Increased options for controlling mikania vine (*Mikania micrantha*) with foliar herbicides

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Summary *Mikania micrantha* Kunth (mikania vine) is a highly invasive tropical weed that was first discovered in Australia in 1997, and has been the target of a nationally cost-shared weed eradication program since 2003. Field crews have been effectively treating the weed with herbicide solutions containing 1 g a.i. L^{-1} of fluroxypyr. During the eradication program there have been limited opportunities to test alternative foliar herbicides or rates. A newly discovered infestation provided sufficient immature vines to compare the effectiveness of eight herbicide treatments.

Herbicide solutions containing 0.7 g a.i. L^{-1} of fluroxypyr, 1.02 g a.i. L^{-1} of triclopyr, 1.98 g a.i. L^{-1} of triclopyr and 1.05 g a.i. L^{-1} of triclopyr + 0.35 g a.i. L^{-1} of picloram + 0.028 g a.i. L^{-1} of aminopyralid were equally effective as the current treatment containing 1 g a.i. L^{-1} of fluroxypyr. In these treatments, average mikania presence declined from over 98% of sub-quadrats before treatment to 0–2% presence five months after treatment. Three other treatments were significantly less effective. On average, mikania vine was present in 75% and 31% of sub-quadrats treated with solutions containing 0.06 g and 0.12 g a.i. L^{-1} of metsulfuron-methyl respectively. It was also present in 88% of sub-quadrats in plots treated with 3.6 g a.i. L^{-1} of glyphosate, which was similar to untreated control plots (94%). Several rates of fluroxypyr and triclopyr based herbicides were identified as cost effective alternatives to the current treatment and provide more options for treating this weed.

Keywords Fluroxypyr, triclopyr, eradication, metsulfuron-methyl.

INTRODUCTION

Mikania micrantha Kunth (mikania vine, Asteraceae) is a rampant, smothering tropical weed, readily capable of vegetative dispersal and seed dispersal by wind, water or machinery. It is one of the most serious weeds across tropical Asia, the Indian sub-continent and Pacific regions (e.g. Banerjee and Dewanjii 2012) and has been the subject of a national cost-shared eradication program in Australia since 2003 (the National Four Tropical Weeds Weed Eradication Program, NFTWEP). It was first discovered in north Queensland near Mission Beach in 1997 and further infestations were found around Mission Beach, Forrest Beach, Ingham and Speewah (Brooks *et al.* 2008).

Eradication programs must be able to implement effective control measures across the entire incursion (Myers *et al.* 2000). The NFTWEP field crews routinely use the herbicide Starane™ Advanced as a foliar spray (equivalent to 1 g a.i. L^{-1} of fluroxypyr) on large patches of mikania vine and have not reported issues with the efficacy of this treatment. Additional control measures include the physical removal of isolated vines in the rainforest and spraying with glyphosate products approved for aquatic use where vines grow near creeks. By the end of 2013, 46% of all mikania infestations had transitioned to the monitoring phase (i.e. no plants present for one year or more) (S. Brooks unpublished data). While infestations are being effectively managed and progressing towards eradication, the NFTWEP primarily depends on the 1 g a.i. L^{-1} of fluroxypyr herbicide to treat mikania vine. Issues may arise if there were changes in availability or registration of this product, or if more mikania vine is found in situations (such as aquatic, cropped areas, some grazing lands or rainforest vegetation types) where this herbicides use is not permitted or desirable. Herbicide control of mikania vine is currently conducted under the minor use permit for the control of environmental weeds APVMA (2013). Additional research would support an application for a minor use permit for mikania vine should one be sought. Program stakeholders requested a trial of metsulfuron-methyl based herbicides for use on rainforest margins.

For several years, there were insufficient areas of immature vines discovered to enable a replicated herbicide trial. However, the discovery of a new infested patch near Mission Beach in 2012 provided enough vines to conduct the trial outlined below. Immature vines are required for this research as seed production threatens the eradication goal.

MATERIALS AND METHODS

The trial was located on previously cleared, privately owned land adjacent to a banana plantation and patches of rainforest, near Mission Beach (17°51' S, 146°05' E and 48 m above sea level). The site was discovered during extended ground surveys on 22 August 2012. Immature mikania vines had formed a dense cover amongst tropical grasses and other weeds over an area of approximately 0.1 ha.

