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Diquat and Sodium Alginate for Weed Control in Rivers

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INTRODUCTION

In many situations it is necessary to control aquatic weeds in rivers, however, it is frequently undesirable to kill all the weeds. Some form of partial control can often solve the problem caused by the weeds while leaving untreated areas as a habitat for fish and wildlife. Traditionally, partial or localized control of river weeds has been achieved by hand-cutting, a method with high labor costs and short term effects. Herbicides can be used for localized control in flowing water but only against emergent or floating weeds where the chemical can be applied as a spray on to the exposed foliage. Herbicides have not been used successfully for localized control of submersed weeds in rivers because, when added to the water, the herbicide is rapidly dispersed and removed from the intended treatment area.

One way to overcome this problem is to 'stick' the herbicide to the weeds and a technique has been described by Barrett (1). The herbicide diquat dibromide is mixed with a solution of sodium alginate and the resultant viscous solution can be poured, or injected directly onto weeds where it will stick, even in fast flowing water. The alginate reacts with calcium ions to form a gel, from which diquat gradually diffuses and is rapidly absorbed by the weed bed on to which it is sticking. The rate at which the diquat leaves the alginate depends on several factors, one of which is surface to volume ratio of the alginate strings sticking to the weed beds. This ratio varies in each situation as the force of water acting on the weed bed tends to stretch and flatten the alginate strings. Thus, it is difficult to determine the rate of release of the diquat from the alginate. The purpose of these experiments was to compare the effects of diquat released from alginate strings with known exposure periods to the aqueous formulation of diquat dibromide.

METHODS AND MATERIALS

Three experiments were carried out in the River Eden in Cumbria, England. The river in the region of the experiments is 50 to 100 m wide with a depth of up to 1.5 m. The dominant weed species in the river are *Ranunculus fluitans* Lam. and *Ranunculus penicillatus* (Butcher) C D K Cook. The experiments were conducted during periods of low water in June 1977 (experiment II) and June 1978 (experiments I and III). The discharge of the river was approximately 7 m^3/s at the time of treatments and the maximum water velocity measured was 0.8 m/s. The calcium content of the water was fairly stable during low water at a level of 25 ± 3 mg/l.

The treatments were applied to individual beds of *R. fluitans* which were selected for uniformity of size and growing conditions (depth of water, velocity, etc.). The weed beds were chosen so that water passing through a treated bed would also flow through a number of beds of *R. fluitans* or *penicillatus* downstream, but would not come in contact with other treatments.

The formulation of diquat/alginate was the same as used in previous experiments (1) containing diquat dibromide 100 g/l cation, sodium alginate 30 g/l and calcium citrate 2 g/l. The treatments involving aqueous solutions of diquat dibromide were prepared by diluting the formulated product Reglone, (registered trademark, ICI Plant Protection Division), with river water.

TREATMENTS

Experiment I Instant Application

1. 100 g diquat (cation) in 1 liter sodium alginate solution applied to the leading edge of a weed bed.
2. 100 g diquat (cation) diluted to 5 liters and poured on to the leading edge of a weed bed.
3. 100 g diquat (cation) in 1 liter sodium alginate and diluted to 5 liter with river water and poured on to the leading edge of a weed bed.

Experiment II 40 min Application

1. 100 g diquat (cation) in 1 liter sodium alginate solution applied to the leading edge of a weed bed.
2. 100 g diquat (cation) diluted to 5 liters with river water and released through a capillary tube on to the leading edge of a weed bed for 40 mins.

Experiment III 120 min Aplication

1. 100 g diquat (cation in 1 liter sodium alginate solution applied to the leading edge of a weed bed.
2. 100 g diquat (cation) diluted to 10 liters with river water and released through a capillary tube on to the leading edge of a weed bed for 120 min.
3. 100 g diquat (cation) in 1 liter sodium alginate diluted to 10 liter with river water and released through a capillary tube on to the leading edge of a weed bed for 120 min.

The treatments in experiments I and III were replicated twice, and in experiment II the treatments were replicated

three times. The techniques used for applying the herbicides were the same as those described by Barrett (1).

Treatment effects were assessed visually by two independent observers and the results were averaged.

Effects on downstream weed beds were recorded as presence or absence of a visible effect as there was considerable variation in the density and distribution of weed beds between replicates and no attempt was made to quantify the degree or area of weed control.

