Haller, W. T., A. M. Fox, and C. A. Hanlon. 1992. Inhibition of hydrilla tuber formation by bensulfuron. J. Aquat. Plant Manage. 30:48-49 (note).

Haller, W. T., J. L. Miller, and L. A. Garrard. 1976. Seasonal production and germination of hydrilla vegetative propagules. J. Aquat. Plant Manage. 14:26-29.

Netherland, M. D., W. R. Green, and K. D. Getsinger. 1991. Endothall concentration and exposure time relationships for the control of Eurasian watermilfoil and hydrilla. J. Aquat. Plant Manage. 29:61-67.

SAS Institute Inc. 1988. SAS/STAT® User's Guide, Release 6.03 Edition. Cary, NC:SAS Institute Inc. 1028 pp.

Van, T. K., W. T. Haller, and L. A. Garrard. 1978. The effect of day length and temperature on hydrilla growth and tuber production. J. Aquat. Plant Manage. 16:57-59.

Van, T. K. and V. V. Vandiver. 1992. Response of monoecious and dioecious hydrilla to bensulfuron methyl. J. Aquat. Plant Manage. 30:41-44.

J. Aquat. Plant Manage. 30: 58-62

Improving Herbicide Efficacy in Spring-Fed Tidal Canals by Timing and Application Methods

ALISON M. FOX AND W. T. HALLER

ABSTRACT

Over a three year period starting in 1987, endothall, rhodamine WT dye and herbicide/dye combinations were applied to tidally influenced canals for aquatic weed control in Crystal River, Florida, in addition to an operational mechanical harvesting program. Applications were accomplished using unweighted-hoses, long weighted-hoses and granules at different times of year, when dye half-lives (indicating rates of water exchange) in the canals varied from 11 to 120 hours. Placement of dye or herbicides by weighted-hoses and granules near the bottom of the canals in summer and winter conditions, reduced rates of dye or herbicidal tidal dilution out of the canals and increased their theoretical contact time with hydrilla (*Hydrilla verticillata* (L.f.) Royle.). Comparison of hydrilla regrowth following herbicide application or mechanical harvesting showed that herbicide treatments usually provided acceptable weed control for at least twice as long as mechanical harvesting.

Key words: Hydrilla, water exchange, rhodamine WT dye, regrowth, endothall, mechanical harvesting.

INTRODUCTION

Research has been conducted in the freshwater, tidally influenced Three Sisters canals of Crystal River, Florida, since 1987 to determine factors such as tides, vegetation density, water temperature, etc. that may have caused unpredictable results in the use of herbicides for control of hydrilla (Fox et al. 1988, 1989, 1991a, and 1991b). A total of 24 rhodamine WT dye treatments were made, with and without concurrent herbicide applications, to three canals under the various conditions outlined above. Rhodamine WT was found to be stable under conditions in the canals (Fox et al. 1991b) so that reductions in its concentration (measured in half-lives) were used to estimate rates of water exchange over several tidal cycles. It was determined that water exchange in these three canals was nearly identical and that they could be used as replicates to compare different herbicide application conditions and methods (Fox et al. 1988).

Patterns of tidal water circulation are driven by differences in temperature from water surface to canal bottom and in relation to groundwater temperatures. Fastest rates of water exchange occur in the summer with dye half-lives of <25 hours, followed by winter conditions with dye half-lives of 25 to 60 hours, and rates are slowest during fall and spring isothermal conditions with dye half-lives of 70 to 120 hours (Fox et al. 1991a). After developing a model which effectively predicted rates of water exchange based on standardized bottom water temperature data in the canals (Fox et al. 1991a), previous dye and herbicide application results were reviewed.

The longer a herbicide is in contact with target vegetation, the more likely acceptable weed control will be achieved. Netherland et al. (1991) showed under laboratory conditions that the minimum contact time for endothall (the dipotassium salt of 7-oxabicyclo[2,2,1]heptane-2,3-dicarboxylic acid) required to achieve >85% hydrilla biomass reduction was 24 hours, at a concentration of 3 mg l^{-1}, the maximum rate permitted for use in Florida. Thus, it appeared that if uniformly diluted in the water column, endothall (the primary herbicide permitted in Crystal River) would not be effective in the summer due to its short retention time in the canals. Results of endothall applications during fall isothermal conditions, however, were found to be predictable and effective (Fox et al. 1991b).

