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TESTING THE EFFICACY OF LOW VOLUME HERBICIDE APPLICATIONS ON *Chromolaena odorata*

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ABSTRACT

Siam Weed (Chromoleana odorata) is the target of an eradication program in north Queensland; however some infestations occur on ground inaccessible to high volume, ground based herbicide spray equipment. Four foliar herbicides were applied to dense infestations of mature Siam Weed in March 2009, near Townsville, north Queensland. Low volume, high concentration solutions containing 40 g L^{-1} a.i. glyphosate, 1.2 g L^{-1} a.i metsulfuron-methyl, 10 g L^{-1} a.i. fluroxypyr + 0.7 g L^{-1} a.i. aminopyralid and 15 g L^{-1} a.i. triclopyr + 5 g L^{-1} a.i. picloram + 0.4 g L^{-1} a.i. aminopyralid were applied using a 5 L backpack and hand gun (or splatter gun). Relatively small amounts (approximately 24-28 mL) of the high concentration solutions were applied to each bush and assessments of the replicated treated and untreated control plots were conducted 76, 207 and 356 days after treatment. These assessments demonstrated that the fluroxypyr and triclopyr based herbicides controlled 96 to 100% of plants. The metsulfuron-methyl and glyphosate based herbicides controlled 40 and 57% of plants respectively 12 months after treatment, when 3% of untreated control plants were dead. The trial demonstrated that this application method and either of two herbicides provides an additional tool for controlling Siam weed in remote areas, which are inaccessible to traditional higher volume foliar herbicide applications. Lower volume herbicide solutions reduce the volume of water and thus the effort needed to effectively treat less accessible infestations.

Keywords: *Chromolaena odorata*, Australia, splatter gun, fluroxypyr and triclopyr.

INTRODUCTION

Siam weed (*Chromolaena odorata* (L.) King & Robinson) is a large multi-stemmed perennial shrub in the Asteraceae family. It was first discovered on mainland Australia in 1994 near the towns of Mission Beach and Tully on the tropical coast of north east Queensland. Infestations of Siam weed have also been found in other tropical coastal areas of Queensland, including the Johnstone River and Maria Creek catchments since 1994, Murray River catchment (1997), Russell River catchment (2005) and near the town of Mossman (2003).

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Siam weed has also been found in the drier inland areas of the Upper Herbert catchment south of Mount Garnet since 1997, and in the Black and Ross River catchments west of Townsville since 2003.

In recognition of the serious problem, a weed eradication program was established targeting Siam weed commenced in 1994 (Waterhouse, 2003) and continues today. The eradication program is managed by Biosecurity Queensland (within the Department of Employment, Economic Development and Innovation) with funding received via national cost share arrangements from the Federal, Queensland and other state governments potentially affected by Siam weed. The availability of effective measures to control Siam weed in a range of situations is an integral component of the eradication program, as for the program to be successful the entire population has to be effectively treated (Panetta and Timmins, 2004).

Eradication program field crews annually survey thousands of hectares on foot to control scattered seedlings and survey in riparian or hilly areas that are not readily accessible to spray equipment; as a result most plants are physically controlled. Where herbicides are used they are usually high volume foliar applications of fluroxypyr- or triclopyr-based. Such applications are effective but they rely on being able to transport sufficient volumes of water and herbicide to the infestations by vehicle or on foot to treat the plants.

Many Siam weed infestations, particularly near Townsville, occur on steep rocky ground and are hundreds of metres away from tracks, so they can not be accessed by the ground based equipment used to apply high volume foliar herbicides. In these situations eradication field staff were walking into remote infestations and physically digging out plants, including the basal ball, from rocky soils on steep hills in humid tropical conditions, a particularly slow and arduous activity, especially when the first treatments may need to be applied to high densities of large plants. To investigate potentially more efficient control measures a trial was conducted to determine if Siam weed can be effectively controlled by a low volume foliar herbicide spray, containing a higher concentration of active ingredients than would be applied in high volume sprays.