RESULTS AND DISCUSSION

Treatment I (100 g diquat cation in 1 liter sodium alginate solution) which is common to all three experiments always produced the same effect (Table 1). The treated weed bed was completely destroyed and no regrowth occurred during the two months while observations continued. Additionally, in all treatments a channel was cleared through downstream weed beds. In one treatment this channel could be detected for over 40 m but in other treatments shading or increased water depth reduced the weed population beyond 10 to 20 m downstream so that the length of channel could not be determined accurately.

TABLE 1. THE EFFECT OF 100 G DIQUAT CATION IN 3 FORMULATIONS ON WEED BEDS TWO WEEKS AFTER TREATMENT.

Treatment	Experiment I[a] instant application	Experiment II 40 min.	Experiment III 120 min.
1. Diquat + alginate 3%	4+	4+	4+
2. Diquat + water	0	0	1
3. Diquat + alginate (diluted)	0	not included	3+

[a] (0 = no visible effect, 4 = complete removal of weed bed, + indicates the presence of an effect on weed beds downstream.

Treatment 2 (100 g diquat cation as aqueous solution) produced no detectable effect either on the treated bed or on those downstream when applied instantly (experiment I), or over 40 min (experiment II). When the diquat was released for 120 min (experiment III) there was very slight damage to a few stems on the treated weed bed but there was no detectable effect on weeds downstream.

Treatment 3 (100 g diquat cation in sodium alginate diluted to 5 liters and 10 liters in experiment I and III respectively) produced no effect when poured instantly on to the weed beds (experiment I), but was almost as effective as the more viscous alginate solution when released over 120 min. It gave almost complete control of the treated weed bed and produced a channel which could be detected for about 30 m in one replicate and about 15 m in the other.

There was no variation in the scores of the two observers except for the diluted diquat/alginate treatment in experiment III when a variation of $\pm$ 1 occurred.

In all three experiments the viscous diquat-alginate treatments completely controlled the weed beds on to which they were placed, possibly because the alginate held a high concentration of diquat against the stems on to which it was sticking. It is unlikely, however, that the alginate was touching every stem in the bed, and it was not touching the stems of weed beds growing downstream which were also killed. This suggests that the diquat was gradually released from the alginate over a longer period than the 120 min. which was tested with the aqueous diquat treatments. The diluted diquat-alginate solutions were not effective when added instantly to the water, but when applied over 120 min, they were nearly as effective in controlling the treated weeds and some downstream beds as the more viscous solutions. Even in very dilute concentrations, alginate forms a 'floc' in the presence of calcium ions and it is possible that this floc retained the diquat in the vicinity of the plants for a sufficiently long enough time to increase uptake by the weeds compared with the aqueous diquat formulation.

Observations on the weed beds were continued for two months after treatment during which time no improvement in the degree of control by the aqueous diquat formulations was noted and the slight damage which was caused by the 120 min exposure disappeared. During this time, there was no regrowth of the plants treated with the viscous diquat-alginate (treatment 1) although there was some regrowth in the beds treated with diluted formulation (treatment 3) which damaged the weeds without completely controlling them.

Observations on the invertebrate fauna living on the treated weed beds were made by scientists of the North West Water Authority using drift nets located immediately downstream of the beds. Although not conclusive, these data indicate little or no acute toxic effect on these animals during the 24 hr period following treatment.[1] The decomposition of the dead weeds must, however, result in a loss of habitat for some of these animals which will drift downstream. As the technique described allows weeds to be controlled in localized areas where clear channels of open water are required, the invertebrates and fish fry will be able to find an alternative habitat in untreated weed beds.

These experiments indicate that by using alginate as a carrier for diquat, it is possible to achieve localized control of weeds in fast flowing water in a way which may be acceptable even in areas where high water quality and conservation interests are important.

LITERATURE CITED

1. Barrett, P. R. F. 1978. Some studies on the use of alginates for the placement and controlled release of diquat on submerged aquatic plants. Pestic. Sci. 9:425-433.

[1]Report ref. BN34 (4/79). Investigation of possible acute effects of the aquatic herbicide diquat alginate on the benthic invertebrate community downstream of a river treatment trial. North West Water Authority, London Road, Carlisle.