AQUATIC WEED CONTROL

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Summary

Diquat dibromide and paraquat di-(methyl sulphate) are promising herbicides for the control of many floating and submerged aquatics. Recommendations made in this paper are mainly tentative, as experimental error is large owing to many factors, such as water movement, weed movement, and storms. Neither chemical is harmful to fish and most weed species are successfully controlled by over-all or injection application.

NITROGEN BUILD-UP in lakes, rivers and drains has caused many weeds to assume economic importance. The use of such waterways for sewage disposal and the general increase in land fertility has encouraged the rapid growth of floating and submerged aquatics. Even the successful control of emergent aquatics such as *Glyceria maxima* has often led to the increase of such species.

SUBMERGED WEEDS

Lagarosiphon major and *Anacharis canadensis*

Lagarosiphon major has increased greatly in lakes Rotorua and Rotoiti. It also threatens to cause problems in the hydro lakes on the Waikato River. Local residents claim this weed has caused a general rise in lake levels, made fishing and swimming more difficult, and made beaches untenable, particularly after storms.

Initial tests showed that in large tracts of water at concentrations of 10, 20 and 40 p.p.m. for the bottom acre-foot of water, fenoprop gave a superior check to 2,4-D products of similar formulation; fenac was superior to 2,4-D but inferior to fenoprop. Later work with fenoprop granular and liquid preparations gave poor results when used at 5 and 10 p.p.m. for the bottom acre-foot of water. The results were unfavourable, even at the optimum time of application when water temperatures were high and the *L. major* was in the vegetative stage of growth.

Arsenical preparations applied at 10 p.p.m. throughout the entire depth of water gave no more than a slight check. Diquat dibromide at 0.5 p.p.m. of the diquat ion gave excellent results, particularly when used in November at the vegetative growth stage of the *L. major*. This treatment has been effective when used as an aerial spray or by injection. The optimum concentration has not been determined, but lies in the 0.05 to 0.5 p.p.m. range.

Potamogeton ochreatus

Information is not complete on this species, but control with diquat dibromide is satisfactory when the material is injected or where this species is growing in a pure association. Chlorinated aromatics also have given control when applied as an over-all application.

Nitella species

Some algae, such as *Spirogyra*, appear susceptible to diquat dibromide. *Nitella* and *Ulothrix* are completely resistant at rates of 0.5 p.p.m. throughout the entire depth of water.

Azolla filiculoides var. *rubra*

This species is confined to stagnant or near-to-still water. Under suitable conditions it regenerates rapidly and has proved troublesome in stock ponds. Adequate control is obtained with both diquat dibromide and paraquat di-(methyl sulphate) at rates as low as

TABLE 1: TRIAL DETAILS FOR LAGAROSIPHON MAJOR

Locality	Date of Application	Materials	Formulation	Rate of Application in p.p.m.	Water temperatures 2 ft below surface	Plot Size	Depth of Water in ft	State of L. major	Effectiveness
Lake Rotorua 3 replications	Dec. 23, 1959	2,4-D Fenoprop Fenac	Granulated 10% Granulated 10% Granulated 20% Granulated 10%	10, 20 and 40	62° F	½ ac	2½ to 5	Early reproductive stage	No effect Some response Slight effect
Lake Rotorua	Nov. 24, 1960	Fenoprop Fenoprop	Granulated 10% Polypropylene glycol butyl ethyl ester	5 and 10	62° F	2.4 ac.	2½ to 5	Vegetative stage	No effect No effect
Lake Rotorua	Mar. 19, 1961	Fenoprop Diquat	Granulated 10% Dibromide 20% active	5 and 10 0.5	62° F 64° F	1.2 ac 1 ac	2½ to 5 5	Approaching dormancy	No effect Kill approx. 3 ac.
Lakes Rotorua and Rotoiti 3 replications	July, 3, 1961	As ₂ O ₃ Diquat	5.6 As ₂ O ₃ per gal. Dibromide 20% active	10 1	60° F	1 ac	4, 5 and 10 4 and 14	Dormant stage	Slight tinge Complete kill 1 ac
Lakes Rotorua and Rotoiti 2 replications	Nov. 30, 1961	Diquat Fenoprop	Dibromide 20% 72% Potassium salt	1 and 2 5 and 10	68° F	1 ac	4, 6, 3½, and 5 5	Vegetative stage	Kill approx. 8 to 10 ac Possibly slight damage only
Lake Rotorua 2 replications	Feb. 8, 1962	Diquat	Dibromide 20%	1 and 2	70° F	1 ac	7, 8 and 9	Approaching dormancy	Approx. 3 ac destroyed before results annulled by storm

Granulated material applied at p.p.m. for bottom acre-foot of water.
Liquids applied at p.p.m. throughout entire depths of water.
All materials were applied aerially.

0.5 lb a.i. per acre as a surface spray. An allied species (*Salvinia* overseas), is apparently only controlled by paraquat di-(methyl sulphate). Chlorinated aromatics applied as a surface spray also give some control, but cause water contamination which is a serious problem in stock ponds.

