

Evaluation of Fluridone for Weed Control in New Zealand

R. D. S. WELLS, B. T. COFFEY AND D. R. LAUREN¹

ABSTRACT

The efficacy of the herbicide fluridone was evaluated using cultured lagarosiphon (*Lagarosiphon major* (Ridley) Moss), elodea (*Elodea canadensis* Michaux), egeria (*Egeria densa* Planchon), hydrilla (*Hydrilla verticillata* Royle), eel grass (*Vallisneria gigantea* Graebner), curled pondweed (*Potamogeton crispus* L.), hornwort (*Ceratophyllum demersum* L.), and salvinia (*Salvinia molesta* Mitchell). Trials conducted in spring, summer and autumn examined the effects of fluridone on plant growth at concentrations ranging from 0.003 to 100 mg/l. A 48% aqueous suspension and a 5% pellet formulation were tested. Regardless of its formulation, at 1 mg/l, fluridone produced a marked albescence in growing tissues, but this transient symptom had little effect on plant growth. At 10 mg/l there was still little herbicide damage to older plant tissue but in the 100 mg/l treatment fluridone was an effective herbicide. The efficacy of fluridone on lagarosiphon in laboratory tests at 1 mg/l was affected little by temperatures of 10 C and 28 C, pHs of 4 and 10, or by maximum noon-day light levels of 200 $\mu\text{E m}^{-2} \text{s}^{-1}$ and 2000 $\mu\text{E m}^{-2} \text{s}^{-1}$ P.A.R.

Key words: Sonar, herbicide screen, efficacy, chemical control, light, pH, temperature.

INTRODUCTION

Fluridone, the chemical (1-methyl-3-phenyl-S-[3-trifluoromethyl]phenyl]-4 (H)-pyridinone) was developed as a pre-emergence herbicide for weed control in cotton (3, 13). It was subsequently reported to be of high post-emergence activity against a wide range of aquatic vascular plants (1, 6, 11, 12) continuing to provide excellent control of weeds at levels as low as 0.03 mg/l (8). Limited translocation of fluridone has been reported in aquatic plants (9) and it appears to interfere with the synthesis of RNA, proteins and carotenoid pigments (2, 3, 14). It is a slow acting herbicide, taking 4 to 6 weeks to totally control susceptible aquatic plants (5), but this may be advantageous as no significant reduction in oxygen levels has been recorded following treatment (1, 8, 10).

Efficacy claims have not been substantiated by workers such as Docheretz and Frank (4), who working in California, reported on the basis of greenhouse studies with elodea and two 3 species of *Potamogeton* that fluridone did not appear to be promising as a post-emergence herbicide for control of aquatic weeds. More recently Hall and Westerdahl (7) could not achieve 100% control of hydrilla with fluridone at 20 mg/l and 12 weeks continuous exposure.

¹Technical Officer and Scientists, Ruakura Agricultural Research Centre, New Zealand Ministry of Agriculture and Fisheries, Private Bag, Hamilton, New Zealand.

Fluridone was submitted to the New Zealand Pesticides Board in 1981 for registration as an aquatic herbicide. This paper presents results on the efficacy of fluridone in controlled artificial environments for likely target species in New Zealand.

METHODS

Trials were conducted in outdoor tanks where the effects of herbicide concentration and contact time were described in relation to visual symptoms and growth of experimental plants relative to control plants. Similarly sized apical stem sections or when appropriate, whole plants, were collected from field populations and planted individually in 350 ml plastic pots filled with washed sand. Thirty-five representatives of each species were placed in 1000 l outdoor tanks covered with 92% neutrally absorptive shade cloth. The water was continuously mixed by injecting a 5 l/minute air flow into each tank. The plants were acclimatised for 2 weeks, then 20 plants of each species (5 from each tank) were dried at 80 C in a forced air oven to constant weight. These weights were used as estimates of the initial equivalent dry weights of those replicates used in the trials.

