ENDOTHAL AS AN AQUATIC HERBICIDE

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Summary

Preliminary trial results with liquid and granule formulations of endothal as the disodium salt and as the long chain fatty amine salt against the submerged aquatic weeds *Ceratophyllum demersum*, *Elodea canadensis*, *Potamogeton cheesemanii* and the alga *Nitella hookeri* are presented. The possible effects of the use of these endothal formulations on aquatic plants, fish and other animal life and potable waters are discussed.

INTRODUCTION

AQUATIC WEEDS are becoming a serious problem in New Zealand where they are infesting waters reserved for hydro-electric power generation, recreation, irrigation and drinking supplies. The objective of water weed control measures should seldom be that of total eradication, because aquatic plants have such beneficial functions as aeration of the water, provision of shelter and food for fish and other aquatic organisms, and consolidation of the bed and banks of streams. Partial control by the selective removal of some plants and not others, or by the temporary suppression of all plant growth at certain periods of the year, or more often by a combination of both, is usually more acceptable. Furthermore, the degree to which weeds are to be controlled should depend upon local conditions of land drainage and water use. Chemical weed control is the only method discussed in this paper. However, the other methods of manipulation of the aquatic environment, namely, mechanical and biological control of the undesirable aquatic plants, should also be used in conjunction with chemical treatments to obtain the most economical results.

DESCRIPTION OF WEED SPECIES PRESENT IN TRIALS

The following submerged aquatic weeds were present in the test areas: Hornwort (*Ceratophyllum demersum*; family Ceratophyllaceae) is a rather brittle, dense leafy plant which is without roots. It floats submerged or has stem ends entangled in mud or sunken logs. The ability of hornwort to grow in cold water makes it a potential threat to most lakes and waterways throughout New Zealand. Hornwort, an introduced species, was first noticed at Napier in 1961 and in the Waikato River in 1963. It is now densely present in the dam lakes at Atiamuri, Ohakuri, Whakamaru and Maraetai, and is present in Waipapa and Arapuni. Hornwort infestations are now already the major aquatic weed problem in New Zealand.

Canadian pondweed or oxygen weed (*Elodea canadensis*; family Hydrocharitaceae). Although widely distributed, this well-recognized species

does not pose the threat of hornwort. In fact, it is dominated by both the closely related *Lagarosiphon major*, if present, and hornwort. The filamentous alga stonewort (*Nitella hookeri*; family Characeae) is an unattached submerged plant forming dense, dark green masses in rivers, lakes and streams.

Pondweed (*Potamogeton cheesemanii*; family Potamogetonaceae) has both submerged and floating leaves. It is common in lakes and slow-moving waters where there is some silt on the bottom.

EXPERIMENTAL

Endothal, the main chemical used in these trials, is unlike most other pesticides, since it contains only carbon, hydrogen and oxygen. Overseas, endothal is not employed as the free acid but is formulated for use as a contact aquatic herbicide into aqueous concentrates or impregnated on to clay granules as the sodium, potassium or long chain fatty amine salts. Liquid formulations are applied as concentrates or diluted solutions from spray booms, while granules are normally broadcast. The aim is to obtain a certain concentration of active ingredient throughout the desired treatment depth or plant growth zone.

The endothal formulations used in the present trials were the disodium salt and the cocoamine salt, both formulated as the 5% w/w endothal clay granule (15/30 RVM attapulgate) or as water-soluble liquid concentrates. Two other chemicals were evaluated for comparisons:

- (a) Fenoprop as the butoxyethanol ester formulated as a 4 lb per Imperial gallon emulsifiable concentrate and as a 10% w/w clay granule. Both RVM (quick release) and LVM (slow release) attapulgate clay granules of fenoprop were used.
- (b) Diquat as the standard 2 lb per Imperial gallon liquid formulation.

TRIAL DETAILS

Two trials were laid in the early summer for the control of hornwort and Canadian pondweed. A third trial was laid in late summer for the control of stonewort alga and *Potamogeton* pondweed.

