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Herbicide Trials for the Control of Alligatorweed

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ABSTRACT

Alligatorweed (*Alternanthera philoxeroides* (Mart.) Griseb.) is an introduced aquatic weed that forms nuisance growths in rivers, drainage systems, wetlands, and shallow lakes and is a species with limited or ineffectual control options in New Zealand. Over 8 years, contained trials on established alligatorweed were conducted with a variety of herbicides and repeat applications to find a product or an application rate that would improve alligatorweed weed control and could be implemented into existing eradication programs. When compared with those products currently used for the control and site eradication of alligatorweed (glyphosate and metsulfuron), both imazapyr and triclopyr reduced alligatorweed biomass. Of these two products, however, only imazapyr was effective at reducing the biomass of mature (3 year old) alligator weed plants, following repeat application. Should the aquatic registration of imazapyr in New Zealand be pursued, it has potential use in alligatorweed control and eradication programs.

Key words: alligatorweed, *Alternanthera philoxeroides*, glyphosate, imazapyr, metsulfuron, triclopyr.

INTRODUCTION

Alligatorweed is a stoloniferous perennial weed, forming dense floating mats of vegetation in ponds, swamps, rivers, and grassland (Coffey and Clayton 1988). Alligatorweed was introduced into New Zealand from ship ballast in the early 1900s and has since become widespread in parts of Northland and Auckland (37° latitude and north), with a scattered distribution south of this to 39° latitude in the North Island and a few sites in the South Island (Figure 1). At both aquatic and terrestrial sites, alligatorweed has rapidly displaced a range of native and crop plant species, altering habitats and water and land use (Champion 2008).

Alligatorweed is difficult to control because each node is capable of forming a new plant, and fragments generated from mechanical clearance only encourage its spread (Johnson and Brooke 1989, Sainty et al. 1998). Biological

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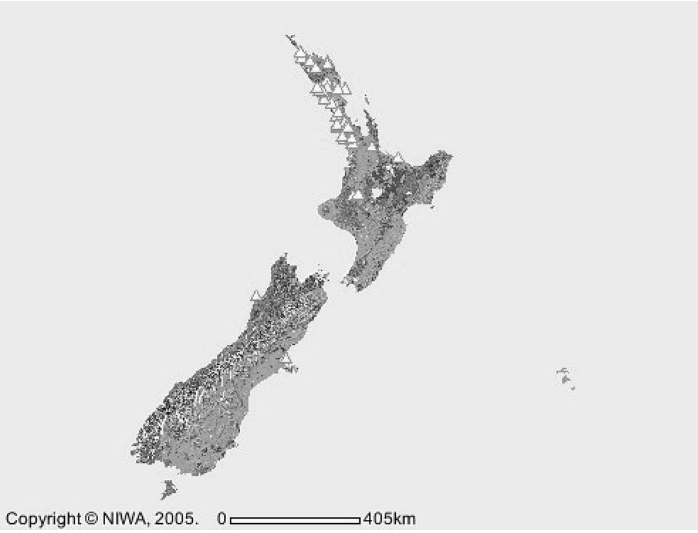

Figure 1. Distribution of alligatorweed sites in New Zealand (FBIS database).

control with insects specific to alligatorweed has been successful in the United States and Australia (Johnson and Brooke 1989), but in New Zealand, biocontrol agents (alligatorweed beetle [*Agasicles hygrophila*] and moth [*Arcola malloi*]) are not considered suitable for widespread control (Stewart et al. 1999, Hayes 2007, Winks 2007). Chemical control options have been limited, with few herbicides registered for use in or over water in New Zealand. Diquat and endothall are registered for use on submerged aquatic weeds, and during the course of this study triclopyr triethylene amine (TEA) was registered for aquatic use (as Garlon® 360), although not in unimpounded flowing water bodies. Some formulations of glyphosate are registered for use where contamination of water may occur, and metsulfuron (under regional resource consent) has been used over water (Champion 1990, 2008). Of these products diquat has previously been trialled on alligatorweed but was not efficacious (NIWA unpublished data). Glyphosate and metsulfuron are used to control alligatorweed in New Zealand and Australia, but several repeat applications are usually required to give adequate control (Sainty et al. 1998), even at the maximum label rate (Champion 2008). Triclopyr has controlled alligator weed in the United States (Langeland 1986, Langeland et al. 2006) and is known to have an environmentally compatible degradation profile and toxicology, and the ability to selectively control a variety of weeds (Petty et al. 2003). Its registration for aquatic use in the United States and reported control of alligatorweed led to its inclusion in the present study. Imazapyr has relatively recently been registered for aquatic use in the United States and has been evaluated as a potential systemic herbicide on other difficult to control marginal aquatic species (Wersal and Madsen 2007). Compared with glyphosate, Imazapyr has established systemic activity in alligatorweed that may be indicative of its potential for long term control (Tucker et al. 1994), and its efficacy has been demonstrated in the field (Allen et al. 2007); hence, it was included in the present study.

