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Article

Efficacy of Chemical Herbicides Using a Novel Encapsulated Delivery Mechanism for Mimosa Bush *(Vachellia farnesiana)* Control

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Abstract: Mimosa bush (*Vachellia farnesiana*) is an invasive woody weed widely distributed in Australia. While it can be controlled using several mechanical and chemical techniques, this study evaluated a novel new herbicide delivery mechanism that minimizes the risk of spray drift and potential non-target damage. It was developed by Bioherbicides Australia and involves the implantation of encapsulated granular herbicides into the stem of intact plants or into the stump after cutting off plants close to ground level (cut stumped). Trials were implemented near Moree (NSW, Australia) on intact (two trials) plants and cut stumped (two trials) plants. For each trial, an untreated control plus the conventional basal bark application of a liquid formulation of triclopyr/picloram mixed with diesel was included for comparison. Encapsulated glyphosate, aminopyralid/metsulfuron-methyl, hexazinone and clopyralid were also tested in all trials. In addition, triclopyr/picloram, and metsulfuron-methyl were included in at least one of the whole plant trials. Aminopyralid/metsulfuron-methyl was consistently most effective at controlling intact plants, whilst aminopyralid/metsulfuron-methyl and clopyralid provided highest mortality when applied to cut stumps of mimosa bush. Overall, highest efficacy was achieved on single stemmed plants, but with some further refinement of the technique it should be possible to achieve similar results for multi-stemmed species.

Keywords: mimosa bush; control; chemical herbicides; encapsulation; implantation.

1. Introduction

Mimosa bush (*Vachellia farnesiana* (L.) Wight & Arn.) is a naturalised species that has become widely distributed throughout northern Australia, particularly in grasslands and savannah areas[1]. At low population densities, it is generally not considered a problem for land managers and could have some benefits, such as providing an alternative animal feed during the dry season[2-4]. Nevertheless, mimosa bush has become a threat in areas where it forms large and dense infestations that compete with pasture grasses for moisture, soil nutrition and light. In high populations, its thorny stems can also interfere with livestock access to water resources (e.g., dams) and disrupt the mustering of animals[5, 6].

Despite the impacts of mimosa bush in the Australian context, there is limited published information on control options for this problematic weed. Despite this, some foliar[7-9], basal bark and cut stump applications using liquid formulations of a limited range of herbicides are recommended for control of mimosa bush[10]. Some of the recommended herbicides for foliar applications include triclopyr/picloram, glyphosate, aminopyralid, metsulfuron-methyl, clopyralid, and fluroxypyr. This technique is beneficial because of its speed of application, but it has potential for spray drift and off-target damage[11-13]. Basal bark spraying has proven effective for many woody weeds in Australia,

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including prickly acacia (*Vachellia nilotica*)[14], mesquite (*Prosopis* spp.)[15], parkinsonia (*Parkinsonia aculeata*)[16], calotrope (*Calotropis procera*)[17] and mimosa bush[18]. The herbicide must be in an oil-soluble form so as it can be mixed with diesel and sprayed around the full circumference of the base of the stem up to approximately 30 cm from the ground level[10]. The cut stump treatment is also one of the most effective options for many woody weeds (including mimosa bush) and uses similar herbicides to those for basal bark applications. It has the advantage of being effective all year round but is time consuming and laborious[10, 19].

Other techniques used for woody weeds include the ground application of granular (e.g. tebuthiuron) and liquid (hexazinone) formulations of residual herbicides. Dry formulations are applied using hand-operated scattering devices or power-driven spreaders and for large areas aircraft application is an economic option[20, 21]. The application is very simple and minimizes pesticide particle movement through the air. Unfortunately, residual effects tend to remain in the soil for a period of time after application, which can cause soil pollution[22].

