8	10	12	14	16
I	0.5	50	60	75	75	65	60	45	25	—
II	1.0	35	50	78	83	70	58	43	20	16
III	1.5	60	80	93	96	95	88	70	48	20
IV	2.0	80	90	98	96	91	88	75	56	30
V	2.5	80	90	100	96	93	85	78	56	36
VI	3.0	75	90	98	96	91	85	79	59	40

The granular formulation of Hydrothol 191 had a slow herbicidal effect upon hydrilla at all treatment concentrations (Table 5). Control was not considered satisfactory. Regrowth of hydrilla was rapid in all treatments. Fish toxicity was not observed; whether the fish moved out of the treated area before death is not known.

TABLE 5. PERCENT REDUCTION OF HYDRILLA POPULATIONS IN DARIEN, GATUN LAKE AFTER APPLICATIONS OF VARIOUS CONCENTRATIONS OF HYDROTHOL 191 (GRANULAR).

Plot No.	Conc. (ppmw)	Percent Reduction Weeks After Treatment 1	2	4	6	8	10	12	14	16
XVII	0.5	10	10	10	11	15	16	13	—	—
XVIII	1.0	15	15	20	23	26	26	21	—	—
XIX	1.5	20	20	23	28	41	46	50	23	—
XX	2.0	20	25	25	33	45	50	46	26	—
XXI	2.5	30	33	38	45	53	60	71	43	—
XXII	3.0	40	43	48	60	66	71	80	46	—

Karmex had a very slow effect on hydrilla. After several weeks some plants were thinning from the surface mat, other plants were losing their leaves from the main stem but most lateral branches appeared healthy and green (Table 6).

Karmex applied at 3, 5, 10, 15 lbs/acre-ft. was not effective on hydrilla. At the highest rate of 15 lbs/acre-ft Karmex never controlled more than 45% of the hydrilla.

SUMMARY AND CONCLUSIONS

Hydrilla was effectively controlled for periods of 12 to 14 weeks by applications of copper sulphate crystals, diquat, diquat-copper sulphate combination, and Hydrothol 191 (liquid).

TABLE 6. PERCENT REDUCTION OF HYDRILLA POPULATIONS IN DARIEN, GATUN LAKE AFTER APPLICATIONS OF VARIOUS CONCENTRATIONS OF KARMEX.

Plot No.	Conc. (lbs/Aft.)	Percent Reduction Weeks After Treatment 1	2	4	6	8	10	12	14	16
VII	3	13	15	21	26	25	23	23	10	—
XIII	5	18	18	28	26	28	26	23	10	—
IX	10	25	26	35	38	40	33	33	23	10
X	15	25	31	35	41	45	40	35	23	10

Hydrothol 191 (liquid) and diquat-copper sulphate combination showed a rapid rate of initial control.

Treatments with diquat and diquat-copper sulphate combination were observed to have no toxic effect on fish present in the area; however, copper sulphate crystals and Hydrothol 191 (liquid) were found to be toxic to fish. Karmex and granular Hydrothol 191 did not give a satisfactory control of hydrilla. In all plots where hydrilla was completely eliminated, it was observed that regrowth occurred from development of turions present in the lake hydrosoil.

LITERATURE CITED

1. Hearne, J. S. 1966. The Panama Canal's aquatic weed problem. Hyacinth Control Journal 5:1-5.