Trial 1 started in March (late summer) 1980. A 48% aqueous suspension of fluridone was added to give absolute levels of 0.01, 0.1 and 1.0 mg/l in the treated tanks. No fluridone was added to the control tanks in any of the trials. The plants tested in this trial were lagarosiphon, egeria, vallisneria, curled pondweed and hornwort.

Trial 2 began in November (late spring) 1981. A 48% aqueous suspension of fluridone was added to the treated tanks to give 0.1, 1.0, 10 and 100 mg/l (Note: The 100 mg/l level is well in excess of the reported solubility of fluridone which was 12 mg/l (5)). This trial tested lagarosiphon, egeria, elodea, hydrilla and salvinia.

Trial 3 commenced in April (autumn) 1983. A 5% pellet formulation was ground to a powder and used to provide four dose rates which were determined by analysis to be 0.003, 0.03, 0.3 and 1.7 mg/l. Lagarosiphon, egeria, elodea and vallisneria were used in this trial. The concentration of fluridone in each tank was monitored for the duration of the trial by collecting six water samples from each tank on day 0 (after fluridone was added), 5, 10, 20, 40, and 60. Each sample was analysed individually using direct HPLC analysis (16) with UV detection at 240 nm.

The trials ran for 60 days during which the visual symptoms of herbicide damage were monitored. After 60 days the total stem length of each of 20 representatives of each species in each treatment were measured. The plants were then processed individually to determine their final dry weights. The remaining plants were transferred to

fluridone-free water so that their recovery potential could be assessed

A series of complementary experiments considered the efficiency of fluridone in relation to temperature, pH and light intensity. Lagarosiphon was used as the test species as it was found to be a relatively sensitive plant to fluridone in trial 2. Sixteen, 10 l containers were filled with a 50 mm layer of sand and 9 l of water. Five stem sections of lagarosiphon were planted in each of the 12 tanks and five additional representatives were dried and used as equivalent dry weight estimates of the starting material. Two tanks were subjected to each set of conditions described in Table 1. All plants except those in the high light treatment were irradiated for a 12 hour day at a constant $200 \mu E m^{-2} s^{-1}$ P.A.R. using truelite fluorescent light tubes. The high light treatment was sunlight (through glass) which provided a maximum noon-day intensity of $2000 \mu E m^{-2} s^{-1}$ P.A.R. The pH 10 treatment was maintained using a boric acid/KCl buffer and pH 4 with $NaHOP_4 \cdot 2H_2O / KH_2PO_4$ buffer. The temperatures were achieved by maintaining the tanks in a cool room and using 150 watt aquarium heater/thermostat units to heat the water to the required temperatures. The plants were acclimatised for 2 weeks then one tank in each condition was dosed with fluridone (48% aqueous suspension) to give 1 mg/l. The treatments were maintained for a further 40 days after which the plants were processed for their final dry weights.

RESULTS AND DISCUSSION

Fluridone produced chlorotic apices in all plants tested at concentrations of 0.01 mg/l and above (Table 2). As the concentrations of fluridone increased so did the extent of apical damage. There were few symptoms seen in mature tissues at concentrations up to 10 mg/l, and then only lagarosiphon lost some mature leaves in the 10 mg/l treatment (Table 2). All plants subjected to the 100 mg/l level, which represented a saturated fluridone solution with approximately 88 mg/l excess solid phase added, were dead and decomposing within 40 days of treatment. Much of the formulation remained in suspension affecting water clarity while some settled as a layer covering the plants. The fine coating of fluridone appears to have had herbicidal activity. This would account for the greater control achieved with fluridone in excess of its solubility. Hall and Westerdahl (7) using a "diluter" system also estimated the threshold level for control of Eurasian milfoil (*Myriophyllum spicatum*) was between 10 and 20 mg/l, the later treatment also being in excess of the reported solubility of fluridone.