Finally, the stem injection technique targets the vascular bundle to transport the herbicide through the plant tissues. This technique is suitable for thinning of native trees and control of woody weeds. There are two traditional types of stem injection, which are the drill and fill method and axe cut method. Drill and fill method uses a battery powered drill to make downward-angled holes into which a liquid herbicide formulation is placed, whereas axe cut method uses an axe to make horizontal cuts to which the herbicide is surface applied[10]. A more recent innovation is the encapsulation of solid formulations of herbicides and their implantation into the stem of woody weeds using a specifically engineered device that drills, implants and plugs the hole. This technique is an alternative approach that has been designed to avoid un-necessary chemical exposure to the environment by ensuring placement and capture of the dose entirely within the target plant. Testing is being conducted on a range of species including prickly acacia (*V. nilotica*), leucaena (*Leucaena leucocephala*), *Eucalyptus saligna* and *E. dunnii*[23].

The control of mimosa bush is an imperative due to the significant threat it poses to agricultural and grazing systems. To expand on the range of available control options, four trials were undertaken to evaluate the efficacy of chemical herbicide capsule application on mimosa bush when applied to the stem of intact plants or to the near ground level cut stump of plants.

2. Materials and Methods

2.1. Site Details

The first intact plant and cut stump trials were conducted approximately 2 km (Figure 1) southeast of Moree, NSW (29°29’15”S 149°53’13”E). The site was located on a treeless plain that had a dense, uniform stand of small mimosa bush plants and an understory of native grass species. The land was designated a government stock route and is used as a transport corridor to move (walk) livestock from one location to another as well as to serve as a public grazing resource in times of drought. As such, it was grazed only periodically. The second series of whole plant and cut stump trials were conducted approximately 27 km east of Moree, NSW (29°28’07”S 150°04’53”E). The site was located in a Eucalypt woodland that had a uniform, medium density stand of relatively large mimosa bush plants and an understory of native grass species.

The sites lie on the Upper Darling Plains which is surrounded by branching rivers notched into a regolith of alluvial sediments. The soils are dominated by Vertosols of moderate fertility. This type of soil has a good capability to transport and store water. Elevation of the area is 346 m AHD and the land is capable of supporting high impact land uses with intensive practical land management[24]. The region is dominantly covered by rain fed cropping and there are several parts of the area where shrubs such as mimosa bush have thickened[25].

