Tactics for the control and possible eradication of terrestrial alligator weed (*Alternanthera philoxeroides*)

Tony Cook[1] and Andrew Storrie[1,2]
[1] NSW Department of Primary Industries, Tamworth Agricultural Institute, 4 Marsden Park Road, Calala, New South Wales 2340, Australia
[2] CRC for Australian Weed Management
Email: tony.cook@dpi.nsw.gov.au

Summary Hard to kill weeds have a range of mechanisms that ensure their survival. The terrestrial form of Alligator weed has an extensive root and rhizome system which causes the weeds' persistence despite the application of some 'short-term' effective chemical options. Tactics that rely upon repeated applications have been successful at greatly reducing the quantity of alligator weed.

This paper will highlight and discuss the newly developed options that have greatly improved control over the past three years. Such tactics include the correct selection and rate of herbicide, adjuvants, sequencing of sprays, growth stage of alligator weed at the time of spraying and the management of desirable species, such as pastures, for maximum competitive effects.

Keywords Alligator weed, metsulfuron methyl, pasture management, slashing, grazing, adjuvants, repeated applications.

INTRODUCTION

Attempts to control or eradicate the terrestrial form have been significantly more difficult than the aquatic form of alligator weed (*Alternanthera philoxeroides* (Mart.) Griseb.). The aquatic form relies upon a moderate network of hollow stems to support itself in water, whereas the terrestrial form has a larger network of thicker, harder roots and rhizomes. The presence of these terrestrial tissues makes the plant harder to kill because there is generally a greater proportion of total biomass of alligator weed underground compared to underwater biomass of the aquatic form. An important factor that makes terrestrial alligator weed resilient to control strategies is the large amount of stored carbohydrates stored in roots and rhizomes (Wilson *et al*. 2007). These carbohydrates can be utilised to promote more above ground biomass, particularly after a disturbance. Some of the carbohydrate reserves are used in the beginning of the growing season (November) to promote vegetative growth. Photosynthetic rates are also at their greatest level in November but gradually decline at the end of the growing season (May), when carbohydrates are sent to the root system for plant survival over winter (Kelley and Hennecke 2006).

Biological control in NSW may have partial success in aquatic areas due to the flea beetle (*Agasicles hygrophila*). However, the terrestrial form is very tolerant to biological agents (Julien *et al*. 1995, Sainty *et al*. 1998). Bowmer and Eberbach (1993) have shown that there are a few herbicides that give effective short-term control. They were either non-selective (glyphosate) or selective (metsulfuron methyl and dichlobenil) herbicides (Bowmer *et al.* 1991). Schooler *et al*. (2007a) proved that alligator weed was unaffected by a single application of herbicide, for a period of at least six weeks after application. However, Bunn (1993) has stated that at least two applications of metsulfuron methyl resulted in consistently acceptable control. In addition, the repeated use of selective herbicides was suggested by Schooler *et al*. (2007b) as a good strategy by promoting competitive beneficial species.

Chemical control of alligator weed is well suited to moderate to large infestations and is recommended for reducing these infestations to smaller infestations (van Oosterhout 2007). Once these infestations are small enough, the decision to eradicate the remaining alligator weed could be made. Alternatively, a decision could be made to tolerate low levels of alligator weed and spray occasionally to maintain suppression of growth.

This paper reports on five experiments with the aim to develop more specific guidelines for the improved control of alligator weed

METHODS AND RESULTS

All experiments were established since 2004. The herbicide treatments were applied using a hand held boom spray, applying a water volume of 150 L ha^{-1} through Hardi® 110-14 nozzles. In all instances, herbicide application was made to healthy, actively growing plants. The following table describes the basic aspects of each experiment.

Experiment AW1 Bowmer *et al*. (1991) investigated several Group B herbicides. From this research, metsulfuron methyl was identified as being an effective herbicide. Since that report there have been many more Group B herbicides released onto the market that may be more effective. This experiment was implemented so that a wider range of Group B herbicides could be tested for alligator weed efficacy.

Table 1. Experiments undertaken on alligator weed in the Hunter region of NSW.

Experiment code	Spray date(s)	Investigating what? (no. of treatments)
AW1	5.12.06	Herbicides similar to metsulfuron methyl as alternatives (24)
AW2	19.2.07	Metsulfuron methyl rate response (12)
AW3	5.12.06	Effects of various adjuvants on metsulfuron methyl performance (14)
AW4	9.12.05	Effect of slashing kikuyu prior to spraying (5)
AW5	3.12.04, 31.3.05, 9.6.05, 7.12.05, 28.3.06, 6.12.06 and 20.2.07	Effects of repeated applications of herbicides for long-term control (16)

Most of the herbicides tested were not suitable for controlling alligator weed. The only exceptions were metsulfuron methyl and imazapyr. The cost of applying imazapyr at 1000 g a.i. ha^{-1} would be prohibitive, unless on very small infestations. At these rates it is a total vegetation control residual herbicide and will leave bare patches whereas metsulfuron methyl at 24 g a.i. ha^{-1} is low cost and does not kill grasses.