The effects of fluridone on plant growth, quantified as changes in total stem length of photosynthetic (green) tissue and whole plant weights are in agreement with the herbicide scores presented in Table 2. In all concentrations up to and including 10 mg/l, none of the plants decreased in length or dry weight relative to their pre-trial estimates, with the exception of lagarosiphon dry weights in the 10 mg/l treatment (Figure 1 c). When compared with their respective controls, some plants showed both loss of dry weight and total stem length reductions (eg. hydrilla and lagarosiphon (Figure 1 a & c), some were affected in only one of these parameters (eg. egeria, Figure 1 b), while

TABLE 1. CONDITIONS OF PH, TEMPERATURE AND LIGHT INTENSITY IMPOSED ON 10 l CONTAINERS EACH GROWING 5 LAGAROSIPHON PLANTS. A CONTROL (NO FLURIDONE) AND A 1 MG/L FLURIDONE TREATMENT WERE SUBJECTED TO EACH CONDITION.

Condition	pH	Temp C \pm 2	Max. light intensity ($\mu E m^{-2} s^{-1}$ P.A.R.)
1	7	20	200
2	7	20	2000
3	7	28	200
4	7	10	200
5	4	20	200
6	10	20	200

TABLE 2. EVALUATION OF THE HERBICIDAL EFFECTS OF FLURIDONE AT VARIOUS CONCENTRATIONS ON A NUMBER OF AQUATIC PLANTS AFTER 60 DAYS.

	Fluridone concentrations mg/l								
	0.003	0.01	0.03	0.1	0.3	1.0	1.7	10	100
TRIAL 1									
lagarosiphon	—	1	—	1	—	2	—	—	—
egeria	—	1	—	1	—	2	—	—	—
vallisneria	—	1	—	1	—	2	—	—	—
curled pondweed	—	1	—	1	—	2	—	—	—
hornwort	—	1	—	1	—	1	—	—	—
TRIAL 2									
lagarosiphon	—	—	—	2	—	3	—	4	5
egeria	—	—	—	2	—	2	—	2	5
elodea	—	—	—	1	—	2	—	3	5
hydrilla	—	—	—	1	—	2	—	2	5
salvinia	—	—	—	1	—	2	—	2	5
TRIAL 3									
lagarosiphon	0	—	1	—	1	—	3	—	—
egeria	0	—	1	—	1	—	3	—	—
elodea	0	—	1	—	2	—	2	—	—
vallisneria	0	—	1	—	1	—	2	—	—

¹Herbicide scores: 0 = No effect, 1 = Chlorotic new growth, 2 = Some necrosis in young leaves, 3 = Necrotic apices, 4 = Some necrotic mature leaves, 5 = Plant kill.

others were not affected (eg. elodea, Figure 1 d). The data set for all species in all three trials showed that fluridone had no greater efficacy than that illustrated for lagarosiphon in Figure 1 c. Fluridone was not an effective herbicide in any of the treatments up to and including the 10 ppm treatment. It had only slight effects on plant growth even at concentrations well above the dose rate of 0.08 ppm and within the time frame of 4-6 weeks recommended by the Elanco Products Company (5). Plants transferred to fluridone-free water recovered quickly with much of their chlorotic tissue regaining its green colour.

The analytical data collected in trial 3 indicated that the rate of fluridone decay in the experimental tanks was slow. More than 50% of the initial dose remained in all samples taken from the treated troughs at the end of the trial (Figure 2). The lack of efficacy seen in these trials was therefore not due to a loss of herbicide.

Trials 1, 2, and 3 were conducted outside in temperatures from 12-32 C using water of neutral pH and low mineral content. Fluridone efficacy was not improved in

