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Improved Application Techniques For Aquatic Herbicides

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ABSTRACT

Two gallons of 6,7-dihydrodipyrido(1,2-*a*:2′,1′-*c*) pyrazinediium dibromide (diquat) were used with either copper sulfate pentahydrate (copper sulfate) or copper triethanolamine complex (cutrine-plus) in an invert carrier to control hydrilla (*Hydrilla verticillata* Royle), eelgrass (*Vallisneria neotropicalis* Marie Vict), coontail (*Ceratophyllum demersum* L.), and southern naiad (*Najas guadalupensis* (Spreng.) Morong.) in Florida. Herbicide efficacy was evaluated in each test area, and water residue samples were collected and analyzed for diquat content. The submersed weed population was reduced 80% or more within 28 days after application. Residual levels of diquat were below the EPA interim tolerance of 0.01 ppm 3 days after application.

INTRODUCTION

Aquatic weed control with herbicides is only a part of water management, but a very vital part if our waterways are to continue to be useful. Allowed to grow unchecked, aquatic weeds can interfere with irrigation, drainage, fish production, transportation, and recreation.

The need for efficient weed control resulted in the development of herbicides for submersed aquatic weed control. Some of the most effective herbicides were acrylaldehyde (acrolein), 7-oxabicyclo[2.2.1]heptane-2,3-dicarboxylic acid (endothall), diquat, and 2,6-dichlorobenzonitrile (dichlobenil). The development of these specific herbicides preceeded the development of the proper application technique by several years.

The utilization of these herbicides included the following objectives: (1) reduce the quantity of the herbicide applied to the water; (2) improvement in application equipment to insure placement of the herbicide in direct contact with the target plant; (3) prevention of the accumulation of the copper ion in the hydrosoil; and (4) preservation of fish and shell fish populations in the treated areas.

The proper utilization of aquatic herbicides requires a positive correlation between the problem weed species, the herbicide program to be used, and the application technique.

Several chemical application techniques have been developed, and each method has its specific advantages and disadvantages in a given situation. One of the oldest application methods for the control of submersed aquatic weeds was to treat the entire waterway with the selected chemical. This is often referred to as the total water column treatment method, or the parts per million system. This technique is being used less frequently because of recent improved techniques which treat only the portion of the water column containing the weed plants (5).

However, the parts per million treatment is still occasionally used with herbicides such as acrolein, or other aromatic solvents that are non-selective contact herbicides. This system is used primarily in irrigation and drainage canals in Puerto Rico where rapid water movement prevents successful utilization of the other methods, and where fish are not a major concern. The parts per million treatment should not be used in areas where the chemical is not sufficiently diluted or does not have time to dissipate before reaching fish productive bodies of water (2).

In the early 1960's, many of the lakes within the City of Winter Park, Florida had become overgrown with hydrilla and eelgrass. This heavy growth occurred from the shallow water at the beach to a water depth of over 20 ft. Continuous problems with mechanical weed harvesters coupled with only marginal weed control, emphasized the need for a more effective control system. This situation led McClintock and his associates to investigate several chemical weed control systems in 1969. This investigation is continuing as new herbicides become available. From this intensive program, the Bottom Placement was developed whereby a herbicide or a combination of herbicides could be placed near the bottom of a lake with equipment especially designed for this purpose (5).

In firm, sandy bottom lakes, this technique has provided effective aquatic weed control with the use of diquat (2 gpa), copper sulfate (20 lb/acre, or copper hydroxide triethanolamine (3.2 lb/acre) diluted in water, and applied in 100 gpa. However, at least two applications per year may be necessary.

The Bottom Placement Technique is much more economical and safer than the parts per million treatment system. It is not recommended for flowing water situation, or where the bottom is covered with silt or mud. This technique treats only the lower waters, and the untreated surface water provides an area for fish to escape the effects of the chemical.

In flowing water situations and in water containing suspended silt or mud, the Bottom Placement Technique utilizing the invert carrier for selected herbicides has provided adequate submersed aquatic weed control. This report covers two methods of applying diquat and a copper ion source in an invert carrier system.

DESIGN OF EQUIPMENT

For the Sub-Surface Placement Technique, Lambert and his associates continued to use the equipment designed in 1972 by Gates (3) on the stern of shallow draft airboats operating in dense vegetation.

In order to utilize the Bottom Placement Technique with the invert emulsion carrier system designed in 1972-73 by Bitting (1), a tank mix invert was substituted for the water used by McClintock (5).