The objective of this study was to investigate different herbicide application techniques using treatments of dye, or dye plus herbicide combinations, to determine whether herbicide placement in specific areas of the canals could increase contact time with the target weeds. Results from these studies were then compared to the standard methods of herbicidal and mechanical management of hydrilla previously used in these canals.

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MATERIALS AND METHODS

Dye application and measurement. The Three Sisters Canals in Crystal River were described in detail by Fox et al. (1991a). The 420 m long dead-end canals have mean depths of 2 m and are influenced by a tidal range of up to 1.5 m. Each specific canal-treatment was indicated by the canal name (A, B or C) and a subscript denoting the number of times dye treatments had been applied to the canal (e.g. A_3 = third treatment in canal A).

Liquid rhodamine WT was applied from four hoses trailing behind an airboat, which were either "unweighted-hoses", between 0.5 to 1.0 m long, or were 4 m long "weighted-hoses". Each weighted-hose ended with a 0.5 m long lead-filled pipe, at the top of which were the holes from which the tank mix was pumped. The weighted-hoses dragged along the canal bottom while the unweighted-hoses tended to ride over the vegetation. Rhodamine WT 'granules' were prepared in a similar manner to the granular formulation of endothall, with 1 liter of dye per 45 kg of clay. All dye (liquid or granular) applications were made at low tides, at rates estimated to achieve an average dye concentration of $10\ \mu g\ l^{-1}$ throughout the canal volume at the subsequent high tide.

Dye concentrations were measured on high tides, at four sampling stations evenly spaced along the center of a canal using a continuous-flow field fluorometer (Fox et al. 1991a). Water was fed into the fluorometer by a submersible bilge pump that could be lowered to the desired water depth. Samples were collected at 0.5 m depth intervals from the bottom to the water surface. Water temperature, measured by a thermistor attached to the pump, was recorded and the appropriate temperature correction made to each dye reading (Smart and Laidlaw 1977).

Dye half-lives were calculated from $\log_e$ transformed dye concentrations averaged in the whole canal using a linear regression model as described by Fox et al. (1991a). Comparisons between treatments were made by analysis of variance (SAS general linear procedures model), with significant differences between treatments identified by interactions where $P < 0.05$.

Dates and conditions of treatments in each canal up to A_9, B_3 and C_6 were listed by Fox et al. (1991a). On July 31, 1989 canal A was treated with dye granules (A_{10}) and canal C with dye applied using weighted-hoses (C_7). Dye half-lives for these treatments were compared with an unweighted-hose treatment (C_4) made in June 1988 under similar dense-vegetation, spring-tide, summer conditions. On February 27, 1990 canals A, B, and C were treated simultaneously with granules, unweighted- and weighted-hoses respectively. These treatments (A_{12}, B_4 and C_8) under densely-vegetated, neap-tide winter conditions were compared.

Standardized bottom water temperatures (daytime canal bottom temperatures averaged from the four transects over three days) were calculated for treatments A_{10}, A_{12}, B_4, C_7 and C_8, and half-lives were predicted for these treatments using the model developed by Fox et al. (1991a). Confidence intervals (95%) were calculated for the predicted half-lives, for comparison with the measured values.

Herbicide application and evaluation. Liquid endothall was applied from weighted- and unweighted-hoses, and the granular formulation was applied with a spreader, as described for rhodamine WT. These applications were at rates calculated to achieve 3 mg l^{-1} a.i. endothall at high tide. Herbicide treatments were part of the operational hydrilla management program for the Three Sisters canals. Records of all herbicide and mechanical harvesting treatments between July 1987 and June 1990 were provided by the Citrus County Aquatic Services Division.

The impacts of various management methods on hydrilla density were estimated by fathometer tracings taken along the centers of the canals before and at intervals after treatment. The area of each fathometer tracing filled by vegetation was estimated as a percentage of the total area of each longitudinal-section (Fox et al. 1991a).

