Control of bracken (*Pteridium esculentum*) in Tasmania using wiper application of metsulfuron methyl and glyphosate

K.R. Young[A] and **P.W.G. Sale**[B]
[A] CRC for Weed Management Systems, The University of Melbourne, Melbourne, Australia.
[B] Department of Agricultural Sciences, La Trobe University, Melbourne, Australia.

Summary

Bracken (*Pteridium esculentum*) was effectively controlled for 2.5 years using metsulfuron methyl with and without the addition of glyphosate, applied by a wiper. Wiper application gave more immediate control and there was less regrowth at the end of the experiment compared with sprayed treatments. A mixture of metsulfuron methyl and glyphosate applied through a wiper gave the best results, with up to 95% bracken control. Further investigations of wiper application using a mixture of metsulfuron methyl and glyphosate at seven sites around Tasmania, gave greater than 85% control of bracken when assessed 10 months after application. Results show that only a single pass with a carpet type wiper is required for bracken control. Control of bracken was achieved with applications from January through to May (mid summer through till autumn).

Introduction

Metsulfuron methyl was registered for bracken fern (*Pteridium esculentum* (G.Forst.) Cockayne) control in 1987, when applied with a handgun at 0.1 g a.i. L^{-1} and through a boom sprayer at 36 g a.i. ha^{-1} in 1988 (Arends and Velthuis 1990). Since registration, metsulfuron methyl has been used in Australia extensively for bracken control. As metsulfuron methyl is toxic to clover (*Trifolium* spp.) and other legumes (Popay *et al.* 1985, Turner *et al.* 1986), its use through a boom or handgun sprayer can result in clover being eliminated from a pasture. However, the height differential between the clover and bracken can be used to selectively apply metsulfuron methyl by using a wiper applicator, avoiding direct physical contact with the clover. As metsulfuron methyl is less toxic to common pasture grass species such as ryegrass (*Lolium perenne* L.), phalaris (*Phalaris* spp.) or cocksfoot (*Dactylis glomerata* L.) (West and Richardson 1987, Standell and West 1989, West and Standell 1989) the height differential is only required between the legume and the bracken.

The effectiveness of wiper applicators to apply herbicides for bracken control in Australian pastures has been demonstrated by several workers using two types of wipers, rope wicks (Winkworth and Hamilton 1986, Moore and Jones 1988) and carpet wipers (Winkworth and Hamilton 1986, Hamilton 1990). Herbicides assessed for bracken control using wipers are; asulam (Winkworth and Hamilton 1986, Hamilton 1990), glyphosate (Winkworth and Hamilton 1986, Moore and Jones 1988, Hamilton 1990) and metsulfuron methyl (Hamilton 1990). The best bracken control was obtained by applying glyphosate (Winkworth and Hamilton 1986) or metsulfuron methyl (Hamilton 1990) with a carpet wiper. A direct comparison between wiper application and spraying has not been documented.

A field experiment was established at Flowery Gully in northern Tasmania in the summer of 1989, to compare herbicides and application methods for bracken control. Preliminary observations at this site indicated that a mixture of metsulfuron methyl and glyphosate, applied by a wiper applicator, achieved a rapid reduction in live bracken frond numbers. A number of field trails were therefore established at locations around Tasmania in the autumn of 1989, to determine the efficacy of a mixture of metsulfuron methyl with glyphosate, applied by wiper.

This paper documents the results at the Flowery Gully site over a 2.5 year period, and the short term results (10 months) for seven locations around Tasmania (Figure 1).

Materials and methods

Flowery Gully experiment

A randomized block experiment with three replicates was conducted at Flowery Gully, Tasmania (41°S Latitude, 147°E Longitude) which has a 900 mm per annum rainfall, and consisted of an improved pasture paddock that had been invaded by bracken.