Low volume treatments are applied in small amounts broadly across patches of weeds with a hand held 'splatter', 'drenching' or 'gas' gun attached to a 5 L backpack of herbicide solution. Owing to the small areas treated in this trial, a 20 mL applicator with a manual trigger was used. Manual operation also allows the operator to vary the amount of herbicide solution deployed onto smaller plants up to the maximum of 20 mL per shot. An alternative applicator can be attached to a small propane gas cylinder via a regulator to power the trigger and fire the gun, the gas driven trigger deploys a set shot of up to 50 mL of herbicide. Low volume applicators such as 'splatter' guns have been recognised as an effective and efficient way of treating woody shrubs with systemic herbicides for a number of years (e.g. Toth and Smith, 1984). Recently, more research and publicity has led to more widespread use on weeds such as lantana (*Lantana camara* L.) (State of Queensland, 2006). The advantages of the splatter gun herbicide application method include: more specific targeting of vegetation to be treated, thereby reducing off-target damage, application of small volumes of high concentration herbicide mixture to plants to reduce chemical usage, no requirement to cover all foliage, and use in areas of difficult access or sensitive vegetation. Application recommendations include a marker dye to identify splattered bushes, squirting large droplets from 6–10 m away and applying approximately 15–20 mL per splatter to achieve a recommended application rate of 2 x 2 mL per 0.5 m of bush height.

MATERIALS AND METHODS

Location

A trial was established on the western side of the 'Pinnacles' (steep hills to the west of Townsville) in the Alice River catchment in March 2009. The trial was located at 19°23'56 ''S, 146°35'54''E and approximately 230 m above sea level. The vegetation is predominantly a sparse *Eucalyptus* or *Corymbia* woodland with open mid story trees and shrubs and a grassy ground dominated by *Heteropogon* species (Queensland Herbarium 2011). The site has a locally common duplex soil, specifically soil type Dy3.43 (map unit Va78), a hard setting soil with mottled yellow clayey subsoils and a moderately deep A horizon (Isbell *et al.,* 1968). It is occasionally grazed and burnt but otherwise largely unmanaged. A controlled burn of the site was done on 2/10/2008, the effects of which are being monitored in parts of this infestation. The fire reduced the cover of lantana on the trial site, but the grass layer and larger diameter Siam weed plants recovered quickly and grew well over the 2008-9 wet season. Though drier in March 2009, good rainfall in the preceding four months ensured that the soil was moist and the plants actively growing when treated (Table-1).

Table-1. Total monthly rainfall (mm) from the 5th of September 2008 at 'The Pinnacles' rainfall alert station. Data collated from Bureau of Meteorology (2011).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2008									27	0	194	131	352
2009	671	880	13	59	11	3	0	0	0	0	28	174	1839
2010	560	343	219	38	7	40	2	117	44	46	316	501	2233

Trial Design and Assessment

The trial included three replicate blocks with four herbicide treatments and an untreated control plot, all randomised within each block. Each of the 15 plots was established around 10 large tagged Siam plants, seven days prior to treatment. Tagged plants were assessed prior to treatment and at 35, 207 and 356 days after treatment (DAT). The pre-treatment and final two assessments included maximum live leader length and average plant height, two diameters of the basal ball at right angles, and total number of leaders. An assessment of herbicide damage on a 1 to 9 scale, adapted from Vitelli (1990) (Table-2) was conducted 35, 207 and 356 DAT. In some cases it was noted that the initial herbicide damage varied between leaders on the same plant; in these cases the damage score reflected the least damaged leader. During the 207 and 356 DAT assessments, plants were scored as dead (=9) if they had no leaves, appeared rotten and were very easily pulled from the ground. If none of the leaders were green, even when the bases were scraped with callipers but the plant was still standing, it was scored 8, especially in the assessment at 207 DAT.

Table-2. Herbicide damage assessment score (modified from Vitelli (1990)).