RESULTS AND DISCUSSION

Comparisons of dye retention times between treatment methods. The use of weighted-hoses and granules in summer and winter significantly prolonged dye half-lives compared to unweighted-hose treatments (Table 1).

Predicted dye half-lives based on standardized bottom water temperatures (Table 1) indicated half-lives that would have been expected for treatments A_{10}, A_{12}, B_4, C_7 and C_8 had unweighted-hoses been used. The actual half-life of the unweighted-hose treatment C_8 was well within the 95% confidence range of the predicted half-life. Actual half-lives for both weighted-hose treatments (B_4 and C_7) and the summer granule treatment (A_{10}) were significantly different from their predicted values. The actual half-life

TABLE 1. COMPARISON OF ACTUAL DYE HALF-LIVES (t½) WITH THOSE PREDICTED FOR UNWEIGHTED-HOSE TREATMENTS UNDER THE SAME CONDITIONS OF STANDARDIZED BOTTOM WATER TEMPERATURES (TEMP). ACTUAL t½ WITHIN A SEASON OR APPLICATION METHOD ARE SIGNIFICANTLY DIFFERENT FROM EACH OTHER UNLESS BOTH VALUES MARKED BY *.

Application method	Canal	Temp (C)	Predict t½[a] (hr)	Range of 95% C.I.[b]	Actual t½ (hr)
			Summer		
Unweighted-hoses	C_4	24.2	–[c]	–[c]	24.7
Weighted-hoses	C_7	25.6	7.2	2.4 - 21.4	43.9*
Granules	A_{10}	26.5	3.0	0.8 - 10.6	82.7*
			Winter		
Unweighted-hoses	C_8	21.2	54.2	29.9 - 98	42.2
Weighted-hoses	B_4	20.9	49.1	18.9 - 89	97.7*
Granules	A_{12}	21.6	61.7	34.1 - 111.8	111.5*

[a] If temp > 23.3 C then Log_e (t½) = 27.1 - 0.98 × temp.
if temp < 23.3 C then Log_e (t½) = -2.9 + 0.33 × temp.
Regression equations from Fox et al. (1991a).
[b] 95% confidence intervals.
[c] Data used to produce predictive model.

for the winter granule treatment (A_{12}) was at the upper 95% confidence limit of its predicted value.

Comparisons between the seasons for weighted-hose and granule treatments (A_{10} compared with A_{12}) and (C_7 compared with B_4) were not significantly different, unlike the seasonal variation found between unweighted-hose treatments (Fox et al. 1991a). This lack of seasonal differences in dye retention time for these application methods showed that it was possible to overcome the effects that the most significant environmental influence (i.e. water temperature regime) had on herbicide retention in these canals.

Effects of application method on dye placement. Dye applied in granules or, especially, with weighted-hoses, remained at highest concentrations at the bottom of the water column. This often resulted in extreme differences in dye concentration within just a few centimeters depth at the bottom of the water column. An example is presented in Table 2 of how localized high dye concentrations could become and remain, particularly within the bottom 0.5 m of the water column, after the dye application with weighted-hoses B_4. Dye concentrations were determined from 0.25 m above the bottom for only a few sampling times so these data were not included in the half-life calculations or comparisons, but might need to be considered in future placement studies.

Considering summer and winter data only, analyses of variance comparing dye concentrations (averaged over transects and time) between the top and bottom halves of the water column showed significant vertical differences for all but treatment A_{10}. The top/bottom ratios for these average concentrations (Table 3) had been found for unweighted-hose treatments to all be > 1 in the summer (average = 3.1), indicating higher dye concentrations in the top half of the water column. The reverse (values all < 1, average = 0.63) was observed in the winter (Fox et al. 1991a).

The summer granule treatment A_{10} had a top/bottom ratio of 1.26, which was shown by analysis of variance not to be significantly > 1, and was significantly lower than all summer half-lives resulting from applications using unweighted-hoses (outside the 95% confidence interval, Table 3). The summer weighted-hose treatment C_7 had a completely reversed vertical distribution of dye with a top/bottom ratio of 0.60.