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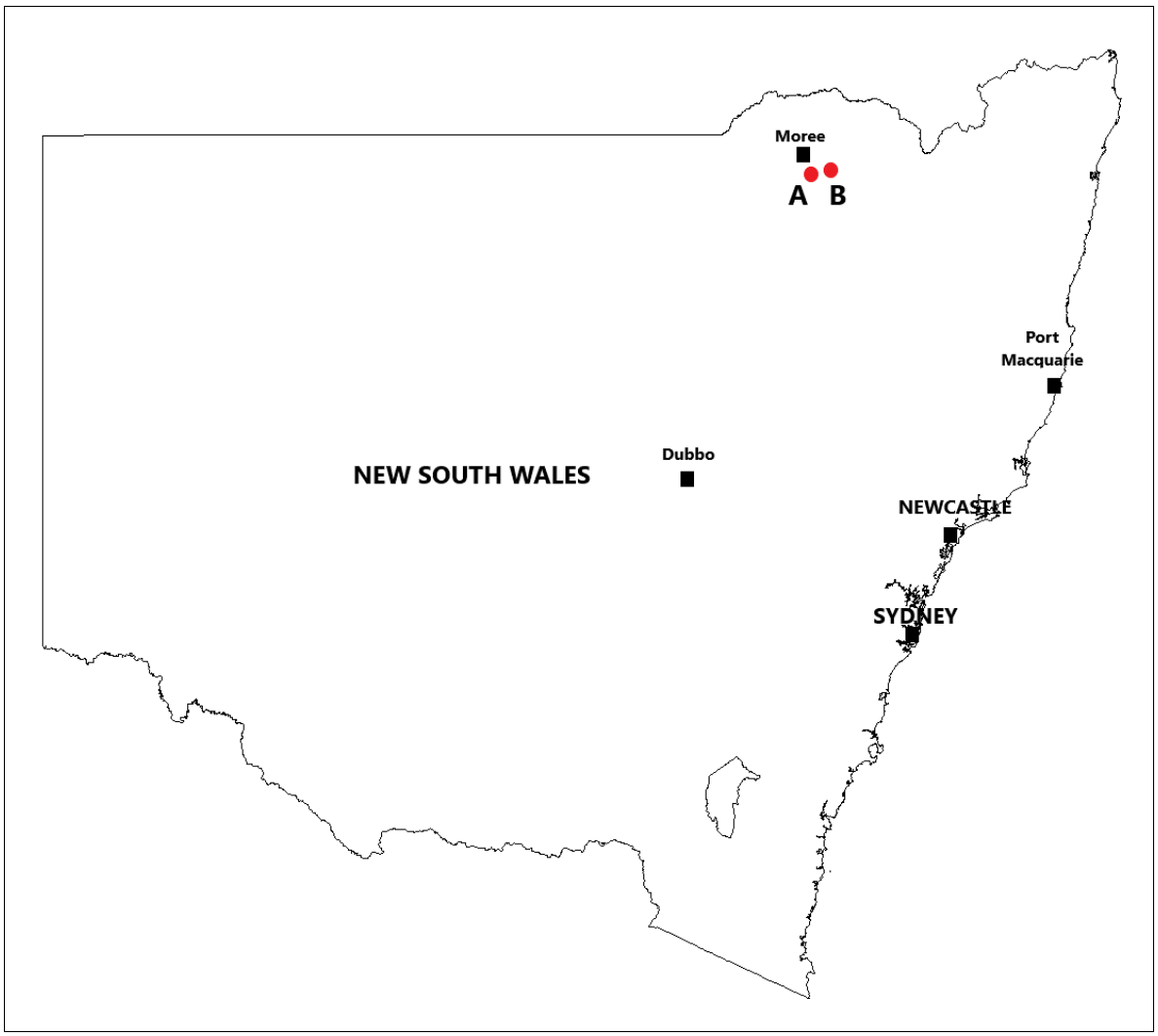

Figure 1. Intact plant and cut stump trial locations at Moree, NSW; (A) first round of trials and (B) second round of trials.

2.2. Rainfall and Temperature

Monthly total rainfall data recorded at the Moree Airport weather station (the nearest to the experiment sites) were obtained from the Australian Bureau of Meteorology[26]. During the initial treatment period, the highest rainfall was obtained in October to December 2018, which is the wet season. Throughout year 2019, conditions were mostly dry, however high rainfall was recorded during the first three months of 2020 (Figure 2).

2.3. Intact Plant Trials

The intact plant trials were established on 12 July 2018 and 29 March 2019, respectively, using a Randomized Complete Block Design. The 2018 trial (trial 1) incorporated eight herbicide treatments and four repetitions, whilst the 2019 trial (trial 2) had six herbicide treatments and four repetitions. Experimental units were groups of 15 mimosa bush plants that had their GPS location recorded and a plot number placed on or close to the first plant. The mimosa bush plants in trial 1 had an average height of 1.54 ± 0.04 (SE) m and canopy width of 2.19 ± 0.1 (SE) m. In trial 2, the plants were generally larger than those in trial 1, with an average height of 2.16 ± 0.11 (SE) m and canopy width of 3.09 ± 0.17 (SE) m. Furthermore, trial 1 plants were mostly multi-stemmed (Figure 3A & 3B), with an average number of 1.53 ± 0.07 (SE) stems, whereas in trial 2 the majority of plants were single-stemmed (Figure 3C).