Current management programs in New Zealand aim to control alligatorweed infestations on a site-specific basis north of Auckland and eradicate all sites south of Auckland. Sites for eradication include the Waikato River delta and wetlands, as well as rural and urban terrestrial sites within the Waikato Region. Current control methods for alligatorweed at these sites are predominately herbicidal, with some manual removal. The herbicides include metsulfuron (which is permitted regionally for use specifically for the alligatorweed eradication program) and glyphosate for aquatic sites, and triclopyr ethoxyethyl ester with picloram for terrestrial sites. Although the management programs are reducing the number and extent of alligatorweed sites (Champion 2008), alligatorweed is still regarded by waterway managers as a problematic plant that has limited or ineffective control options available. Herbicides or rates that can be used in or over water with greater efficacy for alligatorweed control continue to be sought to improve the tools for this program.

In this study, alternative chemical options to glyphosate and metsulfuron were evaluated for alligatorweed control in contained trials, using products selected for their reported efficacy on alligatorweed and potential for future aquatic use (Petty et al. 2003).

MATERIALS AND METHODS

Three trials were conducted over 8 years using plants of two different age groups, young and old. Young plants were established and treated within the same year, and old plants had multiple growing seasons before treatment. The combination of product choices for each trial was based on results of the preceding trial or trials. For each trial, alligatorweed basal stem material was planted (MAF Biosecurity New Zealand exemption permit) in 60 L plastic tubs that were two-thirds filled with topsoil, overlaid with a ~10 cm layer of sand, and then filled with water (~8cm water depth). Plants were grown outdoors for the duration of the study (on the NIWA Ruakura campus), with an initial establishment period of at least 2 months for the first two trials before herbicide was applied, at which time the shoot growth was dense and plant cover was at least 80% of the surface area of the tub. Prior to the last trial the alligatorweed had three growing seasons (summers) in the tubs before herbicide application in the spring of the fourth growing season. Each year fertilizer (Osmocote) was applied (using label rates for container plants) to the tubs in spring. In all three trials there were six replicates of each herbicide treatment and untreated controls that were randomly assigned to the tubs.

Trial 1: Alligatorweed was cultivated in early spring of 2000 and treated in summer (December) with imazapyr (Arsenal®) at 0.24 or 0.48 kg a.i./ha, or metsulfuron (Escort®) at 19, 36, or 72gai/ha, or triclopyr TEA (Garlon® 360) at 3.2 or 6.5 kg a.i./ha, or with triclopyr and picloram (as Tordon® Gold) at 0.24 and 0.12 kg ai/ha or 0.48 and 0.24 kg a.i./ha, respectively. Herbicides were applied with a hand held sprayer (in all trials) with an application volume of 200 L/ha. Plants were monitored for 13 months after treatment (MAT) and then destructively harvested.

Trial 2: In the spring of 2002, alligatorweed was planted in tubs, and plants were treated in summer (Jan 2003) with triclopyr TEA at rates of 6.5, 9.7, or 13 kg a.i./ha. Plants were monitored until the following spring (Oct 2003), when half of all treated tubs were re-sprayed with the same initial herbicide and rate. Plants were then monitored until autumn (Mar 2004) and then destructively harvested (i.e., at 13 MAT).

Trial 3: Alligatorweed was planted in spring 2004 (October) and cultivated until summer 2007 (Feb) when plants were treated with the herbicides glyphosate (Roundup® G2; plus Uptake® adjuvant oil) at 6.4 kg a.i./ha, imazapyr at 0.16, 0.48, 0.64 kg a.i./ha, metsulfuron at 36 g a.i./ha, or 6.5 kg a.i./ha triclopyr TEA. Plants were monitored for 10 MAT at which time half of all treatment tubs were re-sprayed with the same herbicide and rate. Plants were then monitored throughout the summer growing season and destructively harvested in autumn, 3 months after re-treatment (Mar 2008).