TABLE 2. EXAMPLES OF VERTICAL DISTRIBUTIONS OF DYE CONCENTRATIONS FROM SIMULTANEOUS TREATMENTS MADE WITH THREE APPLICATION METHODS ON FEBRUARY 27, 1990, TO CANALS A, B AND C. ALL DATA FROM TRANSECT 1 TAKEN 54 HOURS AFTER TREATMENT.

	Dye Concentration (µg l⁻¹)		
Height above canal bottom (m)	Granules A_{12}	Weighted-hoses B_4	Unweighted-hoses C_8
3.5	0.9	0.7	0·5
3.0	0.9	0.7	0.5
2.5	1.1	0.7	1.1
2.0	1.9	0.9	2.7
1.5	4.2	1.6	3.2
1.0	6.5	3.2	4.2
0.5	7.1	24.5	4.2
0.25	10.5	28.4	–

TABLE 3. RATIOS OF DYE CONCENTRATIONS (AVERAGED OVER ALL TRANSECTS AND SAMPLING TIMES) FROM THE TOP AND BOTTOM HALVES OF THE WATER COLUMN (T/B RATIO).

Summer		Winter	
Canal	T/B ratio	Canal	T/B ratio
Unweighted-hoses			
A_1	4.68	A_4	0.71
A_2	5.63	A_9	0.39
A_6	1.72	B_2	0.78
A_7	1.73	C_2	0.75
B_1	2.24	C_6	0.75
C_3	2.00		
C_4	4.11		
Average	3.08	Average	0.63
95% C.I.[a]	± 1.31	95% C.I.	± 0.24
		C_8	0.60
Weighted-hoses			
C_7	0.60	B_4	0.34
Granules			
A_{10}	1.26[b]	A_{12}	0.38

[a] 95% confidence intervals.

[b] Only treatment where no significant difference between average top and bottom dye concentrations in analysis of variance.

The winter treatment applied with unweighted-hoses, C_8, had a top/bottom dye ratio (0.60) that fit well into the winter pattern of vertical dye distribution (Table 3). The use of granules and weighted-hoses exaggerated this distribution further with top/bottom dye ratios of 0.38 and 0.34 respectively, both of which were significantly less than the winter, unweighted-hose average. The only other comparable ratio (0.39) was for unweighted-hose treatment A_9 which had the coldest standardized bottom water temperature (19.2 C) and shortest winter dye half-life (26.6 hrs).

The contrasting summer and winter patterns of vertical dye distribution were presented by Fox et al. (1991a) as evidence to support their temperature-driven water circulation model. In that study, winter treatments had low top/bottom ratios, which were associated with low standardized bottom water temperatures and short half-lives (e.g. A_9, C_6). Winter weighted-hose and granule treatments (B_4 and A_{12}) resulted in top/bottom ratios similar to A_9 but were not associated with such low temperatures or short half-lives. These results support the suggestion that dye distributions arising from weighted-hose and granule application methods do not conform to the thermally-influenced, water circulation model of Fox et al. (1991a). It appeared that by placing the dye at the bottom of the water column the weighted-hose and granular application methods reduced the influence of the water circulation patterns on dye dilution rates.

Dye half-lives were calculated from the whole canals in these studies, rather than from different depths, because such data can be most readily compared between treatment methods and conditions. Such relative comparisons are the primary objective of these studies because dye half-lives indicate the maximum potential retention time of a herbicide, which may be significantly longer than an actual herbicide half-life. Unlike endothall, rhodamine WT is a fairly inert and stable compound in aquatic environments. Over a short period of time, dye and endothall half-lives may be similar (Fox and Haller 1990), but endothall is removed from water relatively quickly by microbial decomposition. Thus over several days the half-life of endothall may be considerably shorter than rhodamine WT, the discrepancy increasing as retention time lengthens.

Efficacy of herbicide treatments. Vegetation density data from canals A, B and C collected between July 1987 and June 1990 were compiled with all records of operational management. Data pertinent to the longevity of management methods have been summarized in Table 4. The incomplete nature of this table indicates the influence of the operational weed control program on these treatments. Unweighted-hose treatments in the fall, when dye half-lives had been greater than 70 hours were consistently successful over the three years so it was considered unnecessary to try weighted-hoses or granules at this time. No unweighted-hose treatments were made in the summer when dye half-lives were < 24 hours because these would have wasted herbicide with ineffectual weed control.