The eight treatments that were allocated randomly to plots within the three blocks, are listed in Table 1. The herbicides were applied by either a felt carpet wiper (Weedswiper®) on 7 February 1989 or by a small plot boom sprayer on 1 March 1989. The later application date for the spraying treatments was due to very windy conditions when the wiping treatments were applied, which made spraying in small plots unfavourable due to spray drift. The Weedswiper uses an electronic sensor to ensure that the felt pads are maintained at saturation point. The felt pads measured 2 × 0.25 m and were changed between each wiping treatment to avoid carry over contamination. All wiping treatments were wiped in two directions (up and back). The high wiping rate for metsulfuron methyl (6 g a.i. L^{-1}) was extrapolated from the registered boom spray rate of 36 g a.i. ha^{-1}, based on the assumption that the wiper applicator applied 6 L of herbicide solution per hectare. This application rate is based on previous unpublished data for application to several thistle species, using this type of wiper applicator. The small plot boom sprayer was calibrated to apply 232 L ha^{-1} at 250 kPa through Spraying Systems® XR 11002 flat fan nozzles. A comparison of two spray additives, Pulse® and Ulvapron® were compared, using the lower metsulfruon methyl spraying rate. All other treatments had Pulse added.

Table 1. Treatment details for Flowery Gully experiment.

Treatment number	Active ingredient	Application rate	Additive	Applicator	Application date
1.	Metsulfuron methyl	6.0 g a.i. L^{-1}	Pulse 2 mL L^{-1}	Wiper	7 February 1989
2.	Metsulfuron methyl	3.0 g a.i. L^{-1}	Pulse 2 mL L^{-1}	Wiper	7 February 1989
3.	Metsulfuron methyl + glyphosate	1.5 g a.i. L^{-1} 120 g a.i. L^{-1}	Pulse 2 mL L^{-1}	Wiper	7 February 1989
4.	Glyphosate	120 g a.i. L^{-1}	Pulse 2 mL L^{-1}	Wiper	7 February 1989
5.	Metsulfuron methyl	36 g a.i. ha^{-1}	Pulse 2 mL L^{-1}	Boom sprayer	1 March 1989
6.	Metsulfuron methyl	24 g a.i. ha^{-1}	Pulse 2 mL L^{-1}	Boom sprayer	1 March 1989
7.	Metsulfuron methyl	24 g a.i. ha^{-1}	Ulvapron 10 mL L^{-1}	Boom sprayer	1 March 1989
8.	Untreated				

The bracken was fully unfurled at application time, with some senescent bracken fronds present when the spraying treatments were applied. The wiper was set as low as possible to just avoid contact with the clover content of the pasture. Erect grasses present (perennial ryegrass) were wiped along with the bracken.

The plot size was 2 × 20 m. A buffer strip, 1 m wide was included around each untreated plot. The purpose of the buffer strip was to reduce the possible effect of rhizomes from the untreated areas affecting neighbouring plots. The buffer strips were treated with 36 g a.i. ha^{-1} metsulfuron methyl applied through the same boom sprayer as the spraying treatments.

Live bracken fronds were counted in January 1989, prior to herbicide application, and then again on 22 March 1989 (three weeks after spraying application), May 1989, monthly from September 1989 to October 1990 and then in February 1991, May 1991 and August 1991. The total number of live bracken fronds (any fronds which were still green or partly green) in ten 0.25 m^2 permanent quadrats in each plot were counted at each assessment time. Counts were square root transformed before undertaking an analysis of variance for each assessment. Statistical analysis was carried out using Genstat 4.

Field trials

Seven trial sites were located throughout Tasmania (Figure 1) and treated in the autumn of 1989, with a mixture of metsulfuron methyl and glyphosate, following its rapid brown out (rate of decrease in number of live fronds) at the Flowery Gully site (Figure 2). At all sites, metsulfuron methyl at 1.5 g a.i. L^{-1} plus glyphosate at 60 g a.i. L^{-1} with the wetter Pulse at 2 mL L^{-1}, was applied by the Weedswiper to an area of 8 × 25 m (Table 2). Most applications were applied in March 1989, although a later application occurred at the Copping site. The bracken fronds were double wiped at all sites, with an additional single wiping treatment at the Copping and Waterhouse sites. Untreated areas were adjacent to treated areas.