Three replicate blocks of nine plots were established on 18 October 2012. Each plot was 4 × 4 m in size and surrounded by a 1 m buffer. The plot buffer was created at establishment with an application of Weedmaster® DUO® (3.6 g a.i. L^{-1} of glyphosate) to surrounding ground level vegetation. This was to help delineate the plots and limit potential interactions between treatments. Nine treatments listed in Table 1 were randomly assigned to plots within blocks.

Pre treatment assessments were undertaken on 18 October 2012 and 21 November 2012. Because the mikania vine was a tangled mat of intermingled vines with multiple points of root attachment, tagging and recording individual plants was impossible. Instead, presence and/or percent cover of mikania were recorded in small sub-quadrats.

All assessments were conducted on 4 × 1 m^2 quadrats (as a 2 × 2 m block) around a pin marker in the centre of the treated area. The percentage of mikania vine covering the ground was recorded in four, 50 × 50 cm sub-quadrats per quadrat, which provided 16 sub-quadrat readings per plot. Readings were summed to calculate average cover per square metre and per plot, and tallied to provide presence data per plot.

Herbicide treatments were applied between 8:30 am and 1:30 pm on 23 November 2012. It was a sunny day with temperatures ranging between 27 and 29°C. Humidity dropped from 74 to 65% during application, and the wind was a light north-north-easterly at less than 8 km h^{-1}. Red Spraymate™ Spray Marker Dye (150 g L^{-1} Rhodamine B) was added to each herbicide mixture at a rate of 1 mL L^{-1} of solution. Fifteen litres of each treatment was prepared to treat mikania vine at a volume of 3000 L ha^{-1}. It took approximately seven minutes to treat each plot (16 m^2), with a backpack sprayer and hand wand.

Post-treatment assessments were conducted 26 (19 December 2012) and 152 (24 April 2013) days after treatment (DAT) using the same methodology as the pre-treatment assessments. By late April 2012, flower buds had started to form on some plants near the trial, but no flowering was observed in the untreated control plots. As this species is an eradication target all mikania vine in the trial area, including the control plots, were treated with Starane Advanced (1 g a.i. L^{-1} of fluroxypyr) after the last assessment.

Genstat 14th Edition (VSN International) was used to undertake analysis of variance on the plot means (three per treatment) to determine if there were significant treatment effects at each assessment time. Fisher's protected least significant difference (LSD) identified which treatments differed from each other.

Table 1. Herbicide treatment details.

Product	Active ingredients	Active rate	Active (g L^{-1})	Amount of product used per L water	Cost of herbicide per L of water ($)*
Control					
Brush-Off®**	Metsulfuron-methyl	600 g kg^{-1}	0.06	0.1 g	0.02
Brush-Off®**	Metsulfuron-methyl	600 g kg^{-1}	0.12	0.2 g	0.04
Garlon™ 600***	Triclopyr	600 g L^{-1}	1.02	1.7 mL	0.03
Garlon™ 600***	Triclopyr	600 g L^{-1}	1.98	3.3 mL	0.06
Grazon™ Extra***	Triclopyr, picloram, and aminopyralid	300 g L^{-1} + 100 g L^{-1} + 8 g L^{-1}	1.05 0.35 0.03	3.5 mL	0.12
Starane™ Advanced***	Fluroxypyr	333 g L^{-1}	0.67	2 mL	0.05
Starane™ Advanced***	Fluroxypyr	333 g L^{-1}	1.00	3 mL	0.07
Weedmaster® DUO®**	Glyphosate	360 g L^{-1}	3.60	10 mL	0.07

* Based on approximate commercial prices of 20 L of liquid herbicide or 200 g container of Brush-Off at the time of the trial.
** 2 mL L^{-1} of Pulse® penetrant was added to these treatments at a cost of $0.09 L^{-1} of solution.
*** 5 mL L^{-1} of Uptake™ spraying oil was added to these treatments at a cost of $0.03 L^{-1} of solution.