For all trials, alligator weed tubs were monitored frequently to determine onset of initial symptoms of herbicide application. Percent cover of alligatorweed in each tub and the number of shoots (i.e., number of new shoots [recovery]) after the loss of all leaves following initial herbicide application was recorded. Because percent cover data were determined to be an equivalent indicator of plant recovery to the shoot number, shoot data were not recorded for all trials, and only the percent cover data are presented. Plants were destructively harvested, separating root and shoot biomass, at the conclusion of each experiment. The alligatorweed was dried to constant dry weight and weights were recorded. Plant biomass (square root transformed) data were analyzed using ANOVA (analysis of variance) with Dunnett post hoc tests. All mention of statistical significance refers to $P < 0.05$.

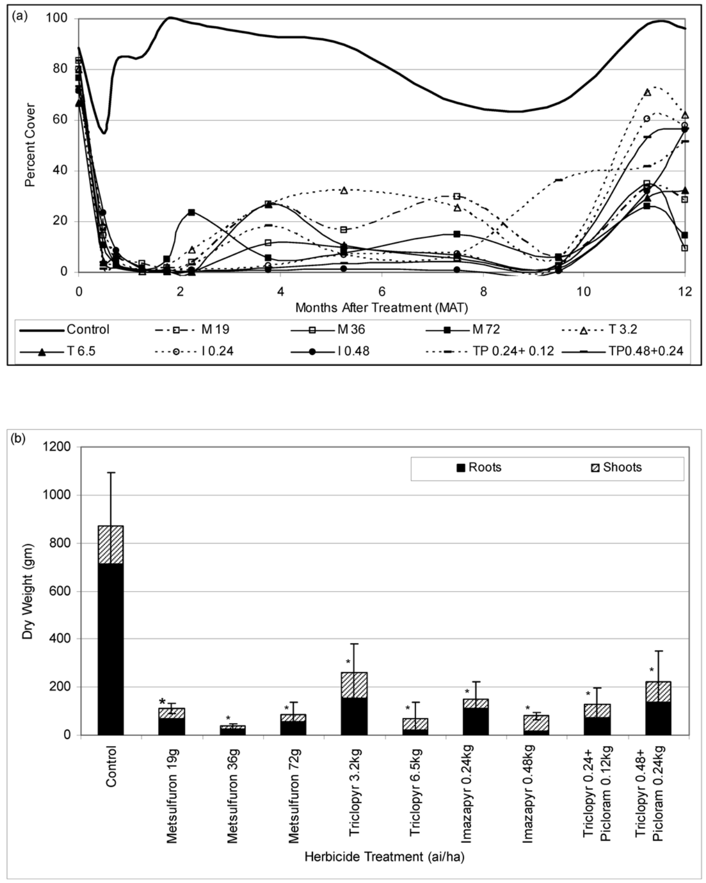

Figure 2. Alligatorweed percent cover (a) and biomass (b) in the first trial. Data are means (n = 6) across each treatment in (a) and (b), with standard deviations shown by the error bars (b). M, T, I and TP represent metsulfuron, triclopyr TEA, imazapyr and triclopyr with picloram, respectively (a). An asterisk (*) represents a significant difference from the control plants for that treatment (ANOVA; Dunnett's test; $P < 0.05$) (b).

RESULTS AND DISCUSSION

In Trial 1, plants exhibited symptoms (e.g., wilting, stem deformation) within a week after treatment with all four products, with a subsequent decline in the cover of viable alligatorweed (Figure 2a). However, as early as about 2.5 months after treatment (MAT) there were signs of alligatorweed recovery (new shoots) and increased plant cover for some treatments (metsulfuron and the lowest rate of triclopyr TEA; Figure 2a). In late winter, the alligatorweed in all tubs, including the control plants, exhibiting some degree of seasonal decline from frost damage (~8 to 9 MAT), from which there was recovery within the subsequent month (Figure 2a). At harvest, 1 year after treatment, the biomass of alligatorweed from all treated tubs was significantly less ($P < 0.005$) than the alligatorweed biomass from the untreated control tubs, with treated plants having less than half the biomass of the control plants (Figure 2b). Among the treatments, product efficacy was comparable with the efficacy of the currently used metsulfuron.