Trial 1

Lake Whakamaru. Treated on 1/10/68

The trial site consisted of a solid mat of floating and submerged hornwort growing in a shallow inlet two feet deep. Unreplicated treatments were applied to plots contained by plastic film enclosures, 5 ft square and 3 ft high, held in place by four corner steel rods and anchored to the bottom. The plots completely enclosed a body of water preventing both dilution of the chemical applied and also weed invasion from outside. Liquid treatments were applied by pouring the diluted chemical over the surface of the enclosed area and granules were evenly spread by a shaker can.

Trial 2

Lake Whakamaru. Treated on 1/11/68

A mat of floating and submerged hornwort plus some Canadian pondweed was present in a shallow inlet two feet deep. Trial procedure was as described for Trial 1.

Trial 3

Hamilton Lake. Treated on 25/2/69

This trial area consisted of a mass of stonewort growing in three feet of water to within one foot of the surface. Patches of *Potamogeton* were present in all plots but the plants showed few surface floating leaves.

Unreplicated treatments were made to plots 200 ft × 200 ft covering nearly one acre. The granules were applied in a double grid fashion with a Seymour granule applicator from a small punt.

All trial evaluations were made by sampling the weed at two water levels: (a) from the surface to a foot depth and (b) up to one foot from the bottom. The ratings were made visually by two independent observers and recorded on the 0 to 10 scale, 0 being the no effect level and 10 indicating complete kill of the plant tissue.

RESULTS

Diquat gave excellent surface kill but insufficient bottom kill of hornwort, possibly owing to its loss of effectiveness through adsorption on the silt (Table 1). As reported by Matthews (1962) for *Lagarosiphon*, diquat has also given excellent initial control of Canadian pondweed (Table 2).

Endothal both as the disodium and cocoamine salts in liquid and granule formulations has shown almost complete surface and bottom kill of hornwort. No real differences between liquid or granule treatments have shown up in these shallow water depths but it is possible that the granule formulation of endothal would be superior in deeper water. Both forms of endothal either as liquid or granule have shown little activity against Canadian pondweed. Endothal cocoamine granules have shown promising results against stonewort (Table 3), an algal problem not controlled by diquat (Leonard and Greenland, 1965).

TABLE 1: TRIAL 1 — CONTROL OF HORNWORT

Treatment (lb/surface acre)		ppm	Hornwort Control (after 30 days)	
			Surface Kill	Bottom Kill
diquat	11.2	2	10	4.5
endothal (cocoamine salt)	11.2	2	10	8.0
endothal-granule (disodium salt)	11.2	2	10	7.5
fenoprop EC	11.2	2	8.5	4.0
fenoprop (RVM granule)	11.2	2	9.5	7.5
fenoprop (LVM granule)	11.2	2	9.5	8.5
endothal (cocoamine salt)	5.6	1	9.5	8.0
fenoprop EC	5.6	1	9.5	5.5
fenoprop (RVM + LVM granule)	5.6	1	9.0	7.5

TABLE 2: TRIAL 2 — CONTROL OF HORNWORT AND CANADIAN PONDWEED

Treatment (lb/surface acre)					ppm	Hornwort Control (after 50 days)	Canadian Pondweed Control	
diquat	....	....	....	....	5.6	1.0	9.0	7.0
endothal (cocoamine salt)	..				5	0.9	7.5	1.5
endothal (cocoamine salt)	....				10	1.8	8.5	1.5
fenoprop EC	....				10	1.8	8.0	3.5
endothal (cocoamine)	5 +							
fenoprop EC (ester)	....				10	0.9 + 1.8	9.5	2.5
endothal (cocoamine)	2.5 +							
fenoprop EC (ester)	....				5	0.45 + 0.9	8.5	2.0
endothal-granule (cocoamine salt)	....				5	0.9	7.0	0.5
endothal-granule (cocoamine salt)	....				10	1.8	9.0	1.5
fenoprop (RVM granule)	....				10	1.8	9.8	1.0
endothal (cocoamine)	5 +							
fenoprop (ester - RVM granule)	....				10	1.8 + 0.9	7.5	1.5
endothal (cocoamine)	2.5 +							
fenoprop (ester - RVM granule)	....				5	0.9 + 0.45	8.3	1.5