Score	Damage description
1	No effect
2	Leaf yellowing, up to 50%leaf drop
3	50-75% Leaf drop
4	75-100% Leaf drop
5	100% Leaf drop, lateral branches damaged
6	Lateral branches dead, some leaders still alive
7	All leaders damaged, probably die
8	All leaders appear dead
9	All leaders dead and base rotting

The presence of regrowth from the base and along leaders was recorded on a 1 to 5 scale (1= abundant, 2= frequent, 3= common, 4= rare and 5= none). Regrowth that exhibited herbicide damage was also noted, although there were only a couple suspected cases of regrowth injury.

The number of plants with developing flower buds was also recorded 76 DAT. To prevent seed production, all flower buds were removed from plants in the trial area and incinerated. The number of seedlings in each plot was also recorded 356 DAT and divided by the plot area to determine seedling density.

Treatments

All plots contained a sprawling mass of intertwined Siam weed leaders and some contained more than 10 plants; the approximate total area and amount of each herbicide used in the trial are shown in Table-3. Treatments were applied in 20 mL shots from a 'Forestmaster' applicator plus a 'lantana' nozzle manufactured by N.J. Philips, on the morning of 20/3/2009. The equipment was rinsed with clean water between applications. Two litres of solution were prepared for each treatment and leftover herbicide was used to create a buffer around the trial so the area was obvious to the eradication program field crew working in the area. The non-ionic wetter/spreader/penetrant Pulse® (Nufarm)(1020 g/L polyether modified polysiloxane) along with red Spraymate™ Spray Marker Dye (150 g/L Rhodamine B) was added to each treatment at a rate of 2 mL and 1mL per litre of solution respectively. When purchased in small quantities at 'over the counter rates', these additives cost $0.18/L of splatter gun solution. No rain was recorded at the Pinnacles flood alert station for three weeks after treatment application (Bureau of Meteorology 2011). All Siam weed in the trial area was controlled after the final assessment.

Table-3. Herbicide treatments details.

Herbicide trade name	Active ingredient	Active concentra-tion	Active rate (a.i g/L)	Herbic-ide mix rate	Cost of herbicide in 1 L solution at trial rate* ($AUD)	Amount of herbicide applied in 20 mL 'shots' (mL)	Sum of 3 plot areas (m^2)
Brush-off®	metsulfuron-methyl	600 g/kg	1.2	2 g/L	0.4	840	79.6
Grazon® Extra	triclopyr + picloram + aminopyralid	300 g/L + 100 g/L + 8 g/L	15 5 0.4	1:20	1.75	800	75.8
Hotshot®	fluroxypyr + aminopryalid	140 g/L + 10 g/L	10 0.7	1:14	1.49	740	72.8
Weed-master® Duo	glyphosate	360 g/L	40	1:9	0.68	740	75.1
Control							101.7

*Based on commercial prices of 20 L of herbicide or 200 g container of Brush-Off between the trial and publication. Costs will vary with alternative brands, quantities and over time. 1 L of splatter gun solution will supply 50 x 20 mL shots.

RESULTS

One way ANOVA with randomised blocks was used to analyse the mean plot data, which was normally distributed. However, most of the data presented is the net effect of the herbicides summed across three plots and 30 plants per treatment. There were no significant differences (P=0.05) between mean plant sizes prior to treatment, with plants averaging 2.1 m tall and with 4.8 leaders per plant (Table-4) across all treatments. 76 DAT there were flower buds on all the untreated control plants and six of the herbicide treated plants (Table-4).

Table-4. Mean pre-treatment plant morphology data and flowering occurrence in each treatment.

Treatment	Number of live leaders (pre-treatment)	Average of maximum leader length (m)	Average plant height (m)	Mean sum plot basal area (cm^2)	Number of plants flowering (76 DAT)
Control	154	2.47	2.20	59.02	30
Brush-Off	127	2.70	2.13	57.43	5
Weed-master Duo	144	2.37	1.99	55.00	1
Grazon Extra	122	2.13	1.82	41.40	1
Hotshot	182*	2.62	2.29	60.93	0

*One large plant had 35 leaders.