Ten 0.25 m^2 quadrats were randomly selected for both the wiped and control treatments at all sites. Live frond numbers were counted within each quadrat, on 17 or 18 January 1990 (at Castra, Smithton, Mole Creek and Waterhouse sites) or on 30 or 31 January 1990 for other sites.

At the sites where only one wiping treatment occurred, comparisons between the wiped and the untreated counts were analysed using Fishers studentized t-test, assuming non equal variances. At sites with more than one wiping treatment (Copping and Waterhouse), the counts were compared using analysis of variance.

Results

Flowery Gully experiment

All the wiping treatments produced significantly lower (P<0.05) frond numbers compared with the untreated control by March 1989, six weeks after application. The reduction in frond numbers was maintained for the next 27 months (Figure 2). While there was no significant difference between the wiping treatments, the mixture of metsulfuron methyl and glyphosate had fewer live fronds during the experiment, especially from October 1990 till August 1991, when other treatments had frond regrowth occurring. Generally, the glyphosate wiping treatment was not as effective as the other wiping treatments, with brown out being slower, and the level of control being less than the other wiping treatments.

The spraying treatments had a slower decline in live frond numbers than the wiping treatments, although control levels were not significantly different within one year from application. This slower decline in frond numbers may not be due to method of application but possibly due to the time of application, as spraying treatments were applied three weeks after the wiping treatments. The least effective treatment was the spraying treatment containing the adjuvant Ulvapron. This treatment required eight months (till September 1989) before frond numbers were significantly less than the untreated control and only maintained this significant reduction for a period of 15 months (till February 1991).

Field trials

At most sites, the treatments gave greater than 90% control (reduction in live frond numbers compared to the untreated), when measured 10 months after application (Tables 3 and 4). However at the Wilmot and Waterhouse sites, there was less than 85% control achieved.

The wiping treatments at Copping and Waterhouse, all gave significant reductions in bracken frond numbers (Table 4). Single wiping gave similar control to double wiping at both sites. The later

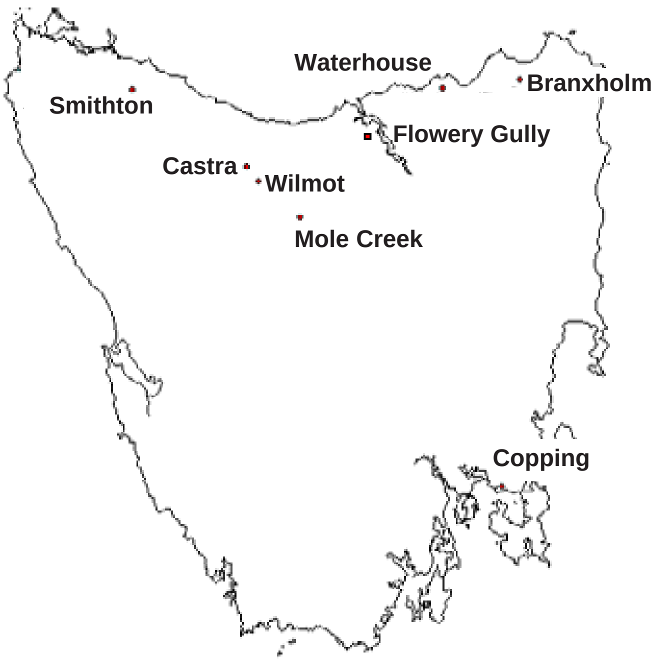

Figure 1. Locations of all experimental sites: Flowery Gully, Branxholm, Castra, Smithton, Mole Creek, Wilmot, Copping and Waterhouse.

Table 2. Treatment and site information for field trials around Tasmania.

Site	Annual rainfall	Application date	Wiping frequency
Branxholm	1077 mm	9 March 1989	Double
Castra	950 mm	16 March 1989	Double
Smithton	1104 mm	16 March 1989	Double
Mole Creek	1083 mm	17 March 1989	Double
Wilmot	950 mm	16 March 1989	Double
Copping	584 mm	31 March 1989	Single
Copping	584 mm	31 March 1989	Double
Copping	584 mm	18 May 1989	Double
Waterhouse	600 mm	9 March 1989	Double
Waterhouse	600 mm	9 March 1989	Single

herbicide application at the Copping site had lower live fronds numbers, though this was not statistically significant from the other treated areas.