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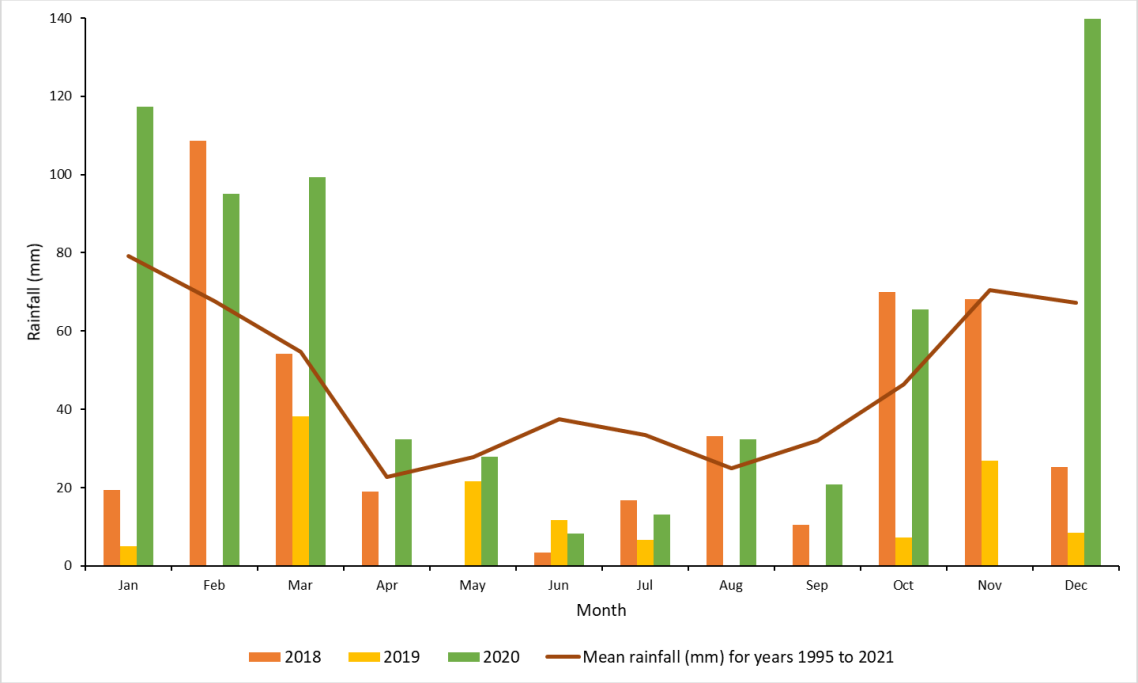

Figure 2. Monthly rainfall (mm) at Moree Airport for years 2018, 2019 and 2020[26].

The treatments comprised stem implantation of six (trial 1) or four (trial 2) encapsulated herbicides, a benchmark basal bark treatment of triclopyr/picloram mixed (Access®, Corteva Agriscience Australia) with diesel, and an untreated control (Table 1).