Duckweeds

These are usually a complex of *Lemna minor*, *Wolffia arrhiza*, and *Spirodella oligarrhiza*, and often grow in association with other still-water species. Duckweeds are usually the first to appear, followed closely by such species as *Callitriche stagnalis* and *Azolla*. Both paraquat di-(methyl sulphate) and diquat dibromide at rates as low as 0.5 lb a.i. per acre, as a surface application, have been equally effective.

Callitriche stagnalis

This species, in particular, often occupies slow-moving water once emergent vegetation has been removed. Interim results only are available. Diquat dibromide and paraquat di-(methyl sulphate) as a surface application exercise some control. These species grow so compactly that the injection method may be superior to surface application. Excellent control has been obtained with chlorinated aromatics as a surface spray.

Aponogeton distachyus

Interim results indicate that excellent control may be obtained with diquat dibromide as an injection method at rates of 5 to 10 p.p.m. throughout the entire depth of water. To date only small quantities, maximum $\frac{1}{3}$ gal, have been used per plot. If plot sizes were larger so that a proportionately larger amount of diquat dibromide could be employed, there is a strong possibility that the concentration may be lowered considerably.

Glyceria fluitans

In the vegetative stage, paraquat di-(methyl sulphate) as a surface application, has given inadequate control but shows stronger possibilities as an injection method. In the reproductive stage, this material at 1 to 2 lb a.i. per acre has given adequate control.

CHEMICALS

The failure of various preparations of 2,4-D, fenoprop, fenac and 2,6-DBN to control floating and submerged aquatic weeds in small and large tracts of moving water emphasizes that these materials must be absorbed slowly into the plants. Granular preparations have been successful only when applied to enclosed bodies of water. No specific data are available, but trials indicate that granular formulations take at least 48 hours to be dispersed and absorbed by the weeds. Except in enclosed bodies of shallow water and where the concentration of 5 to 10 p.p.m. can be built up and maintained throughout the entire depth of water, no control is obtained. Their use appears limited to dams or ponds where the outflow may be cut off for at least 48 hours. Liquid preparations appear to act more quickly, and, provided concentrations of 5 to 10 p.p.m. throughout the entire depth of water can be maintained for a period of 24 to 48 hours, adequate control of susceptible species is obtained. To achieve this economically, the water must be static.

ARSENICAL PREPARATIONS

Arsenical preparations and organic arsenicals such as cacodylic acid, in spite of their high specific gravity, have not been effective when applied to sections of large bodies of water. It appears necessary to apply sufficient material to build up a concentration of 5 to 10 p.p.m. throughout the entire depth of water area, so that a lethal

level of arsenic remains in the water for a period of several days. This is practical only for small tracts of static water or near static water. In Table 2 samples were taken within one hour of application. For details of application, see Table 1.

TABLE 2: ARSENICAL ANALYSES

Lake	Plot	Depth	Jun. 20, 1961*	Dates sampled		
				Jul. 2, 1961†	Jul. 4, 1961	Jul. 11, 1961
Rotoiti	4 ft deep	Surface	0.006	2.40	1.04	0.006
		Bottom	0.006	5.20	1.06	0.006
Rotorua	10 ft deep	Surface	0.006	0.68	0.56	0.006
		Bottom	0.006	1.40	0.08	0.014
Rotorua	5 ft deep	Surface	0.006	3.00	0.08	0.006
		Bottom	0.006	5.20	0.28	0.006

* Natural level of arsenic in water.

† Date of application.

(Analyses done by Dominion Laboratory, D.S.I.R.)

The analyses show that the rate of dispersal was rapid and that within 24 hours of application the concentration was about or less than 1 p.p.m. of arsenic. One week after the application the level of arsenic in the water was virtually the pre-spray level.

DIQUAT AND PARAQUAT

Diquat dibromide and paraquat di-(methyl sulphate) have proved very effective in large bodies of moving water, even at cool temperatures. The activity of these materials is such that a specific area of weeds can be controlled in a large tract of water. In lakes their activity is such that under optimum conditions rates as low as 0.05 p.p.m. throughout the entire depth of water may be satisfactory.

For faster moving water, such as streams, 5 to 10 p.p.m. may be necessary. These materials are rapidly absorbed, but in the absence of bright sunlight appear systemic. Diquat dibromide is very safe for fish. Trout were not affected at a concentration of 70 p.p.m. Their rapid breakdown in soil allows these materials to be used for irrigation purposes, but limits their effectiveness in muddy water.

For large bodies of water, the method of application is not important. Aerial distribution has caused the diquat dibromide to disperse more readily to untreated areas than where the material has been injected. This is not a drawback if large areas are to be treated, but is a disadvantage if small areas of several acres are to be treated in large tracts of water.

CONCLUSIONS

- (1) Diquat dibromide and paraquat di-(methyl sulphate) are extremely promising herbicides for the control of floating and submerged aquatics.
- (2) Diquat dibromide is most effective on broad-leaved weeds.
- (3) Paraquat di-(methyl sulphate) is most effective on grass weeds.
- (4) Both materials are effective when applied aerially or by injection.
- (5) Rate of application depends on water movement.
- (6) Neither material is harmful to fish at concentrations effective for aquatic weed control.

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