Discussion

Bracken frond numbers were reduced and maintained at low levels for 2.5 years at the Flowery Gully site, by all treatments. The wiping treatments in particular, gave rapid brownout and maintained a high level of control for the remainder of the experiment (Figure 2). The spraying treatments using the wetter Pulse gave similar bracken control to the wiping treatments, though they were slower to brownout. The spraying treatment using the adjuvant Ulvapron, gave the least reduction in frond numbers and had the greatest regrowth.

The rapid brownout by the wiping treatments could be due to the wiper applying herbicides to the underside of the bracken fronds. Moore and Jones (1988) observed the application of herbicide to the underside of fronds when using rope wick wipers. The author's have also observed this occurring with the Weed-swiper. Al-Jaff *et al.* (1980) indicated that the uptake of herbicide is likely to be greater on the lower surface on the frond, due to more numerous trichomes and stomates than on the tough waxy upper surface. Kirkwood (1990) also demonstrated the greater herbicide uptake from the abaxial surface of a bracken frond. Alternatively, the rapid brown out may be due to time of application, as wiping treatments were applied three weeks before the boom spray applications. Fagan *et al.* (1990), found that early summer applications were marginally better than autumn applications when applying metsulfuron methyl using a boom sprayer. Also, Moore and Jones (1988) recorded a reduction in bracken control with glyphosate when applied by rope wick in March (80% fully unfurled fronds at application) compared to application in December or January (both 75% fully unfurled fronds at application). This indicates that application on more mature fronds is less effective, and this may have occurred with the boom spray treatments in this study. However in our field trials, we achieved good bracken control (Tables 3 and 4) with all applications applied in March and as late as May. Given that young fronds have a greater uptake of herbicides, while older fronds have a greater capacity to translocate herbicides, (Gaskin and Zabkiewicz 1990, Veerasekaran 1975 cited by Kirkwood 1990), there is need to determine the growth stage of bracken when herbicide should be applied, to achieve the optimal combination of both absorption and translocation of the herbicide to the bracken rhizome. It is important to get translocation of the herbicide into the large bracken