APPLICATION OF HERBICIDES

The invert system as used by Lambert and his associates may be described as a double invert. The conventional emulsion is a thin dispersion of oil in water, whereas the invert emulsion is a carrier system in which the dispersion process is reversed and crowds larger amounts of water into smaller amounts of oil resulting in a thick or invert emulsion.

The double invert is pre-mixed separately in a mixing unit carrying two 105-gal tanks for the water phase and the oil phase respectively. In the water phase tank: 4 gal diquat plus 20 lb of copper sulfate containing 25.2% metallic copper plus 75 gal liquid sugar as a weighting agent are thoroughly mixed together in sufficient water with mechanical agitation to provide 75 gpa of the finished product. In the oil phase tank: a four to one mixture of xylene and a suitable inverting agent are thoroughly mixed together with mechanical agitation at the rate of 85 gal and 20 gal, respectively.

Two separate tanks in the airboat receive the pre-mix. The two phases are brought together through an invert valve that has a line pressure of 100 psi and a 20-lb vacuum. This valve encloses the water in oil and applies the invert emulsion at the rate of 37.5 gpa.

The invert emulsion carrier system is applied by the Sub-Surface Placement Technique by injection into the water at the stern of the airboat at a depth of 3 to 6 inches. The invert spray enters the water as fine, almost microscopic droplets, with an approximate density of mayonaise. The invert slowly settles onto, and adheres to the plant parts of the submersed weeds where the herbicides are released into the plant tissue as the film spreads across the vegetative mass.

Tests were conducted in October 1973 by the Southwest Florida Water Management District using the Sub-Surface Placement Technique to apply the invert carrier system in five replicated 2-acre plots on Princes Lake. The plots were evaluated visually for 60 days to determine the phytotoxic effects of the herbicide system. Water samples were collected at a depth of 3 ft below the lake surface with a pole water tube. Samples were stabilized with 3.37 oz of concentrated sulfuric acid per gal of water. These samples were analyzed for diquat residue by Pattison's Laboratories, Harlingen, Texas.

Additional tests were made on Canal 31, southeast of Kissimmee, Florida, utilizing the Bottom Placement Technique with a single 50-gal fiberglass tank with mechanical agitation. The invert was prepared by premixing in a 5-gal plastic jug 4.75 gal of xylene and 1.5 qt of a suitable inverting agent which was then added to the spray tank. The agitator ran throughout the mixing procedure. Then the tank was filled with water to the 40 gal level. At this time, 12.5 lb of ammonium sulfamate (AMS) in 2.5 gal of water was added to the tank as a weighting agent. With the addition of the AMS, the invert became a homogeneous yellow liquid. In addition, 2 gal of a chelated copper complex containing 9% metallic copper were carefully and slowly added to the invert in the tank. This is a critical stage, because an excess of copper ions, may cause the invert to collapse. Finally, 1 gal diquat in sufficient water (approximately 4.5 gal) was added to fill the tank. These steps which were done slowly and carefully provided a finished invert carrier system that was a bluish-white, stable, smooth liquid. One-hundred gallons of invert were applied per acre.

The plants were evaluated visually for phytotoxic effects of the herbicide system and water samples were collected at the center of the plots and 0.4 mile downstream at 3 ft below the surface of Canal 31 with similar equipment as described for the Princes Lake plots.

RESULTS AND DISCUSSION

Invert carriers of diquat plus the two copper sources resulted in good control of hydrilla, eelgrass, coontail, and southern naiad within 28 days after application with both the Sub-Surface Placement and the Bottom Placement Techniques (Table 1). The weed mass was 2 ft below the surface, defoliating, and rapidly decaying in the Princes Lake Sub-Surface treatment plots 28 days after application. However, the Canal 31 Bottom Placement plots indicated the weed mass to be 3 ft below the surface and rapidly decaying 14 days after application of the invert herbicide system.

The use of the Bottom Placement Technique with an invert carrier appears to make it possible to use diquat in muddy water. In the Canal 31 plots, which were established in turbid water, the herbicide system provided 90% control of the submersed weeds. This observation is contrary to the diquat label and extensive experience with the herbicide.

The Sub-Surface Placement Technique provides a successful method for the control of submersed weeds in situations where the trailing hoses of the Bottom Placement Technique cannot be maintained near the bottom because of the dense mass of vegetation.

As indicated in Table 2 residual levels of diquat 3 ft below the surface in the center of the plots and at a similar depth 1 mile downstream were below 0.01 ppm except for the plot center samples collected 30-minutes after treatment in the Princes Lake plots. Similar results were obtained in the Canal 31 plots where the residual levels of diquat 3 ft below the surface at the lake end and 0.4-mile downstream at the dam were below 0.01 ppm except for the samples collected at the dam 1 day after treatment (Table 2). In both locations, diquat levels dissipated rapidly after these treatments.