Various assumptions had to be made to estimate longevity of control shown in Table 4, because fathometer tracings were not always collected regularly enough to show when the effects of a treatment had been outgrown. It was assumed that:

1) when a canal had vegetation in 80% of its longitudinal section the effects of previous weed control treatments were considered to have ended,
2) harvesting indicated that regrowth had reached 80% of the canal section, i.e. end of the previous treatment,
3) when treatments were applied prior to a re-establishment of at least 80% vegetation (e.g. 11 Oct 1989, canal C) the time at which regrowth from the previous treatment would have reached 80% was projected from the latest vegetation estimates and approximate rates of regrowth for that season (determined from fathometer records in other canals or years).

TABLE 4. WEEKS OF HYDRILLA CONTROL AFTER MANAGEMENT, LISTED BY SEASON AND AVERAGED PER METHOD.

Application method	Summer	Fall	Winter	Spring
Unweighted-hoses	–	19[a]	11[b]	9.5
Weighted-hoses	22[d]	–	14	11
Granules	10	–	–	12[c]
Harvesting	4	10[e]	9	5.5

[a] Average of 16, 16, 23, 16.5, 25[d].
[b] Average of 14, 8.
[c] Average of 12.5, 11.
[d] Canal re-treated before regrowth had reached 80% vegetation, longevity of original treatment projected from regrowth rate estimates.
[e] No fall harvesting data, estimate projected from regrowth based on assumptions in text.

Herbicides provided longer hydrilla control than mechanical harvesting within the same season (Table 4). Endothall treatments made with unweighted-hoses were very effective in the fall although there was some variation between canals and years. Weighted-hose and granule treatments provided longer-term weed control than unweighted-hose treatments in the other seasons. Ten weeks after the weighted-hose treatment in the summer of 1989, canal C was retreated when the vegetation comprised only 49% of the longitudinal fathometer tracing. A projection of regrowth in the fall from the original treatment indicated that the overall effect of the summer application might have lasted for a further 12 weeks, making this a highly effective treatment.

The longevity of the effects of management techniques will depend not only on the initial efficacy of hydrilla removal, but also on the rate of regrowth. In the relatively constant temperatures of these spring-fed canals, rates of hydrilla growth are probably as much influenced by seasonal changes in daylength as by temperature variations. Differences in the longevity of control provided by harvesting reflect seasonal variations in regrowth rates, since the initial efficacy of harvesting does not vary with season. If the longevity of control resulting from herbicide treatments was not proportional to harvesting values, this indicated that the season, or application method, had an influence on the initial treatment efficacy. For example, regrowth after the summer, weighted-hose treatment of endothall in canal C (C_7) would have been expected to be rapid after the initial removal of plant biomass. The longevity of hydrilla control after this treatment indicated that the placement of the herbicide at the plant bases may have severely disrupted the ability of the hydrilla to regrow from surviving stems.

An important consequence of these dye and herbicide studies has been that management practices in these canals are now more predictable and the limitations of each technique better understood. Use of appropriate methods under particular conditions should result in more reliable hydrilla control than in the past. With this improved confidence in the available management tools, effective policy decisions concerning the management of these canals will be more feasible and economical.

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LITERATURE CITED

Fox, A. M. and W. T. Haller. 1990. Use of Rhodamine WT dye to predict herbicide dissipation in moving water. Proceedings of the EWRS/AAB 8th Symposium on Aquatic Weeds, 1990. 105-110.

Fox, A. M., W. T. Haller and K. D. Getsinger. 1988. Preliminary study of the dilution of dyes in tidal canals of the Crystal River, Florida. Proceedings, 22nd Annual Meeting, Aquatic Plant Control Research Program. Miscellaneous Paper A-88-5, US Army Engineer Waterways Experiment Station, Vicksburg, MS. pp. 195-201.

