CONTROL OF SUBMERGED WEEDS IN FLOWING WATER USING VISCOUS GEL DIQUAT

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SUMMARY

Aqueous diquat and a range of viscous formulations of diquat were applied to submerged weeds growing in flowing water. No effective control was achieved with small plot treatments. This was attributed to rapid dilution effects. Lethal herbicidal effects were achieved when larger 50 m sections of stream were treated using gel diquat formulations.

INTRODUCTION

Diquat was first used for submerged weed control in 1961 in Lake Rotorua, New Zealand, and generated considerable overseas interest (Anon 1962). Although successful weed control has been reported for flowing water (Matthews 1963), normal application techniques have not enabled sufficient concentration or contact times to be achieved (Robson 1968). This has led to recommendations that diquat be used in non-flowing waters but not in flowing water (Holm and Yeo 1980).

Barrett (1978) reported aqueous diquat failed to control submerged weeds in flowing water even when released over a 40 min. period. Controlled release over 120 mins. caused only slight damage. Effective control was achieved when alginate diquat (a viscous sinking gel) was applied to flowing water, even with flows up to 80 cm/sec.

Clayton and Tanner (1982) reported that viscous diquat was able to overcome aerial drift of fine spray, improve placement accuracy, and extend the depth of submerged weed control. These trials were in lakes where water was near motionless. There are extensive drainage weed problems in N.Z. and drainage boards are often required to exercise strict control over the growth of submerged weeds in their streams, rivers and drains. Since submerged weeds in flowing water often prove difficult and costly to control, an investigation was initiated on the effectiveness of gel formulations of diquat in flowing water.

DIQUAT FORMULATIONS

Aqueous diquat (Reglone) was used directly and with additions of gelling agents. The viscosity of viscous formulations was adjusted by varying the addition rate of gelling agents to form products which could be exuded as solid stream jets and which formed discrete strings or droplets when applied to water. Aqueous diquat was diluted 1:1 with tap water and added rapidly with agitation to the gelling agent powders wetted with propane-1,2-diol or glycerol. All viscous formulations used therefore comprised 10% solutions of diquat.

A guar gum formulation was prepared using Burtonite V7E at 12.5 g/litre and a carboxymethyl cellulose (CMC) formulation prepared using Nymcel ZYF90 at 19 g/litre. Two viscous sodium alginate diquat formulations were used, PP100 an experimental product developed by ICI Plant Protection Division (UK) and Torpedo a similar product prepared in New Zealand and recently released onto the local market. Calcium sequestering agents have been deleted from the latter formulation because of the predominance of soft waters in New Zealand.

A visco-elastic formulation was prepared by addition of a poly-carboxylate polymer additive Nalquatic G2026 at 20 mls/litre. This product is presently unavailable in New Zealand.

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METHODS

A preliminary trial was carried out in February, 1983 in the Whangape stream, a turbid slow flowing (approximately 0.1 m/sec) stream in the lower Waikato basin. Five metre square plots containing dense growths of egeria (*Egeria densa*) were sprayed at a rate of 2 g ai/m² with either aqueous, viscous CMC, viscous alginate (PP100), viscous guar gum or visco-elastic diquat formulations using a forced displacement, air pressurised (150 kg f/m²) vessel to deliver a premeasured volume through a 1 mm open orifice nozzle onto the water surface. Plots were spaced approximately 50 m apart in areas of similar flow, plant height and density. Results were visually assessed 5 weeks after spraying.

Later trials were performed in the Te Mata stream, a small clear stream with a flow rate of 0.2-0.35 m/sec, situated near Raglan. In mid March 1984 five metre sections of the stream spaced at least 50 m apart were sprayed with either aqueous, viscous alginate (Torpedo), viscous guar gum or visco-elastic diquat formulations. The stream was approximately 2 m wide and 1 m deep in the area sprayed and supported dense growths of lagarosiphon (*Lagarosiphon major*). Each formulation was applied to the water surface of two plots at the rate of 1 g ai/m² using 50 ml plastic syringes.

In early April 1984 three 50 m sections of the Te Mata stream, spaced 400-500 m apart were sprayed at the same rate with either aqueous, viscous alginate (Torpedo) or viscous guar gum diquat. These were applied using a hand-pumped backpack sprayer fitted with a 1 mm open orifice nozzle. Results in both the Te Mata stream trials were checked 2 weeks after spraying and final assessments made after 6 weeks. In all trials weed beds immediately upstream of treated sites were used as controls.