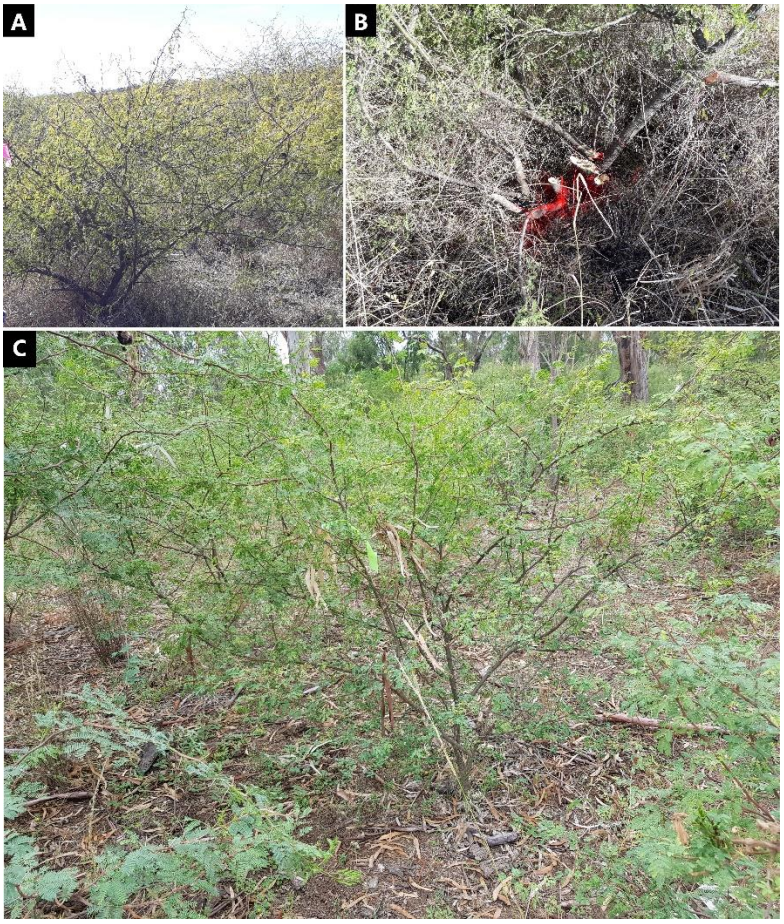

Figure 3. (A) & (B) Multi-stemmed plant in Trial 1; (C) single-stemmed plant in Trial 2.

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Table 1. Chemical herbicide treatments for the intact plant trials.

Treatment	Description	Dose of product per capsule	a.i. concentration in product
Control	Untreated plants	No treatment	
TyP-diesel	Conventional/basal bark application of Triclopyr/Picloram + diesel	Diluted 1:60	Triclopyr 240g/L Picloram 120g/L
G	Stem implanted with Di-Bak G™	350 mg glyphosate/capsule	700 g/kg
AM	Stem implanted with Di-Bak AM™	155 mg aminopyralid + 125 mg metsulfuron-methyl/capsule	375 g/kg 300 g/kg
H	Stem implanted with Di-Bak H™	350 mg hexazinone / capsule	750 g/kg
TyP	Stem implanted with Di-Bak TyP™	120 mg triclopyr + 40 mg picloram / capsule	300 g/kg 100 g/kg
C	Stem implanted with Di-Bak C™	450 mg clopyralid / capsule	750 g/kg
M	Stem implanted with Di-Bak M™	330 mg metsulfuron-methyl / capsule	600g/kg

For trial 2, the TyP treatment was not applied, because of poor efficacy in trial 1. Furthermore, treatments M (metsulfuron-methyl) and AM (aminopyralid/metsulfuron-methyl) demonstrated comparable mortality, therefore only one of these treatments (i.e. AM) was applied in subsequent trials.

Herbicide capsules were manufactured by Bioherbicides Australia Pty Ltd (www.bioherbcides.com.au) containing dry formulations of key herbicides typically used for control of woody weeds. The herbicide capsules were implanted using the Injecta® capsule delivery method (Bioherbicides Australia Pty Ltd) (Figure 4). The Injecta® is a custom designed applicator with the following key components: the head unit with three sharp spikes to lock it firmly onto the plant surface; an 8 mm drill bit to bore a hole of 25 mm depth, a removable magazine which holds 30 herbicide capsules and plugs, a body, handle and shaft to which a cordless drill is attached. This device allows the operator to drill a hole and rapidly implant the capsule followed by the plug. The purpose of the plug is to seal the capsule into the plant. The sap from the plant should reduce the integrity of the capsule and dissolve the herbicide. A hole is drilled into the plant at pre-determined intervals. To determine the number of capsules to apply to a plant, the circumference of the stems was measured near the base. One capsule was then applied to stems with a circumference up to 15 cm, two capsules were applied where the circumference was greater than 15 cm and less than 30 cm, and three capsules were applied where the circumference was greater than 30 cm and less than 45 cm. The capsules were then applied approximately 15-30 cm from ground level.

Basal bark application of herbicide mixture (Access® manufactured by Corteva Agriscience™) was undertaken using a 5 L pressurized shoulder sprayer (Nylex®) with the nozzle adjusted to a coarse droplet spray. The whole (complete surface) of the lower 30 cm of every plant stem was sprayed to the point of runoff as per manufacturer instructions.

