EVALUATION OF ENDOTHALL FOR AQUATIC WEED CONTROL IN NEW ZEALAND

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SUMMARY

The dipotassium salt of endothall showed potential for controlling hornwort (*Ceratophyllum demersum*), curled pondweed (*Potamogeton crispus*), hydrilla (*Hydrilla verticillata*) and lagarosiphon (*Lagarosiphon major*) in New Zealand. Hornwort and curled pondweed were reduced to near zero biomass by 0.5 mg/litre with a 48 h exposure. Hydrilla and lagarosiphon required exposure times of 48 and 22 h respectively at 5 mg/litre for a similar level of control. Canadian pondweed (*Elodea canadensis*), egeria (*Egeria densa*) and the nuisance alga, water net (*Hydrodictyon reticulatum*), were not susceptible within recommended concentrations (0.5 - 5.0 mg/litre) nor were the non-nuisance native, macro-algae, nitella (*Nitella hookeri*) and stonewort (*Chara fibrosa*).

Keywords: endothall, aquatic weeds.

INTRODUCTION

Endothall (7-oxabicyclo [2.2.1] heptane-2, 3-dicarboxylic acid), is a contact membrane active herbicide which contains only carbon, hydrogen and oxygen (Keckemet 1969). It bio-degrades rapidly and completely without any toxic intermediate compounds and does not bind to or leave residues in the hydrosol or accumulate in food chains (Reinert and Rodgers 1987). The dipotassium salt of endothall is marketed as Aquathol K. This formulation is of low toxicity to fish and most other aquatic life with most species tolerant to 100 mg/litre or more (Keckemet 1969; Armstrong 1974; Penwalt 1984). It has been registered in the U.S.A. since 1960 for the control of hydrilla, Eurasian watermilfoil (*Myriophyllum spicatum*) and hornwort. The recommended use rate is from 0.5 to 5 mg/litre.

The only herbicide currently registered for submerged aquatic plant control in New Zealand is diquat, which is used mostly in clear water lakes where the target species are the introduced oxygen weeds, lagarosiphon, Canadian pondweed and egeria. Diquat is of limited use in water with high levels of inorganic suspensoids as it is rapidly bound to clay particles. Endothall is not de-activated by adsorption to suspensoids in turbid water and so could be of use, particularly in situations such as lowland lakes and in drainage systems where waters are often turbid. It may also extend control to weed species such as hydrilla and curled pondweed which are poorly controlled by diquat.

The objectives of the present investigation were to test the effects of the dipotassium salt of endothall on hydrilla and a range of other target and non-target aquatic plants to determine whether it would be potentially useful for weed control in New Zealand. A wide range of concentrations and exposure times were tested to determine which combinations of exposure time and concentration were herbicidal.

METHODS

The species tested were: hydrilla, egeria, lagarosiphon, Canadian pondweed, hornwort, curled pondweed, a stonewort (*Chara fibrosa*), nitella, and the filamentous green alga, water net. Similar sized apical cuttings (c. 150 mm long) of the macrophytes were potted in 450 ml plastic pots filled with topsoil with a sand overlay, with 12 replicates per treatment, and acclimatised in an outdoor tank for about 3 weeks (December/January 1993) before the trials. In the case of water net, 10 g wet weight

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was floated in separate 10 litre plastic tubs, one for each treatment, and the experiment was run inside a glasshouse for quarantine purposes.

A sample of the dipotassium salt of endothall (Aquathol K), liquid concentrate was obtained from the manufacturer. Treated plants were subjected to 0.5, 2.5, 5, 25, and 50 mg/litre for a range of exposure times. Concentrations were maintained by daily replacement of herbicide solutions. Plants were then rinsed and transferred to a large 12 m long x 1.5 m wide x 0.6 m deep culture tank along with untreated controls. The tank was flushed with a 2 litre per minute flow of dechlorinated Hamilton City tap water. Water temperatures ranged from 17 - 25°C, pH was near neutral and the water was soft (less than 20 mg/litre CaCO₃).

The trial was run in January 1993 using concentrations and exposure times (see Fig. 1) which were near the threshold herbicidal rates (predicted from two preliminary trials conducted in April and November 1992). Post-treatment observations of plants were made daily to record symptoms of herbicidal effects, and after 21 days all portions of the plants remaining were recovered and dried to constant weight at 80°C. The treatment was defined as 'controlling' the target species when biomass was reduced to 10% of the pre-trial dry weight.

RESULTS

Initial herbicide effects were seen within 3 days of treatment, with chlorosis causing green plant tissue to fade in colour to a dull grey-green colour. Where symptoms were severe, chlorosis affected most of the plant within 1 week and then plants began to fragment and decay. Re-growth, if any, occurred from sediment level. Where injury was less severe, some chlorotic tissue recovered and growth was evident within 1 week of treatment.

Hydrilla in the untreated control grew rapidly showing a three-fold increase in dry weight during the 3 week trial (Fig. 1A). A number of treatments had increased in dry weight relative to the pre-trial samples, although they were significantly lower than the control (eg. the 5 mg/litre treatments with 3 or 22 h exposure). These treatments exhibited no herbicide injury symptoms. A 48 h exposure at 5 mg/litre was required to control the plant.