In Trial 2 where three rates of triclopyr TEA were evaluated for alligatorweed control, the triclopyr seemed to be less efficacious at the comparable rate of 6.5 kg a.i./ha, even though the control plants had similar biomass across the two trials. In contrast, signs of recovery (new shoots) and an increase in percent plant cover took longer in trial two than trial one (i.e., 3 to 4 months in year 2 compared with 1.5 months in year 1; Figure 3a). In addition, even plants that received a second application of triclopyr in spring had no or slightly lower biomass at harvest than those plants that received a single herbicide application (Figure 3b). Only repeat spray at double rate had a similar mean biomass (~100 g) to the 6.5 kg a.i./ha treatment rate of the first year (Figure 3b).

In Trial 3, percent cover data show a decrease in alligatorweed following initial herbicide application and for up to three months following treatment (Figure 4a). Repeat application on plants in half of the treatment tubs in spring (November) shows declining plant cover up to 2.5 months following application for all treatments except glyphosate (Figure 4a). However, even with repeat application, neither the glyphosate nor the triclopyr were considered efficacious, with mean shoot biomass for both treatment types similar to

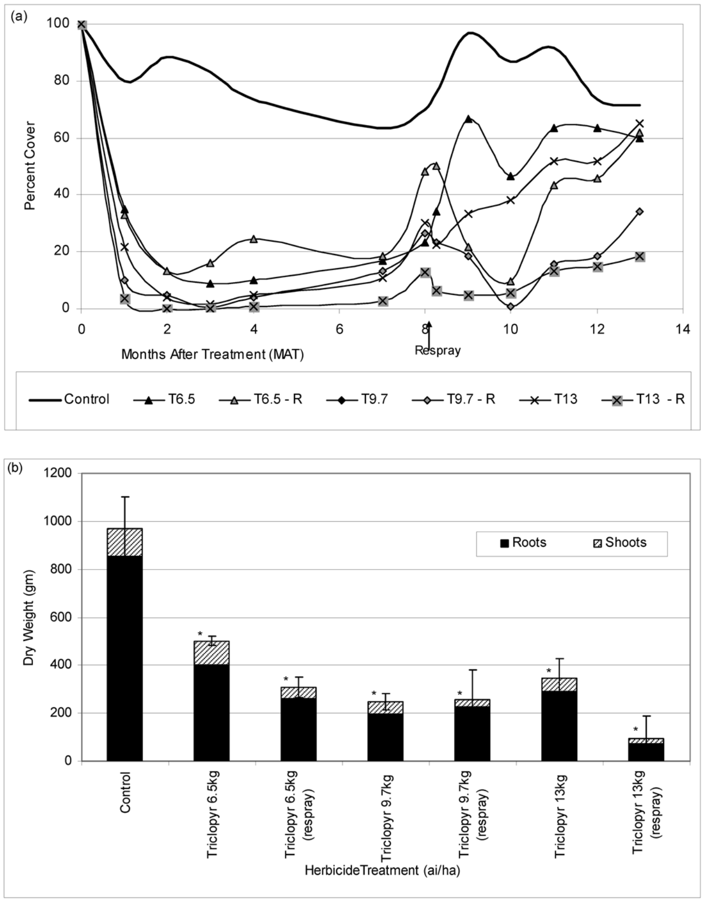

Figure 3. Alligatorweed percent cover (a) and biomass (b) in the second trial. Data are means (n = 3) across each treatment in (a) and (b), with standard deviations shown by the error bars (b). T represents triclopyr TEA and R designates the data from resprayed alligatorweed tubs (a). An asterisk (*) represents a significant difference from the control plants for that treatment (ANOVA; Dunnett's test; P < 0.05) (b).

