

# CONTROL OF HORNWORT (*CERATOPHYLLUM DEMERSUM*)

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## Summary

Trials conducted over the period February 13, 1967 to March 30, 1969 have indicated excellent control of hornwort (*Ceratophyllum demersum*) can be achieved with diquat at 2 ppm when maintained for a contact period of 30 minutes and at 0.5 ppm when applied to static water as a surface application. The cocoamine salt of endothal when maintained for a contact period of 30 minutes at 3 ppm and at 3 ppm when applied to static water as a surface application and the disodium salt of endothal at 3 ppm, when applied as a surface application to static water, whereas no control was achieved with this material at 3 ppm when maintained in contact for 2 hours. In trials where hornwort was exposed after lowering of the water level, diquat at 1 and 2 lb a.i. per acre has given excellent control whereas little or not control was achieved with the ester of 2,4-D at 8 lb, the amine salt of 2,4-D at 8 lb and fenoprop ester at 4 lb, all materials being applied as a spray application. The technique of exposing hornwort and allowing natural dehydration to effect a kill has given excellent control provided adequate hot dry conditions are available to achieve complete dehydration.

## INTRODUCTION

Hornwort (*Ceratophyllum demersum*) is a free-floating species, no roots are present, and no permanent anchorage is necessary for growth. It is known to become attached to bottom mud and entangled in lake obstructions, and it grows with equal vigour in sluggish back-waters and moderate currents.

First recorded in New Zealand at Napier (R. Mason, pers. comm.) and in the Waikato River Hydro Lake Ohakuri in 1963, where by blocking the water intake screens it was directly responsible for a major power disruption; since this unwelcome introduction it has appeared downstream, affecting other hydro stations in varying degrees. Its known distribution at present is restricted to the Napier and Waikato River areas.

## METHODS

Hornwort, being a free-floater and not restricted by permanent anchorage, presented many difficulties experimentally. Techniques adopted for this series of trials were:

- (1) Clear 0.005 polyfilm plots of 8 ft square where applied chemical is restricted within the enclosure. Visual assessment only.

- (2) Times by rates trials using weighed amounts of weed maintained in contact with chemicals contained within plastic containers. After a predetermined time limit, samples are washed clean and returned to the lake anchored in Netlon nylon mesh bags. Assessment is by weighing remaining weed after a sufficient time lapse for all likely reaction to be completed.
- (3) Exposed weed trials. This technique involves exposing weed by lowering the water level and relying on either a surface application of chemical or natural dehydration for control.

## RESULTS

### TRIAL 1

Sited at Atiamuri Hydro Lake. Polyfilm type plot, size 8 ft × 8 ft. Water depth 6 ft. Water temperature 1 ft below surface, 66° F. Treatments applied February 13, 1967. Two replicates.

| <i>Treatments</i><br>(ppm) |      |      |      |      |                        |
|----------------------------|------|------|------|------|------------------------|
| diquat 0.5                 | .... | .... | .... | .... | on one acre-foot rate  |
| diquat 1.0                 | .... | .... | .... | .... | on one acre-foot rate  |
| diquat 2.0                 | .... | .... | .... | .... | on one acre-foot rate  |
| diquat 0.5                 | .... | .... | .... | .... | throughout water depth |
| Control                    |      |      |      |      |                        |

Hornwort at time of treatment was vigorous and varied from visible on surface growth to 2 ft below the water surface. Hornwort was the predominant species with all plots supporting some Canadian pondweed (*Elodea canadensis*) and *Lagarosiphon major*. The trial was observed at intervals over an 11-month period. Within 8 days of treatment, a severe depression of hornwort was visible with the main mass of plants suppressed to the bottom at all treatment rates. While 0.5 and 1.0 ppm on top acre-foot had suppressed hornwort, plants remained green, 2.0 ppm on top acre-foot and 0.5 ppm, throughout water depth had resulted in a more severe check with 20% of foliage already decomposing. *Lagarosiphon major* and Canadian pondweed had been severely affected by all treatments with decomposition already well advanced. By 4 months the effects of treatments were fully apparent with decomposition complete in some plots; 0.5 ppm on top acre-foot had given plants a severe check. However, recovery was evident with some growth up to 2 ft; 1.0 ppm on top acre-foot had also given a severe check, eliminating a considerable amount of plants. However, on remaining plants green shoots were observed; 2.0 ppm on top acre-foot and 0.5 ppm throughout water depth had resulted in a 100% clearance. *Lagarosiphon major* and Canadian pondweed had been eliminated by all treatments.

By 9 months after initial treatment, the trend observed at the 4-month stage was still very much in evidence. However, plants that were only slightly affected were making good recovery.

A final assessment at 11 months indicated that at 0.5 ppm on top acre-foot rate hornwort had made good recovery and was identical to control; at 1.0 ppm on top acre-foot rate, there was 20% of hornwort visible. These had recovered from the depression effects and were in a healthy

condition. Although this treatment rate resulted in a partial clearance only, remaining plants were severely affected and probably would require a further season to reach their former density. Both the 2.0 ppm on top acre-foot rate and 0.5 ppm throughout water depth remained clear.