Untreated egeria plants more than doubled in dry weight during the trial. Egeria was not susceptible to endothall and showed no symptoms of herbicide damage at recommended concentrations (up to 5 mg/litre). A 96 h exposure at 50 mg/litre was required to control the plant (Fig. 1B).

Untreated lagarosiphon control plants increased by c. 35% in dry weight during the trial. At 5 mg/litre, a 22 h exposure was required to control the plants (Fig. 1C).

Canadian pondweed shoots were prone to fragmentation (including the control), resulting in greater variability in the results. Growth had occurred in the untreated control plants as some new shoots were evident, but the loss of biomass (due to fragmentation) meant that no significant biomass increases were recorded (Fig. 1D). Canadian pondweed was of low susceptibility to endothall requiring 48 h exposure at 50 mg/litre to control it.

Hornwort doubled in biomass in the untreated control during the trial. Hornwort was controlled by endothall within the recommended dose rates using 2.5 mg/litre and an exposure time of 3 hours (Fig. 1E).

Untreated curled pondweed plants grew rapidly, increasing in biomass up to three fold during the trial. Plants were controlled with 48 h exposure at 0.5 mg/litre and 9 h exposure at 2.5 mg/litre (Fig. 1F).

The stonewort showed no significant changes in dry weight or appearance in any of the treatments. The plant exhibited no herbicide injury symptoms even after 96 h exposure at 50 mg/litre (Fig. 1G).

The nitella plants were highly variable in size, and each portion was of low dry weight (being one cell thick). Treatments were therefore assessed qualitatively. No injury symptoms were apparent even at the maximum concentration tested of 50 mg/litre with a 48 h contact time.

Figure 1: The effect of different rates (0.5 - 50 mg/litre) and exposure times of the herbicide endothall on plant biomass of eight aquatic plant species 3 weeks after treatment.

Water net was not affected by endothall at any of the exposure time/concentrations tested even when subjected to 96 h exposure at 50 mg/litre. Untreated controls were not significantly different in dry weight in comparison with other treatments even though they had doubled relative to pre-trial dry weights (Fig. 1H).

DISCUSSION

Hydrilla, hornwort, curled pondweed, egeria and Canadian pondweed are problem weed species common to both the U.S.A. and New Zealand. The present study showed that curled pondweed and hornwort were more susceptible than lagarosiphon and hydrilla and were controlled within the (U.S.A.) label application rates of 3-4 mg/litre (specified for hydrilla) and 2-3 mg/litre (hornwort and curled pondweed) for spot or lake margin treatments.

Hornwort and curled pondweed are commonly occurring weed species in turbid water where endothall has a major advantage over diquat, as it is not affected by turbid water. These two species are listed among the more susceptible species to endothall (Armstrong 1974). Contact times of 9 h for curled pondweed and 3 h for hornwort at 2.5 mg/litre controlled these species in the present study, suggesting that endothall could readily control these species in New Zealand. Woon and Mason (1969) also reported control of hornwort in Lake Whakamaru (New Zealand) using the disodium salt of endothall, which has similar herbicidal properties to the dipotassium endothall salt tested in the present study (Armstrong 1974).

The concentration and exposure time relationship for hydrilla in the present study was similar to a U.S.A study reported by Netherland *et al.* (1991) in which a 48 h exposure was required at 5 mg/litre endothall, to result in a near total loss of biomass. Variability in field efficacy for hydrilla has been reported (Price 1969; Reinert and Rodgers 1986; Westerdahl 1983) and attributed to slow plant uptake rates requiring long exposure times to achieve adequate levels of control. Such long contact times are not readily achievable without total water body treatment or treatment of large sheltered areas of weed beds. Dissipation rates of water soluble herbicides are dependent on wind generated currents, extent of weed beds and relative size of treated area. Initial concentrations of 5 mg/litre applied to lakes can be reduced to 0.01 mg/litre within 48 h (Westerdahl 1983; Armstrong 1974). In order to achieve extended contact times the granular formulation or the use of a polymeric carrier such as Nalquatic would be recommended for field trials on hydrilla and lagarosiphon. Alternatively the amine salt of endothall is reported to have greater efficacy, though it has a much reduced safety margin for fish (Blackburn *et al.* 1971). Lagarosiphon (not tested in the U.S.A.) was only slightly more susceptible to endothall than hydrilla so similar difficulties are likely to be encountered in achieving adequate exposure times.

Egeria, Canadian pondweed, stonewort, nitella and water net have not previously been reported as susceptible species, and were confirmed to be resistant to endothall in the present study. Canadian pondweed is known to metabolise endothall more rapidly than susceptible species (Keckemet 1969) and this ability could account for its greater resistance to endothall. The lack of efficacy recorded for non-target species such as the stonewort and nitella is a desirable property. These low growing species generally do not cause weed problems. The lack of endothall efficacy for egeria would limit its usefulness in lakes where egeria is a major weed species. For example, Lake Rotorua has extensive weed beds dominated by egeria (Wells and Clayton 1991) and it is possible that use of endothall could even enhance the success of egeria by removing competing species.

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