RESULTS

The assessments proved to be efficient and robust, with the presence data providing a consistent measure of treatment effects. Dry conditions in November and December 2012, and some variation in estimates between assessments influenced the cover data, although the main treatment effects were similar for both coverage and presence measures.

Prior to implementation of treatments, mikania vine was present in all 432 sub-quadrats across 27 plots on 18 October 2012 and in 431 sub-quadrats on 23 November 2012. In contrast, no mikania was present in the two fluroxypyr treatments or the triclopyr + picloram + aminopyralid treatment in either of the post treatment assessments (Table 2). There was also no significant difference in the presence of mikania vine between these three effective treatments and the two rates of triclopyr 152 DAT. Mikania vine was suppressed but not controlled by the two rates of metsulfuron-methyl tested. Whilst there was an initial reduction in the presence of mikania vine in the glyphosate-treated plots, the vines rapidly re-invaded most of the quadrats over the next four months. The buffer created prior to treatment served to separate the treated areas well, although the vines in the glyphosate and control plots were expanding beyond their buffers when the trial concluded.

Table 2. Percentage of sub-quadrats with mikania vine present. For each assessment time, means followed by different letters are significantly different at p=0.05.

Active ingredients and rate (g a.i. L^{-1})	26 DAT	152 DAT
Control	93.8a	93.8a
Glyphosate (3.6)	12.5d	87.5b
Metsulfuron-methyl (0.06)	75.0b	75.0c
Metsulfuron-methyl (0.12)	58.3c	31.3d
Triclopyr (1.02)	6.3e	2.1e
Triclopyr (1.95)	0.0f	2.1e
Triclopyr (1.05) + picloram (0.35) + aminopyralid (0.03)	0.0f	0.0e
Fluroxypyr (0.67)	0.0f	0.0e
Fluroxypyr (1.00)	0.0f	0.0e
SEM	0.89	1.17
LSD statistic	2.68	3.50

DISCUSSION

This trial confirmed the effectiveness of the current treatment (Starane Advanced at 1 g a.i. L^{-1} fluroxypyr) and identified a number of effective and similarly priced alternatives. Applying the lower rate of fluroxypyr would cost approximately \$4.95 compared to \$7.43 if using the higher rate of Starane Advanced in 100 L of water at the current retail price. As limited areas are treated each year and the field crews are satisfied with the higher rate throughout the year, there are no current plans to deviate from the higher rate, though there is now the option to use a lower rate.

In a series of herbicide trials on mikania vine in forestry plantations in the Indian state of Kerala, Sankaran *et al.* (2001) and Sankaran and Pandalai (2004) found no significant difference between Grazon DS (triclopyr and picloram) and Garlon (triclopyr): these two herbicides were consistently more effective than herbicides containing 2, 4-D, paraquat and low rates of diuron. Given the same product names, active ingredients and similar mixture rates were used by Sankaran *et al.* (2001), it is assumed that the triclopyr and glyphosate products tested by Sankaran and Pandalai (2004) are comparable with products and rates used in this study.

Triclopyr, as Garlon 600, achieved 90%+ control of mikania vine, when applied at 1 mL, 2 mL and 4 mL L^{-1} by Sankaran *et al.* (2001) and Sankaran and Pandalai 2004. They found the higher product rate consistently gave a slightly higher level of control (though this was not significant). In Queensland, triclopyr products are listed by APVMA (2013) for spot spray at 3.3 mL to 1 L of water, and at 1.7 mL to 1 L of water on the local Garlon 600 label, which is within the range of the rates found to be effective in India. For the two triclopyr rates in this trial, there are some indications, including the assessment 26 DAT, that the higher rate provides more consistent control. Triclopyr based herbicides are registered for use in certain aquatic situations overseas (eg. Madigan and Vitelli 2012), so it may be useful to trial their efficacy for treating mikania vine growing over creek lines.

Where grazing stock are present, local field crews treating *Chromolaena odorata* (L.) R.M.King & H.Rob. prefer to use 1.05 g a.i. L^{-1} of triclopyr + 0.35 g a.i. L^{-1} of picloram + 0.028 g a.i. L^{-1} of aminopyralid (e.g. Grazon™ Extra) in preference to 1 g a.i. L^{-1} of fluroxypyr (Starane Advanced), which has a seven day withholding period. This trial shows that Grazon Extra could be used to treat mikania vine in paddocks where cattle, to be sold domestically, are grazing.