#### TRIAL 2

Sited at Atiamuri Hydro Lake. Polyfilm type plot, size 8 ft × 8 ft. Water depth 6 ft. Water temperature 1 ft below surface, 70° F. Treatments applied February 7, 1968. Two replicates.

| <i>Treatments</i><br>(ppm) |                        |
|----------------------------|------------------------|
| cocoamine salt of endothal | throughout water depth |
| disodium salt of endothal  | throughout water depth |
| diquat 2                   | on one acre-foot rate  |
| Control                    |                        |

Hornwort growth was vigorous and up to the surface in all plots. Within 20 days all treatments were relatively clear of hornwort with bottom decomposition well advanced, although a small percentage of green foliage was present. All treatments were expected to give 100% control eventually. Owing to the lowering of the lake level soon after these observations were made, no further assessment was possible.

#### TRIAL 3

Sited at Ohakuri Hydro Lake. Water temperature, 65° F. Weight of weed sample used, 400 grams. Treatments applied December 2, 1967. Final assessment made in 45 days. Two replicates.

| <i>Treatments</i><br>(ppm) | <i>Time Samples</i><br><i>Immersed</i><br>(min) | <i>Final wt. of Remaining</i><br><i>Plant Material</i><br>(g) |
|----------------------------|---|---|
| diquat 1.0                 | 15  | 270   |
| diquat 2.0                 | 15  | 145   |
| diquat 1.0                 | 30  | 329.5   |
| diquat 2.0                 | 30  | 0   |
| diquat 1.0                 | 60  | 0   |
| diquat 2.0                 | 60  | 0   |
| diquat 1.0                 | 120   | 0   |
| diquat 2.0                 | 120   | 0   |
| Control                    |   | 550   |

TRIAL 4

Sited at Ohakuri Hydro Lake. Water temperature, 72° F. Weight of weed sample used, 230 grams. Treatments applied December 12, 1967. Final assessment made in 55 days. Two replicates.

| <i>Treatments<br/>(ppm)</i> | <i>Time Samples<br/>Immersed<br/>(min)</i> | <i>Final wt. of Remaining<br/>Plant Material<br/>(g)</i> |
|-----------------------------|--|--|
| diquat 0.2                  | 15   | 485 aA   |
| diquat 0.5                  | 15   | 470 aA   |
| diquat 0.2                  | 30   | 465 aA   |
| diquat 0.5                  | 30   | 490 aA   |
| diquat 0.2                  | 60   | 435 aA   |
| diquat 0.5                  | 60   | 110 bB   |
| diquat 0.2                  | 120  | 385 aA   |
| diquat 0.5                  | 120  | 0  |
| Control                     |  | 501 aA   |
| Interaction                 |  | 5% significant   |
| CV                          |  | 16.6%  |

TRIAL 5

Sited at Ohakuri Hydro Lake. Water temperature, 65° F. Weight of weed sample used, 230 grams. Treatments applied January 16, 1968. Final assessment made in 47 days. Two replicates.

| <i>Treatments<br/>(ppm)</i> | <i>Time Samples<br/>Immersed<br/>(min)</i> | <i>Final wt. of Remaining<br/>Plant Material<br/>(g)</i> |
|-----------------------------|--|--|
| diquat 0.2                  | 15   | 238 abAB   |
| diquat 0.5                  | 15   | 292 aAB  |
| diquat 0.2                  | 30   | 272 aAB  |
| diquat 0.5                  | 30   | 315 aA   |
| diquat 0.2                  | 60   | 334 aA   |
| diquat 0.5                  | 60   | 332 aA   |
| diquat 0.2                  | 120  | 285 aAB  |
| diquat 0.5                  | 120  | 145 bB   |
| Control                     |  | 277 aAB  |
| Interaction                 |  | 5% significant   |
| CV                          |  | 16.0%  |

TRIAL 6

Sited at Ohakuri Hydro Lake. Water temperature, 68° F. Weight of weed sample used, 230 grams. Treatments applied February 6, 1968. Final assessment made in 55 days. Two replicates.

| <i>Treatments<br/>(ppm)</i>     | <i>Time Samples<br/>Immersed<br/>(min)</i> | <i>Final wt. of Remaining<br/>Plant Material<br/>(g)</i> |
|---------------------------------|--|--|
| disodium salt of<br>endothal 3  | 30   | 440  |
| cocoamine salt of<br>endothal 3 | 30   | 0  |
| paraquat 2                      | 30   | 95   |
| diquat 2                        | 30   | 0  |
| disodium salt of<br>endothal 3  | 30   | 450  |
| cocoamine salt of<br>endothal 3 | 60   | 0  |
| paraquat 2                      | 60   | 0  |
| diquat 2                        | 60   | 0  |
| Control                         |  | 437.5  |

In making final assessments of these times by rates trials, all excess water was drained from samples for approximately 4 minutes before recording weights. This procedure was also used in preparing samples for treatment.