Experiment AW2 In response to the results of experiment AW1, the second experiment (AW2) investigated the most suitable rate of metsulfuron methyl. A wide selection of rates was applied, from 0 to 120 g a.i. ha^{-1}, with Uptake® adjuvant added to all treatments at 0.5% v v^{-1} (500 mL 100 L^{-1} water). Although the highest rates tested gave the best control, it would be uneconomic to apply these rates to continuously suppress alligator weed. In addition, application of 90 and 120 g a.i. ha^{-1} of metsulfuron methyl was damaging to pasture species. Although 48 g a.i. ha^{-1} is registered (equivalent to 80 g ha^{-1} of product), slightly less control occurred with half that rate (24 g a.i. ha^{-1} or 40g ha^{-1} of product). Reducing the rate to 24 g a.i. ha^{-1} will make the cost of repeated applications economic.

Experiment AW3 The aim of this experiment was to improve the level of control using 13 different adjuvants. A standard rate of 12 g a.i. ha^{-1} of metsulfuron methyl was used as a sub-lethal dose. This rate was selected so that improvements in control due to adjuvants can be detected. All adjuvants had some positive effect on the control of alligator weed. Metsulfuron methyl at 12 g a.i. ha^{-1} without addition of adjuvant was assessed 77 days after treatment and resulted in 48% ground cover of alligator weed. The three best adjuvants were a cat-ionic wetter, Supercharge® and Adigor® (between 19 and 21% ground cover). However, there appears to be many other adjuvants with very similar levels of control to these three adjuvants. Liase® and LI-700® seem to be the least effective adjuvants due to lower control scores and higher alligator weed ground cover.

Experiment AW4 Initially a kikuyu/alligator weed stand was slashed to various heights from 10 cm to 60 cm and the alligator weed density was assessed 21 days after slashing. Metsulfuron methyl was immediately applied at 24 g a.i. ha^{-1} over the trial area.

Slashing kikuyu promoted alligator weed growth, particularly at lower heights (Table 2). However, this can be seen as an opportunity for better control with the application of the herbicide. This technique is called pasture canopy management and can be used to manipulate the weed density for best chemical control.

Table 2. Density of alligator weed following various slashing heights of kikuyu and 45 days after an application of metsulfuron methyl (24 g a.i. ha^{-1}).

Slashing height (cm)	Alligator weed shoot density (m^{-2})	
	21 days after slashing	45 days after metsulfuron methyl
10	33	0.6
20	15	1.0
30	9	5.1
40–50	6	9.8
50–60	4	8.3

Experiment AW5 This experiment investigated the effects of repeated applications of metsulfuron methyl and glyphosate. Results presented within this paper are only focused on metsulfuron methyl as glyphosate treatments gave unacceptable levels of control. Two rates of metsulfuron methyl were applied each time, 24 and 48 g a.i. ha^{-1} with a non-ionic surfactant at 0.1% v v^{-1}. The site was continuously grazed, minimising competition from the pasture, thus promoting actively growing alligator weed.

Only a few traces of alligator weed emerged after six applications of metsulfuron methyl over a three-year period (Figure 1). Despite initial differences due to rates, both treatments steadily reached excellent levels of suppression.

DISCUSSION

The most cost-effective treatment for larger terrestrial infestations was the repeated application of metsulfuron methyl. The cost of the label treatment

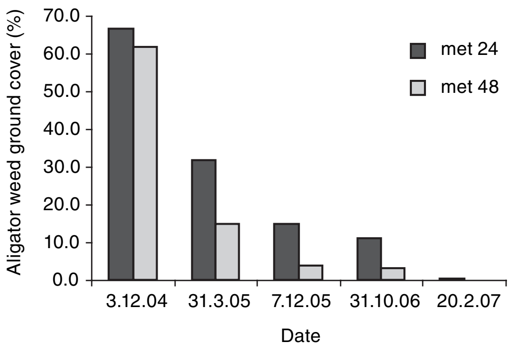

Figure 1. Effect of repeated applications of metsulfuron methyl on alligator weed ground cover over three growing seasons, when applied at two rates (24 and 48 g a.i. ha^{-1} with a non-ionic surfactant at 0.1% v v^{-1}).

would be approximately \$12 ha^{-1}. Reducing the rate from 80 g of product ha^{-1} to 40 g would reduce both cost of treatment and amount of herbicide entering the environment. This reduction in rate would give a slightly lower level of weed control but makes repeated treatment affordable. Adjuvants have been shown to improve control, but there were no significantly outstanding products.

We showed that alligator weed in heavily infested areas (core areas) can be reduced to small weak patches after three years and six applications of metsulfuron methyl. There is a distinct possibility that these core areas can be taken to point where eradication could be considered. To effectively implement control, operators need to fully understand the process of pasture canopy management (van Oosterhout 2007) and its effect on alligator weed growth and control.

Suppression of larger infestations that may lead to eradication clearly requires more detail than the metsulfuron methyl label states. The critical comments of the metsulfuron methyl label currently states, 'follow up application over at least two seasons are essential for complete control'. More detail needs to be included in the critical comments section to fine tune the control strategy. A Pesticide Permit may be obtained to adjust to the new findings presented within or chemical companies may need to review label recommendations accordingly so that people can legally use these new strategies.

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