Fox, A. M., W. T. Haller and K. D. Getsinger. 1989. Factors affecting the dispersion of dyes in tidal canals in the Crystal River, Florida. Proceedings, 23nd Annual Meeting, Aquatic Plant Control Research Program. Miscellaneous Paper A-89-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS. pp. 103-105.

Fox, A. M., W. T. Haller and K. D. Getsinger. 1991a. Factors that Influence Water Exchange in Spring-fed Tidal Canals. Estuaries 14: 404-413.

Fox, A. M., W. T. Haller, K. D. Getsinger and W. R. Green. 1991b. Characterization of water exchange in hydrilla-infested tidal canals of the Crystal River, Florida. Miscellaneous Paper A-91-2, US Army Engineer Waterways Experiment Station, Vicksburg, MS. 50 pp.

Netherland, M. D., W. R. Green and K. D. Getsinger. 1991. Endothall concentration and exposure time relationships for the control of Eurasian watermilfoil and hydrilla. J. Aquat. Plant Manage. 29:61-67.

Smart, P. L. and I. M. S. Laidlaw. 1977. An evaluation of some fluorescent dyes for water tracings. Water Resources Research 13:15-33.

J. Aquat. Plant Manage. 30: 62-65

The Rate of Expansion of Melaleuca in South Florida

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ABSTRACT

Melaleuca (*Melaleuca quinquenervia* (Cav.) Blake) is widely distributed in South Florida and becoming the dominant plant in many areas. The uncontrolled expansion of melaleuca constitutes one of the most serious threats to the existing biological integrity of many ecosystems of south Florida. Aerial photo interpretation and ground truthing surveys were used to determine boundaries of melaleuca infestations at several locations. These boundaries were then digitized from aerial section sheets using AutoCad and Arc/Info GIS software to determine total area of infestation for expansion rate calculations over a 25 year period. The pattern of melaleuca expansion indicated three differential rates of expansion which were characterized as three phases of a sigmoid growth function. The data indicated that when melaleuca infestation had reached approximately two to five percent of the sampled land, it took about 25 years for 95% infestation to occur.

Key words: exotic woody plant, infestation rate, invasion, Everglades, wetlands.

INTRODUCTION

Melaleuca is an evergreen subtropical tree belonging to the Myrtaceae family and is native to Australia, New Caledonia, and New Guinea (Ewel 1986). It was intentionally introduced into South Florida around the turn of the century to afforest the Everglades (Austin 1978). The general belief was that the increased evapotranspiration rate of melaleuca forests would dry up vast areas of wetlands and enable development (Hofstetter 1988).

As a result of both artificial introduction and natural dispersal, melaleuca is now widely established and rapidly expanding in South Florida (Meskimen 1962). Melaleuca is capable of tolerating a broad range of site conditions. It can survive on almost any soil type, tolerates extended periods of flooding, moderate droughts, and tolerates fire and moderate salinity, all conditions characteristic of the wetlands in South Florida (Woodall 1981). These factors, in conjunction with a lack of natural competition, insect feeding and diseases, allow melaleuca to grow more densely in South Florida than in its native range (Thayer and Bodle 1990). Mature melaleuca trees in South Florida commonly form dense canopies which compete with native vegetation and reduce species diversity (Austin 1978).

A single tree may contain millions of seeds stored in capsules on its branches and a single branch may contain seed capsules of different ages. The seeds may remain viable within the seed capsule for several years (Vandiver 1981). Seed release is often related to stress events such as the cutting or breaking off of stems, herbicide treatment, fire or frost damage, as well as natural death (Thayer and Bodle 1990). Because its seeds are encapsulated, melaleuca seedlings can germinate throughout the year (Ewel 1986). Seedfall range is generally restricted to one to one-and-one-half total tree heights (Meskimen 1962). Germinative capacities vary with the length of time that seeds have been retained on a tree: usually 10 to 20% of seeds released germinate (Meskimen 1962).

According to Myers (1975), regardless of the availability of seeds, a certain set of environmental factors must be met before invasion will occur. One very important factor which influences melaleuca colonization is disturbance in the form of an altered hydroperiod. Disturbed sites may

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