The significant factor from these trials is that hornwort requires to be in contact with diquat for a specific period for effective control to be achieved. Endothal (cocoamine salt) appeared to be an active material and good control was achieved at low contact times. However, it was noted in a further observational trial that this material was affected by low water temperatures and very little control was noted at a temperature of 55° F.

Paraquat appeared a little less active than diquat and did not warrant further assessment. Endothal (disodium salt), although giving good control when maintained within a polyfilm enclosure, gave no control at 3 ppm when maintained for one hour and this material would be of use only in static water conditions.

EXPOSED WEED TRIALS

All treatments in the following trials are expressed in terms of lb a.i./acre and were applied by normal spray application using F.154 jets at 20 gal/acre.

TRIAL 7

Sited at Atiamuri Hydro Lake. Treatments applied August 21, 1968.

| Treatments<br>(lb) | Final Samples Taken |        | wt.                              |
|--------------------|---------------------|--------|----------------------------------|
|                    | Same day            | 4 days | 8 days after<br>Treatment<br>(g) |
| BLOCK A            |                     |        |                                  |
| 2,4-D ester .... 4 | 238                 | 103    | 80                               |
| 2,4-D ester .... 8 | 95                  | 80     | 65                               |
| 2,4-D amine .... 4 | 63                  | 87     | 60                               |
| 2,4-D amine .... 8 | 66                  | 63     | 78                               |
| diquat + .... 1    | 0                   | 0      | 4                                |
| Agral L-N .... 2   | 0                   | 0      | 0                                |
| Control ....       | 50                  | 143    | 238                              |
| BLOCK B            |                     |        |                                  |
| 2,4-D ester .... 4 | 74.5                | 60.5   | 47                               |
| 2,4-D ester .... 8 | 117                 | 83.5   | 10.5                             |
| 2,4-D amine .... 4 | 42.5                | 64.0   | 63.5                             |
| 2,4-D amine .... 8 | 39.5                | 36.5   | 11                               |
| diquat + .... 1    | 0                   | 0      | 0                                |
| Agral L-N .... 2   | 0                   | 0      | 0                                |
| Control ....       | 77                  | 76.5   | 69                               |

The lake level was lowered as a normal hydro operation and not principally for weed control.

The weather conditions over the 11-day trial period were those of a typical cool August with rain recorded on 5 days and totalling 1.82 in. Minimum temperature recorded was 28.3° F and maximum 61° F. No record of sunlight was taken. Weed samples taken were of 200 g and were assessed after being returned to the lake for approximately 3 months. Block A was located in an area shaded by overhanging trees. Block B was in an area of maximum sunlight. Notable features from this trial are the very low order of control achieved with the 2,4-D formulations even at the high rates employed, the excellent control achieved with diquat, and the ability of hornwort to withstand a period of exposure even when subjected to maximum sunlight conditions encountered over this August period.

TRIAL 8

Sited at Atiamuri Hydro Lake. Treatments applied to Blocks A and B on January 16, 1969, were diquat plus Agral L-N at 0.5, 1.0 and 2.0 lb and fenoprop ester at 2.0 and 4.0 lb.

The lake was lowered specifically for hornwort control.

The weather conditions over the 16-day trial period were hot and dry with rain recorded on 5 days and totalling 0.86 in. The minimum temperature recorded was 41.8° F and maximum 82.5° F. No record of sunlight hours was taken. Weed samples taken were of 200 g and were assessed after being returned to the lake for one month. Block A was established on an area where maximum drying conditions were expected. Block B

was close to the water edge with hornwort remaining initially a little damp. However, later in the trial period, dry conditions prevailed at this site. The trial was established 3 days after the lake water level was lowered and results indicated rapid dehydration of hornwort had already commenced with no significant differences showing up in Block A. However, in Block B where conditions were a little more damp, diquat appeared the most active material. Further samples were taken on the 8th day after lake lowering. Hornwort by now was in an advanced stage of dehydration and, although samples were immersed in the lake, no growth resulted and all samples disintegrated. It is apparent that, provided adequate hot dry conditions prevail, exposing hornwort to natural drying conditions is an effective control measure.

### CONCLUSIONS

These trials have shown there are three methods available for control of hornwort:

- (1) Chemical control of weed in water.
- (2) Chemical control of exposed weed in damp situations.
- (3) Exposing to natural dehydration.

(1) Diquat by its consistent performance and relatively non-toxic nature appears the most useful of the chemicals tested. For areas where water movement is present, rates of 2 ppm maintained for a contact period of 30 min could be expected to give good control. For areas where static water conditions prevail, 0.5 ppm throughout water depth has given good control.

(2) For treating areas of exposed weed remaining damp diquat at rates of 1 and 2 lb has given good control.

(3) By lowering water level, provided hot dry conditions prevail, natural dehydration is an efficient method of control.

It appears that, with the situations that prevail in the Waikato hydro lakes, a combination of techniques would be the most likely method to achieve maximum control.

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