Larger differences between herbicide treatments were evident at 207 DAT than in the herbicide damage assessment 35 DAT. Therefore, only 207 DAT data is summarised in Table-5. Despite very dry conditions in Autumn 2009 (Table-1), all of the control plants were alive 207 DAT, though one of the control plants on the boundary of a Weed-master Duo plot was treated and incurred herbicide damage (score 7). At the other end of the damage scale, most of the Grazon Extra and all of the Hotshot treated plants were dead or close to dead (Table-5).

Table-5. Summary of herbicide damage assessment (207 DAT) in each treatment, using score of 1 (no effect) to 9 (dead).

Treatment	Herbicide damage score								
	1	2	3	4	5	6	7	8	9
Control	29						1		
Brush-Off		3	2	3	4	8	5	5	
Weed-master Duo	1	1	1	5	3	1	2	16	
Grazon Extra						1		24	5
Hotshot								27	3

The increase in number of live leaders in the untreated control plots and remaining live Weed-master Duo treated plants (Table-6) showed that the heavy wet season rainfall (Table-1) in the three months prior to the final assessment (March 2010) provided good conditions for weed recovery in the absence of effective treatment. The final assessment (356 DAT) thus highlighted the ability of some treated Siam weed plants to recover from severe damage and produce new leaders from the basal ball.

Table-6. Summary of treatment effects on leaders, live plants and seedling recruitment.

Treatment	Number of live leaders (207 DAT)	Number of live leaders (356 DAT)	Number of plants alive (356 DAT)	Mean seedling density plants/m^2 (356 DAT)
Control	153	190	28	5.53
Brush-Off	96	79	17	2.10
Weed-master Duo	39	59	13	4.42
Grazon Extra	3	1	1	5.70
Hotshot	0	0	0	2.73

The splatter application of smaller amounts of herbicides to the leaves is not likely to result in notable suppression of seedling emergence from the seed bank (i.e. pre-emergent herbicide activity). No significant difference (P=0.05) in mean seedling density was recorded in the plots 356 DAT (Table-6). Observations and photos indicated that the existing grass cover remained in the Hotshot, Grazon Extra and Brush-Off treated plots during the course of the trial.

Hotshot

All of the tagged plants treated with Hotshot died. These included the largest plant in the trial, with 35 leaders up to 3.5 m long and a basal ball 22 cm in diameter. There was no flowering or regrowth recorded or observed in the Hotshot treated plots at any of the assessments. High levels of herbicide damage were evident in all the assessments, culminating in 100% mortality 356 DAT. Although one of the more expensive treatments, it was the most successful. Further research is being conducted to investigate whether lower rates of Hotshot are as effective. Since 2009 splatter gun applications of Hotshot have been used to control Siam weed seedlings around plots retained for fire research at this trial site and around other research trials.

Grazon Extra

The one tagged plant that flowered and survived until the final assessment was on the edge of one of the plots; it showed some herbicide damage but was not effectively treated. The remaining 29 tagged plants were all effectively treated with Grazon Extra and showed no regrowth in the final two assessments. This was the most expensive treatment, although it provides an alternative to Hotshot if the price of either alters, or in situations where an alternative treatment is preferred by field crews. The results of this trial also suggest that other post emergent herbicides containing 15 g/L a.i. of triclopyr may also be effective when applied via a splatter gun.

Brush-Off

The Brush-Off treatment prevented flowering on 90% of tagged plants (Table-4) but ultimately only 43% of tagged plants were controlled (Table-6). The reduction in the number of live leaders between the last two assessments (Table-6) reflects the transition of 13 plants from damage score 6 or greater 207 DAT to the dead category 356 DAT. Over the same timeframe, 11 plants from damage categories 6 or lower 207 DAT (Table-5) were undamaged 356 DAT and had produced some new leaders. Overall, the time to mortality of some of the Brush-Off treated plants was greater than those in other treatments. Six plants remained in a partial damage category 356 DAT, although all six showed some fresh regrowth. As the Brush-Off treatment had some effect when applied via a splatter gun (Table-5) and is by far the cheapest treatment, rates greater than 2 g/L used in this trial are the subject of further research. As mortality in this treatment was spread evenly across the basal diameter sizes of the tagged plants (data not shown), care may need to be taken to ensure good coverage along most of leaders on each plant when treating Siam weed with Brush-Off applied via a splatter gun.