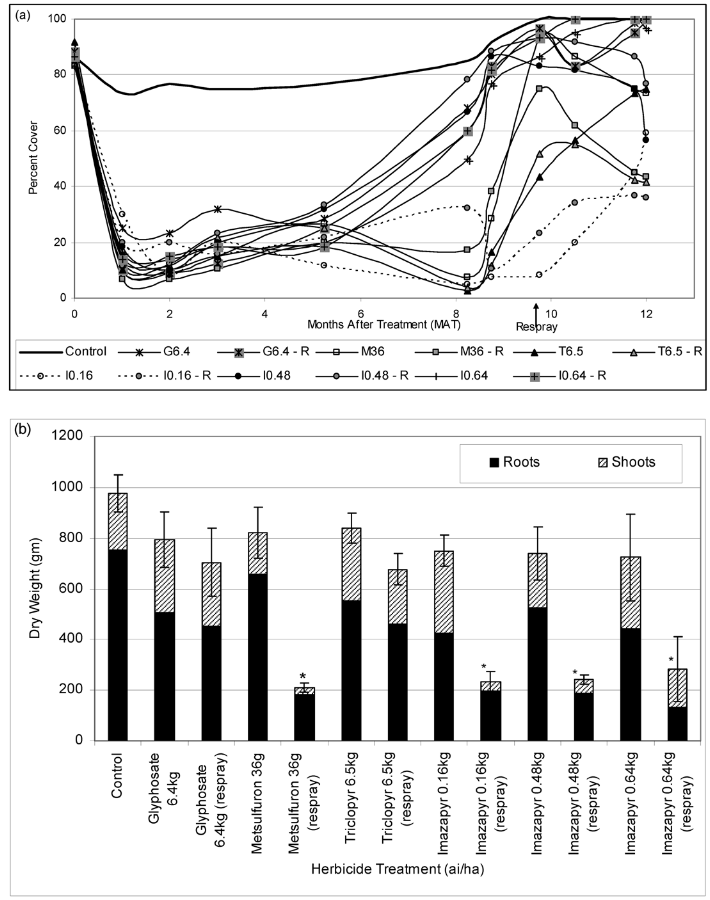

Figure 4. Alligatorweed percent cover (a) and biomass (b) in the third trial. Data are means (n = 3) across each treatment in (a) and (b), with standard deviations shown by the error bars (b). G,M, Tand I represent glyphosate, metsulfuron, triclopyr TEA and imazapyr, respectively, and R designates the data from re-sprayed alligatorweed tubs (a). An asterisk (*) represents a significant difference from the control plants for that treatment (ANOVA; Dunnett's test; P < 0.05) (b).

control plants (Figure 4b). The best results (lowest biomass) were recorded for metsulfuron and imazapyr, where repeat application of herbicide was used (Figure 4b).

Multiple herbicide treatments are currently recommended for alligatorweed suppression in New Zealand (Champion 2008) and Australia using metsulfuron methyl (Sainty et al. 1998, van Oosterhout 2007). In the Australian example, the aim of the first two sprays is to deplete alligatorweed biomass, while the third corresponds with the natural seasonal decline in the plant photosynthesis (van Oosterhout 2007) and, potentially, an increase in the small amount of herbicide that will be translocated to storage organs (Bowmer et al. 1991). The results from the present study and field observations (Champion 2008) corroborate the experience in Australia, where multiple applications of metsulfuron are required during a growing season to suppress alligatorweed when plants are well established (e.g., Trial 3). In contrast, the biomass of alligatorweed that had a second application of glyphosate was not significantly different from those with a single application. Field experience in New Zealand (Champion 2002) and Australia (van Oosterhout 2007) corroborates this finding where glyphosate does not provide adequate control of alligatorweed in the long-term. In New Zealand, glyphosate may be used to treat vegetation surrounding alligatorweed so that the alligatorweed becomes exposed for follow-up treatment by metsulfuron in eradication programs (Champion 2008).

Compared with the currently used products glyphosate and metsulfuron, imazapyr was more effective at controlling alligatorweed than glyphosate, as is reported in the literature (Langeland 1986, Tucker et al. 1994, Allen et al. 2007), and was comparable with metsulfuron. Triclopyr TEA demonstrated significantly reduced biomass in the first trials on younger plants, but biomass was similar to glyphosate-treated plants when the alligatorweed was well established prior to treatment. This has significant implications for field efficacy, particularly at alligatorweed sites where eradication is the aim, as is the case for a number of regions in New Zealand. Because no current product can effectively reduce alligatorweed biomass over a season with one application, multiple applications are required for maintaining consistent control (i.e., keeping biomass reduced) when eradication is the goal.

In current New Zealand eradication programs several applications in one growing season are advocated (Champion 2008), making the ability of a product to reduce the biomass of mature alligatorweed populations the most important factor. Although triclopyr TEA has a relatively favorable environmental toxicology profile compared with metsulfuron for aquatic use, the level of alligatorweed control achieved may limit its application in eradication programs for this plant. Imazapyr not only has recent registration in the United States for aquatic use, and hence the potential for registration to be pursued in New Zealand, but imazapyr results demonstrated a significant reduction in alligatorweed biomass with repeated application on mature plants. Based on the results from the trials presented here, it is likely that imazapyr will provide better results (greater decline in alligatorweed biomass) in the field and that registration for aquatic use would be of benefit for the control of alligatorweed in New Zealand.

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