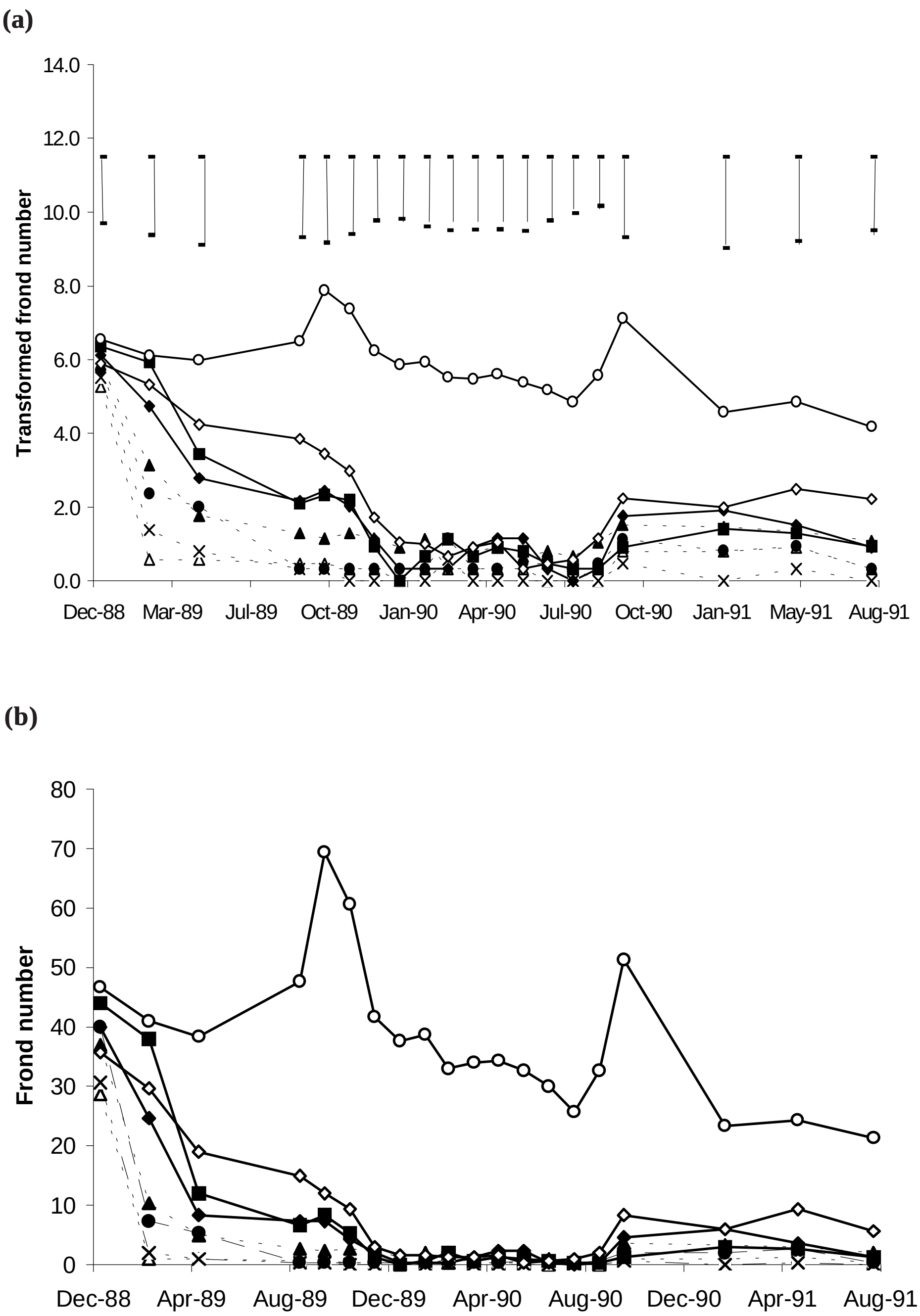

Figure 2. Bracken frond numbers per m² using transformed data (a) and actual frond number (b). Spraying treatments (—): 36 g a.i. ha^{-1} metsulfuron methyl (■), 24 g a.i. ha^{-1} metsulfuron methyl (◆), 24 g a.i. ha^{-1} metsulfuron methyl plus Ulvapron® (◇). Wiping treatments (- - -): 6 g a.i. L^{-1} metsulfuron methyl (●), 3 g a.i. L^{-1} metsulfuron methyl (△), 1.5 g a.i. L^{-1} metsulfuron methyl plus 120 g a.i. L^{-1} glyphosate (×), 120 g a.i. L^{-1} glyphosate (▲) untreated (○). Bars represents Fishers protected LSD (P=0.05).

Table 3. Comparison of wiping treatment to untreated bracken fronds 10 months after application at different sites throughout northern Tasmania.

Site	Wiping frequency	% control	frond m^{-2} treated	frond m^{-2} untreated	t test p
Castra	Double	94	0.4	6.8	0.022
Smithton	Double	100	0.0	4.4	0.029
Mole Creek	Double	97	0.4	14.8	0.001
Wilmot	Double	75	2.4	9.6	0.012
Branxholm	Double	91	1.2	12.8	0.002

rhizome system to effectively control this plant.

Although spraying and wiping treatments eventually reached the same level of control, the rapid brownout by the wiping treatments (or the earlier application) can have several beneficial effects. Firstly, having brownout as soon as possible after application will create greater confidence in the use of the herbicide(s) by the operator than having to wait six to nine months for brownout to occur. Secondly, the rapid brown out of bracken would decrease bracken's competitive effect on pasture species as extra light would pass through to the lower pasture understorey, enabling greater pasture growth (Winkworth and Hamilton 1986). A third beneficial effect of a rapid brownout of bracken is that the extra time without active photosynthesis may improve long-term results as less photosynthate is translocated into the storage organs of bracken.