TABLE 3: TRIAL 3 — CONTROL OF STONEWORT AND POTAMOGETON

Treatment (lb/surface acre)					ppm	Stonewort Control (after 35 days)	Potamogeton Control
fenoprop	....	....	....	10	0.6	2.5	10
endothal (cocoamine salt)	....	....	....	10	0.6	7.5	10
endothal (cocoamine)	5	+					
fenoprop (ester) - RVM							
granule	....	....	....	10	0.3+0.6	3.0	10

Fenoprop has given adequate surface control of hornwort but only the granule formulation gave acceptable bottom kill. The activity of fenprop against Canadian pondweed has been insufficient compared with diquat. Activity of fenoprop against stonewort has also proved inadequate. On hornwort there has been no noticeable difference between the fast disintegrating and the slow disintegrating granules of fenoprop. The combined granule formulation of endothal and fenoprop was completely effective on *Potamogeton* but less than expected in its activity against stonewort.

DISCUSSION

TOXICITY OF ENDOTHAL TO OTHER AQUATIC ORGANISMS

Disodium endothal has a high level of safety to freshwater fish, with a 48 hour mean tolerance level (for rainbow and brook trout) of more than 100 ppm or fifty times the present test level. Overseas treatments of bodies of water with endothal at dosages required to control aquatic weeds can actually result in an increase of food organisms for bottom-dwelling fish, especially in organisms used as fish food (Walker, 1961, 1963).

Under laboratory test conditions, the toxicity of monofatty amine salt of endothal to fish is 15 to 100 times higher than that of the disodium endothal, though field tests at less than 2 ppm have resulted in no kill of fish in moving water. It has been demonstrated that fish have the ability to detect the presence of the cocoamine salt and will move from treated areas. For maximum safety in the use of endothal cocoamine, it is suggested that no more than 10% of a still water lake should be treated at one time with doses in excess of 1 ppm.

DEGRADATION OF ENDOTHAL

Endothal is rapidly degraded and metabolized in 10 to 14 days by micro-organisms which exist in water or moist soil. A build-up of endothal in the aquatic environment does not occur. The metabolism of endothal by various types of organisms demonstrates that its disappearance from water is by degradation rather than by simple adsorption. This is of vital importance for potable waters, as compounds which are adsorbed and only slowly biodegradable can be subject to desorption under certain conditions, and therefore become available again unchanged.

EFFECT OF WEED BREAKDOWN ON AQUATIC ORGANISMS

In enclosed waters, the decaying vegetation raises the organic matter content, which in turn can decrease the oxygen content, making the water less habitable to fish for short periods. In turn, this raises the chlorine requirements for potable waters and in some cases causes algae bloom to form. Obviously only limited areas of enclosed waters such as shore lines or inlets should be chemically treated at any one time wherever possible.

CONCLUSIONS

There is a definite need in New Zealand for a chemical which could be used in potable waters and reservoirs to control aquatic weeds and algae without adversely affecting humans, fish, wildlife, domestic animals or any other desirable organisms.

Endothal can be considered as a chemical closely approaching these standards. It has shown excellent activity against hornwort. The cocoamine salt has shown promising activity against the hard-to-kill alga stonewort on which diquat is not effective (Matthews, 1962). It appears likely that the major aquatic weed problems of enclosed waters in New Zealand can be effectively controlled safely with a combination of chemicals without serious effect on fish population or potable waters. However, the emphasis should be on early treatment to avoid great masses of decaying organic matter, which by oxygen depletion can cause more toxic effects on fish and other aquatic life than through the toxicity of the herbicides themselves.

Further studies with endothal alone and in combination with diquat are warranted to obtain a more balanced control of mixed aquatic weed vegetation so as to avoid undesirable ecological changes in plant populations.

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