TABLE 1. SUBMERSED WEED CONTROL UTILIZING AN INVERT CARRIER OF DIQUAT

Plot Location	Herbicide (concentration/surface acre)	Control rating[c] Days after treatment 0	1	7	14	21	28	60
Princes Lake[a]	2 gal diquat plus 20 lb copper sulfate	0	3	4	5	6	8	9
Canal 31[b]	2 gal diquat plus 25 lb AMS	0	2	4	8	9	9	9
Untreated Check	———	0	0	0	0	0	0	0

[a] Sub-Surface Placement into hydrilla, eelgrass, coontail, and southern naiad.
[b] Bottom Placement into hydrilla and coontail.
[c] Range of visual evaluation: 0 = no control, 10 = complete control.

TABLE 2. RESIDUAL LEVELS OF DIQUAT 3 FT BELOW THE SURFACE IN A FLOWING WATER SITUATION UTILIZING AN INVERT CARRIER.

Plot location	(conc/surface acre)	Hours after treatment at plots	Diquat (ppm)	Hours after treatment downstream[d]	Diquat (ppm)
Princes Lake[a]	2 gal diquat[c] plus 20 lb copper sulfate	0.5	0.1218	0.5	0.0005
		24	0.0049	24	0.0075
		72	0.0046	72	0.0050
		168	0.0008	168	0.0003
Canal 31[b]	2 gal diquat plus 25 lb AMS plus 4 gal cutrine-plus	1	0.0054	1	0.0072
		24	0.0011	24	0.0104
		72	0.0005	72	0.0003
		168	0.0000	168	0.0003

[a] Sub-Surface Placement
[b] Bottom Placement
[c] EPA interim tolerance in potable water of 0.01 ppm Nov 1972.
[d] 1 mile downstream at Princes Lake and 0.4 mile downstream at Canal 31.

The flow in Princes Lake was in excess of 2 million gph, however, the Sub-Surface Placement Technique provided 90% submersed weed control for a diquat cost of $52 per surface acre. In comparison, the ppm or total water column technique for applying diquat in Princes Lake would cost $217 to treat an acre of water which averages 6 ft in depth.

The invert carrier of diquat provided a significant reduction in the amount of herbicide applied per surface acre, i.e., a reduction from 8.4 gal in the above illustration to 2 gal in Princes Lake or a reduction from 12.6 gal in Canal 31 with an average depth of 9 ft to 2 gal. The gate in the dam structure in Canal 31 was not opened during the course of this study; consequently, the 0.4-mile of canal responded similarly to a long, narrow lake or pond since there was little or no water flow in the canal.

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Control Of Egeria In A Virginia Water Supply Reservoir[1]

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ABSTRACT

A 1:1 mixture of 6,7-dihydrodipyrido[1,2-*a*:2′,1′-c]pyrazinediium ion (diquat) and 7-oxabicyclo[2,2,1]heptane-2,3-dicarboxylic acid (potassium endothall) was used at 0.11 and 0.17 ppmw active ingredient respectively to control egeria (*Egeria densa* Planch.) in Chickahominy Reservoir, a Virginia water supply lake. Herbicide efficacy was evaluated in two quadrants selected to represent shallow and deep water conditions. Plant sampling with a cylindrical sampler before, and 42 and 360 days after treatment yielded a quantitative index of plant die-off. Egeria was reduced 94% after 360 days in the deep quadrant and only 6% in the shallow quadrant. The quantity of filamentous algae increased following treatment.

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INTRODUCTION

Walker's Dam Impoundment (Chickahominy Reservoir) is a 1093-ha water supply reservoir located between Richmond and Williamsburg, Virginia. The reservoir supplies water to the city of Newport News, Virginia, and is used extensively for boating and fishing. Reservoir depth is relatively shallow, with 55% less than 0.91 m. Water retention time in the reservoir is great, the impoundment is eutrophic, and water temperatures exceed 30 C during the summer. These conditions have been optimal for the establishment of egeria and most areas less than 1.83 m deep were choked with this hydrophyte. Other floating and submerged plants occurring to a lesser extent were duckweed (*Lemna minor* L.), watermeal (*Wolffia* sp.), coontail (*Ceratophyllum demersum* L.), bladderwort (*Utricularia inflata* Walt., and *U. gibba* L.), milfoil (*Myriophyllum* sp.), yellow water lily (*Nuphar adventa* Ait.), and an oscillatoreacous bluegreen algae *Lyngbya* sp.