Weed-master Duo

Although only one of the tagged plants was flowering 76 DAT, the overall results for the Weed-master Duo plots were mixed. Most of the plants that received high scores (especially 8) at 207 DAT (Table-5) were dead by 356 DAT. However, three highly damaged plants (207 DAT) had recovered by the time of the final assessment through regrowth from the basal ball. Some plants that had partially damaged leaders 207 DAT had recovered and were producing new leaders by 356 DAT (Table-6). Although the low volume application was aimed at the Siam weed foliage, a considerable reduction in live grass cover in the Weed-master Duo treated plots was particularly evident 76 and 356 DAT. Such off-target damage was not observed in the other plots and is undesirable. Bare ground is more susceptible to soil erosion and the replacement of Siam weed with more Siam seedlings or different weeds, rather than the largely native grass cover, which is also essential fuel for the controlled fires planned for this infestation. With an overall control of 57% of tagged plants and notable off target damage, this treatment will not be trialled further.

DISCUSSION

Two of the herbicides tested in this trial provided excellent control of Siam weed. Therefore this serious weed can be effectively treated with a low volume herbicide application administered via a splatter gun. Although the splatter gun can be used to target weeds amongst native vegetation (State of Queensland, 2006) field crews will still need to be careful to avoid non target vegetation or over-treating plants particularly with higher concentrated solutions of herbicide. As this application method is designed to treat only foliage, follow-up control of any missed plants and seedling regrowth will be necessary. In addition to the splatter gun, tools such as high volume spraying from an aerial platform and cutting leaders at the base and treating with a picloram based gel have also recently been permitted under a minor use permit (APVMA, 2011) and provide more alternatives to the physical control of Siam weed in remote areas.

Since the inclusion of 'splatter gun' applications in a minor use permit (APVMA, 2011), the Siam Weed field crew based in Townsville have been using the splatter gun to treat some infestations (S. Brooks, unpublished database data, 2011). As crews use multiple 5 L herbicide solutions each day, there is still a need to carry sufficient water, gas and herbicide for a crew of three or four to treat an infested area (A. Clarke Pers Comm., 2010). To reduce the effort required to carry water to some infestations, the eradication field crews filter water from nearby creeks during the summer wet season and are investigating whether water drops via helicopter to some infestations are feasible (R. Winton Pers Comm., 2011). Since this initial trial, a subsequent trial was established in May 2010 to determine if lower rates of fluroxypyr and/or herbicides containing fluroxypyr, without aminopyralid, are as effective as the Hotshot treatment in this trial. If lower rates of fluroxypyr are found to be equally effective, then significant reductions in the amount of herbicide used and cost will result. A further trial has been established (May 2011) to investigate whether higher rates of the granular Brush-Off could be more effective than the 2 g/L used in this trial. Identifying effective alternative treatments from these subsequent trials would reduce the volume or remove the need to carry any liquid herbicides to infestations.

All the information from this series of trials and field crew records will be used to build a more detailed picture of the relative costs and efficiencies that result from splatter gun herbicide applications, as compared with other control measures. In the case of this first trial, conventional spraying is not possible so the comparison would be with manual control or spraying from an aerial platform. Spraying from an aerial platform was first trialled in this area in 2010 and its effectiveness has not yet been assessed. However, due to the cost of helicopter hire, this treatment may be limited to the initial management of the very dense and the least accessible infestations. Manual control is an effective control measure, but it is slow, strenuous, disturbs the soil and workers may need to excavate the Siam weed basal ball from between or beside rocks. Splatter gun applications effectively treat large plants up to 10 m away, whereas some alternative treatments, such as physical removal and cut stump, field staff are required to access the base of each plant, irrespective of the surrounding vegetation or terrain.

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