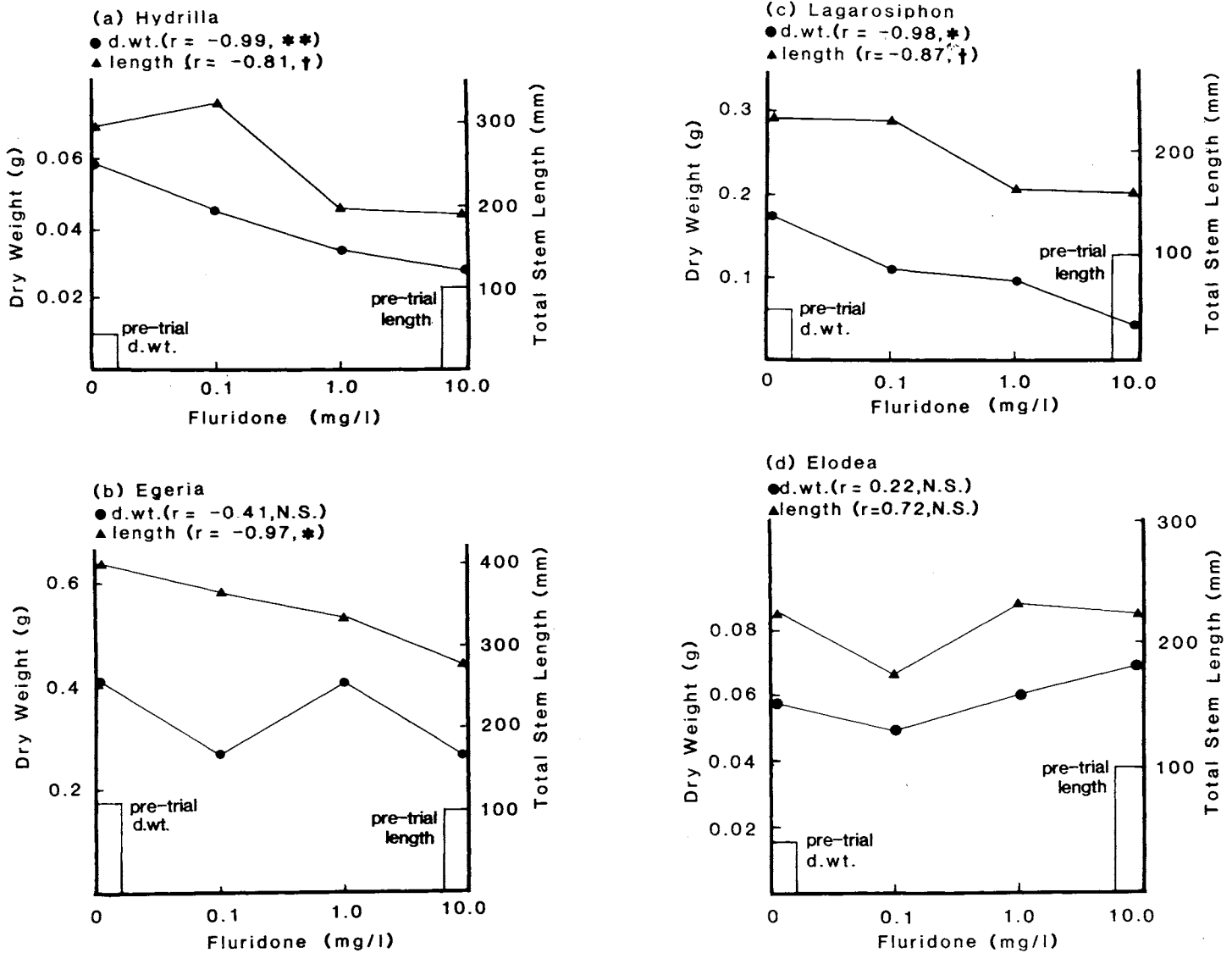


Figure 1. The effect of fluridone on growth of (a) hydrilla (b) egeria (c) lagarosiphon and (d) elodea after 60 days exposure. Values given are the means of pre-trial dry weights, end of trial dry weights and total stem lengths ($n = 20$). Correlations with the linear regression are given (4 data points only).

laboratory tests in which temperatures of 10 and 28 C, pHs of 4 and 10, and light intensities of 200 and 2000 $\mu E m^{-2} s^{-1}$ were considered 1 (Figure 3). These results suggest that the temperatures, pH and light levels of most of New Zealand's aquatic environments would be unlikely to improve the efficacy of fluridone.

The results of the artificial environment studies have been supported more recently by the results from three New Zealand field trials in which lagarosiphon, elodea, egeria, hornwort, pondweed species, milfoil species and charophytes were treated (15). Fluridone has not been effective in controlling a wide range of troublesome aquatic weeds in New Zealand. It is of low herbicidal activity and is therefore unlikely to be registered as a broad spectrum aquatic herbicide for use in this country.