Treatments that had a slower brownout in the Flowery Gully experiment, also had a greater increase in bracken numbers near the end of the experiment (from October 1990). These were the spraying treatments, and two wiping treatments, the higher rate of metsulfuron methyl (6 g a.i. L^{-1}) and glyphosate applied alone. The spraying treatment using Ulvapron took the longest time to brownout; it did not differ significantly ($P<0.05$) from the control until nine months (36 weeks) after application. This treatment also had the greatest recovery of bracken fronds. The two wiping treatments that had the most rapid brownout, metsulfuron methyl at 3 g a.i. L^{-1} and the glyphosate metsulfuron methyl mixture, maintained the highest level of control (>90%) for the length of the experiment (March 1989 to August 1991, Figure 2). The higher rates of metsulfuron methyl, in both the spraying and wiping treatments, took longer to brownout than the lower rates (Figure 2). This raises the possibility that the higher rates were too phytotoxic causing severe cytological effects (collapsed cells and necrotic tissue) as reported by Hallam *et al.* (1987) with glyphosate. The localized death of cells could prevent the further translocation of the herbicide around the rhizome system of bracken.

Both glyphosate (Grossbard and Atkinson 1985) and metsulfuron methyl (Arends and Vethuis 1990) are translocated herbicides. Throughout this experiment and in our field trials, the delineation between treated and untreated plots was readily observed. The only observation that may be related to herbicide translocation was the general decline of the untreated plots in the Flowery Gully experiment. At the start of the experiment these were around 45 fronds m^{-2}, but at the end of the experiment it was close to 25 fronds m^{-2}. Sheffield *et al.* (1989) suggested that a large bracken infestation may in fact be only one plant. If this is the case, then having the majority of the area treated in one form or another may have weakened the whole plant enough to cause a general decline in frond numbers. However, the distinct delineation between treated and untreated plots suggests that there was little herbicide translocation along the rhizome system as would be expected in the source sink relationship of translocated glyphosate and metsulfuron methyl. Further investigation is needed to determine the level of translocation of these herbicides into bracken rhizome.

Table 4. Effects of wiping bracken at Copping and Waterhouse.

Site	Wiping frequency	Application time	% control	Frond number m^{-2}
Copping	Single	March	85	2.2a
	Double	March	88	1.8a
	Double	May	96	0.6a
	Untreated			15.4b
Waterhouse	Single	March	82	3.6a
	Double	March	70	6.0a
	Untreated			16.8b

Means followed by the same letter are not significantly different $P<0.05$.

Moore and Jones (1988) concluded that double wiping was required to obtain maximum bracken control with rope wick wipers. However, from our series of field trails, single wiping is adequate as there was no statistical difference between single and double wiping at both the Waterhouse and Copping sites (Table 4). The reason for this difference may be due to wiper type used in the two studies; Moore and Jones (1988) used a rope wick applicator, whereas a felt carpet wiper was used in this study. Winkworth and Hamilton (1986) and Hamilton (1990) were also able to successfully control bracken through a single application using a carpet wiper. Single wiping reduces the total herbicide applied which has benefits for both the environment and the economics of bracken control.

Further examination of mixtures of glyphosate and metsulfuron methyl is warranted as optimum metsulfuron methyl rates have not yet been established for use through any wiper applicator. Optimum boom spray rates for metsulfuron methyl have been established at 36 g a.i. ha^{-1} with rates as low as 24 g a.i. ha^{-1} being effective if environmental conditions are favourable (Arends and Vethuis 1990, Fagan *et al.* 1990). With glyphosate, the registered label wiping rate is 120 g a.i. L^{-1} through a rope wick applicator. Our results show that low rates of metsulfuron methyl (1.5 g a.i. L^{-1} which equates to 15 g a.i. ha^{-1}) when combined with half the registered glyphosate rate gave effective control of bracken. The effectiveness of lower rates of metsulfuron methyl and glyphosate needs to be investigated. Also there appears a need to determine the optimal application time. This should be based on the physiological stage of bracken not on calendar dates, as this will assist in comparing results between different environments.

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