RESULTS

Only minimal herbicidal effects, restricted largely to terminal shoot apices, were noted in treatments applied to small plots in the Whangape and Te Mata streams. Such effects were concentrated on the downstream margin of sprayed plots and up to 5 m downstream. Differences between replicates in the Te Mata stream were as great as differences between treatments. Small patches of lethal effect were apparent in some treatments where factors such as plant density, and channel morphology minimised water movement.

Major herbicidal effects were however noted in treatments applied to 50 m sections of the Te Mata stream. Tissue chlorosis, areas of rotten tissue and leaf loss were apparent in downstream sections of sprayed plots and in extensive areas immediately below them after 2 weeks. After 6 weeks complete weed bed collapse had occurred in downstream sections of sprayed plots and for up to 150 m downstream. The successfully treated sections subsequently showed significantly lower water levels at standard flows as a result of reduced resistance to flow.

The herbicidal effects of gel diquat formulations were minimal in upstream sections of plots but increased markedly downstream (Table 1). Areas of lethal effect were often interspersed with areas of sublethal effect in upstream sections of the plots and in downstream areas outside the plots. Maximum effects appeared to coincide with the edges of channels and the exposed edges of bends. Below the treated plots dense weed beds separated from the main channel, especially in the lee of bends, often showed reduced or negligible effects.

The unforeseen extent of sublethal effect downstream from the sprayed plots (in excess of 500 m) resulted in an overlap of effect between the viscous guar gum diquat treatment and the aqueous diquat treatment. Consequently the herbicidal effects noted in the latter treatment could not be attributed entirely to the diquat formulation applied to it. At this stage it is not possible to make valid comparisons between the viscous formulations.

TABLE 1: Herbicidal effects within and downstream of two 50 m sections of the Te Mata stream sprayed with different viscous formulations of diquat at 1 g ai/m².

Diquat Formulation	Herbicidal effects* within 10 m sections of sprayed plots (numbered from upstream end)					Extent of downstream herbicidal effects (m)		
	1	2	3	4	5	major	moderate	minimal
Na-alginate	0	a	b	c	c	100	200	400 +
Guar gum	a	b	c	c	c	150	300	500 +

* Herbicidal scores

0 - no effect discernable

a - minimal (low incidence of apical effect)

b - moderate (sublethal - majority of apices and some stems affected)

c - major (collapse and disintegration of weedbeds)

DISCUSSION

Failure of aqueous diquat to control weeds in flowing water has generally been attributed to insufficient contact time being achieved (Barrett 1981). Preliminary indications from trials in controlled climate environs suggest that a minimum contact time of 50 minutes is required to achieve lethal herbicidal effects of lagarosiphon at a concentration of 1 mg/litre at 20 °C. This can be difficult to achieve in lakes even during favourable spraying conditions, and almost certainly accounts for the frequent failure of aqueous diquat to control submerged weeds in flowing water.

Further experimental results from the controlled climate environs indicate that very low concentrations (eg. 0.005 mg/litre) can still achieve equivalent herbicidal effectiveness, provided contact time is extended. The addition of gelling agents to diquat not only has the affect of retaining or localising the placement of diquat, but also causes diquat to be released slowly from the gels as they dissolve. This presumably results in low concentrations of diquat being released over the targeted area for a sustained period of time and can thereby achieve an extended contact time. Barrett (1981) concluded that in flowing water alginate diquat released diquat over a period exceeding 120 mins.

The failure of our small 5 m plot treatments using gel diquat, would appear to be attributable to rapid dilution resulting in inadequate concentrations being achieved. This would also be true for the upper regions of the larger 50 m treatments. Although the release rate of diquat from gels is not dependent on plot size, the treatment of larger plots would result in an accumulative increase in diquat concentrations in the lower reaches of the treatment area and immediately downstream.

Treatment of long reaches of flowing water might best be achieved by taking into account downstream drift effects, particularly when the full width of a channel is to be treated. This may allow a reduction in the amount of gel diquat to be used by reducing the areas sprayed to intermittent treatment sections which are interspersed with larger untreated sections.

The trials on the Te Mata stream demonstrated that effective weed control could be achieved in flowing water. A length of around 1.5 km was treated for a chemical cost of around \$10. Application is simple requiring only a backpack sprayer and could be achieved with minimal labour costs. The same section of Te Mata stream has previously been mechanically cleared of weeds at a cost of around \$2,000 every 18 months (G. Vernon pers comm).

In conclusion it would appear that gel diquat formulations can be used to control submerged weeds in flowing water, and have potential application in drains, streams and rivers. Control is extended beyond the area treated on account of downstream drift. Gel diquat has the potential advantages of reducing control costs and mechanical disruption from over-deepening and widening of channels.

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