ACKNOWLEDGMENTS

We wish to thank Mr. G. Clout of Elanco Products (NZ) and Co. for his close cooperation, Dr. J. E. Waller for statistical analyses, Mr. M. P. Agnew for chemical analyses and the staff of the Aquatic Plant Section, Ruakura for their assistance.

LITERATURE CITED

1. Arnold, W. R. 1979. Fluridone—A new aquatic herbicide. *J. Aquatic Plant Manage.* 17:30-33.
2. Bartels, P. G. and C. W. Watson. 1978. Inhibition of carotenoid synthesis of fluridone and norflurazon. *Weed Sci.* 26:198-203.
3. Berard, D. F., D. P. Rainey, and C. C. Lin. 1978. Absorption, translocation and metabolism of fluridone in selected crop species. *Weed Sci.* 26:252-254.

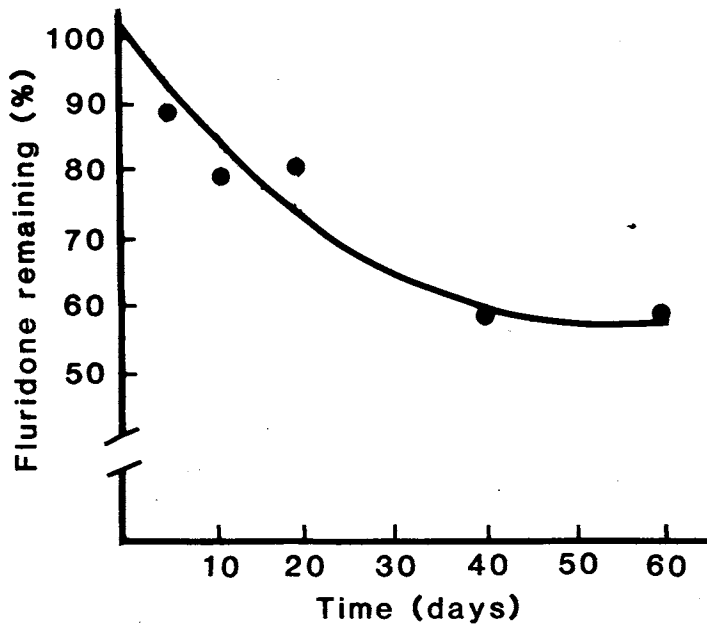


Figure 2. Fluridone remaining in treated 1000 l plant culture tanks expressed as a percentage of initial concentrations. Data are mean percentages of all treatments.

- Dechoretz, N. and P. A. Frank. 1978. Evaluation of velpar, butidazole, and fluridone for the control of aquatic weeds. Proc. West Soc. Weed Sci. 31:111-116.
- Elanco. 1981. Sonar. Technical Manual, Elanco Products Company.
- Grant, D. L., L. C. Warner, W. R. Arnold and S. D. West. 1979. Fluridone for aquatic plant management systems. Proc. South Weed Sci. Soc. 32:293-297.
- Hall, J. F. and H. E. Westerdahl. 1983. Evaluation of *Myriophyllum spicatum* and *Hydrilla verticillata* growth response when exposed to continuous, low concentrations of fluridone. Proc. 36th Ann. Meeting, Southern Weed Sci. Soc.:341.
- McCowen, M. C., C. L. Young, S. D. West, S. J. Parka and W. R. Arnold. 1979. Fluridone, a new herbicide for aquatic plant management. J. Aquat. Plant Manage. 17:27-30.
- Marquis, L. Y., R. D. Lomes and C. P. Yang. 1981. Absorption and translocation of fluridone and glyphosate in submersed vascular plants. Weed Sci. 29:229-236.
- Parka, S. J., S. R. Arnold, M. C. McCowen and C. L. Young. 1978. Fluridone: A new herbicide for use in aquatic weed control systems. Proc. EWRS 5th Symp. on Aquatic Weeds:179-187.
- Rivera, C. M., S. D. West and J. Perez. 1979. Fluridone: An experimental herbicide for aquatic plant management systems. Proc. 32nd West. Soc. Weed Sci.:67-73.
- Sanders, D. R., R. M. Theriot, W. R. Arnold and S. D. West. 1979. Evaluation of two fluridone formulations for the control of hydrilla in Gutan Lake, Panama Canal Zone. U.S. Army Engineer Waterways Experimental Station.
- Thompson, L. G. and M. D. Hammond. 1978. Fluridone, a new broad spectrum cotton herbicide. Proc. West. Soc. Weed Sci. 31:130-132.
- Waldrep, T. W. and H. M. Taylor. 1976. 1-methyl-3-phenyl-5-[3-(trifluoromethyl) phenyl]-4 (1H)-pyridinone, a new herbicide. J. Agric. Food Chem. 24:1250-1251.
- Wells, R. D. S. and B. T. Coffey. 1984. Fluridone—Lake Efficacy Trial. Proc. 37th N.Z. Weed and Pest Control Conf.:42-45.
- West, S. D. and S. J. Parka. 1981. Determination of the aquatic herbicide fluridone in water and hydrosol: effect 12 of application method on dissipation. J. Agric. Food Chem. 29:223-226.