The immature state of the vines on discovery and the absence of seedling emergence in the fluroxypyr and triclopyr treated plots at the final assessment indicates there was not a large soil seed bank present in the trial patch. Thus, no conclusions can be drawn about the relative advantages of pre-emergent components of Grazon Extra (picloram and aminopyralid) over the equally effective post-emergent ingredient (triclopyr in Garlon 600) at a similar rate. While the pre-emergent herbicides would be less suitable for use in and around rainforest vegetation and tropical creeks there may be other disturbed or grassed situations where a more expensive pre-emergent application is warranted.

It is thought that the mikania vine present in the glyphosate and metsulfuron-methyl plots 152 DAT was mostly due to re-growth of existing vines rather than seedling emergence. In the plantation trials reported by Sankaran *et al.* (2001) and Sankaran and Pandalai (2004), glyphosate at 5, 10 and 20 mL L^{-1} controlled more than 70% of mikania vine up to 180 days after treatment, with the higher rates slightly more effective. However this trial suggests that fluroxypyr or triclopyr based herbicides should be used in preference to glyphosate when suitable, as they proved far more effective.

Sankaran *et al*. (2001) found 0.2 g L^{-1} of metsulfuron-methyl reduced mikania vine biomass by 33% and was one of the less effective treatments tested. There was no further testing of metsulfuron-methyl in the eight field trials reported by Sankaran and Pandalai (2004). In this trial, the 0.12 g a.i. L^{-1} rate of metsulfuron-methyl provided approximately 70% control, so a higher rate again could be more effective and still be cost competitive. Although the mikania vine presence also declined between the 26 and 152 DAT assessments in the higher rate tested, the re-growth in those plots looked healthy when inspected and photographed as the trial concluded. A longer trial and/or a higher rate may show this treatment to be more effective; however this field trial had to conclude as the flowering season commenced. An effective metsulfuron-methyl (a Group B herbicide) treatment would be useful as the currently effective treatments all belong to the pyridine herbicide group (Group I), with the same mode of action.

In conclusion, several rates of fluroxypyr- and triclopyr-based herbicides were identified as cost effective alternatives to the current treatment and provide more options for treating this weed.

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REFERENCES

Australian Pesticides and Veterinary Medicines Authority (2013). Minor use permit 11463 – Environmental weeds in non-crop areas. http://permits.apvma.gov.au/PER11463.PDF (accessed 7/5/13). (Australian Government, Canberra).

Banerjee, A.K. and Dewanji, A. (2012). *Mikania micrantha* H.B.K. – a potential and economical threat to global biodiversity with special emphasis on Indian context. Proceedings of the 18th Australasian Weeds Conference, ed. V. Eldershaw, pp. 17-20. (Weed Society of Victoria Inc, Melbourne).

Brooks, S.J., Panetta, F.D. and Galway, K.E. (2008). Progress towards the eradication of mikania vine (*Mikania micrantha*) and limnocharis (*Limnocharis flava*) in northern Australia. *Invasive Plant Science and Management* 1, 296-303.

Madigan, B.A. and Vitelli, J.S. (2012). Herbicide control of submerged bog moss (*Mayaca fluviatilis* Aubl.). Proceedings of the 18th Australasian Weeds Conference, ed. V. Eldershaw, pp. 30-3. (Weed Society of Victoria Inc, Melbourne).

Myers, J.H., Simberloff, D., Kuris, A.M and Carey, J.R. (2000). Eradication revisited: dealing with exotic species. *Trends in Ecology and Evolution* 15, 316–20.

Sankaran, K.V., Muraleedharanm P.K. and Anitha, V. (2001). Integrated management of the alien invasive plant *Mikania micrantha* in the Western Ghats. KFRI Research Report 202, p. 51. (Kerala Forest Research Institute, Peechi, India).

Sankaran, K.V. and. Pandalai, R.C. (2004). Field trials for controlling mikania infestation in forest plantations and natural forests in Kerala: Final report of the Research Project KFRI 333/'99, 52 pp. (Kerala Forest Research Institute, Peechi, India).