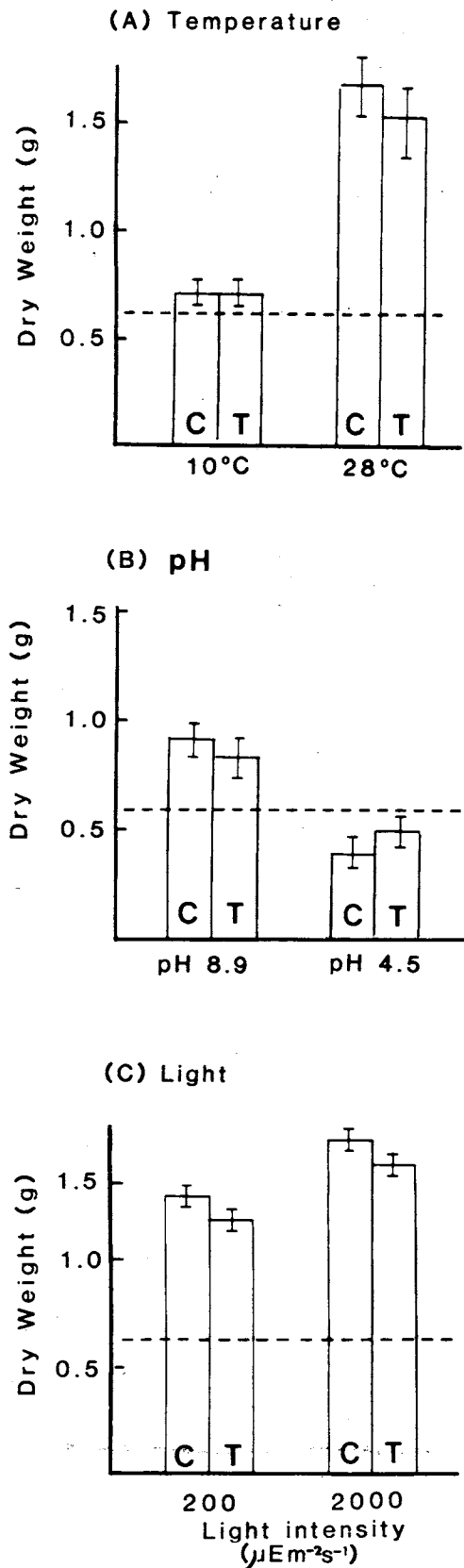


Figure 3. The effect of fluridone on the growth of lagarosiphon at different temperatures (a), pH (b) and light intensities (c). Mean dry weights shown are for 5 plants recovered 40 days after dosing with fluridone to give a 1 mg/l treatment. C = control, T = treated with herbicide, --- indicates pre-trial dry weights and I = standard deviation.