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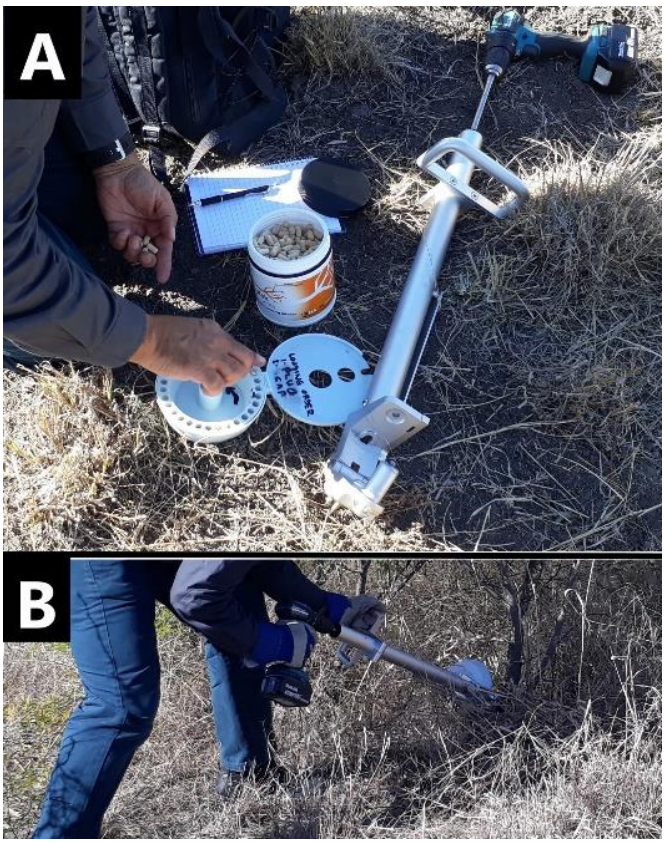

Figure 4. (A) Capsules are loaded into Injecta® magazine followed by plugs; (B) stem implantation using Injecta®.

Monitoring of trial 1 was undertaken 3 months after treatment (MAT) on 18th October 2018, 8 MAT on 29th March 2019 and 15 MAT on 8th November 2019. For trial 2, monitoring was undertaken 8 MAT on 6th November 2019 and 20 MAT on 23rd November 2020. Each time, an estimate of percentage mortality based on the whole canopy cover was undertaken. The canopy cover is formed by a group of individual plant aboveground parts, which include stem and leaves. If 100% mortality was recorded for two consecutive monitoring periods, the plant was classified as dead.

The data was tested following General Linear Model (GLM) ANOVA using Minitab® version 17. Treatment plot means were compared following Tukey's test with 95% confidence. Arcsin transformation was applied to the canopy mortality to fulfill the statistical inference procedure in terms of normality of the data.

2.4. Cut Stump Trials

The cut stump trials (trial 3 & trial 4) were established on 13 July 2018 and 30 March 2019, respectively. For both trials, a Randomized Complete Block Design was used, but the number of repetitions varied. Trial 3 incorporated six herbicide treatments and three repetitions, while trial 4 had six herbicide treatments and four repetitions. Herbicide treatments for both trials were based on those used in the intact plant trials, and included four encapsulated herbicide treatments, a benchmark cut stump treatment of triclopyr/picloram mixed with diesel, and an untreated control (Table 2).

Experimental units were groups of 15 mimosa bush plants that had their GPS location recorded and a plot number placed on or close to the first plant. Mimosa bush plants in trial 3 had an average height of 1.54 ± 0.04 (SE) m and canopy width of 2.19 ± 0.1 (SE) m. The plants were mostly multi-stemmed, with an average of 1.53 ± 0.07 (SE) stems. In trial 4, the plants had an average height of 2.16 ± 0.11 (SE) m and canopy width of 3.09 ± 0.17 (SE) m. Most plants in this trial were larger and single-stemmed compared to those in trial 3.

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Application of treatments involved cutting the stem of plants close to ground level (< 15 cm above ground) using a pole pruning chainsaw (Ryobi®). The stem was then marked with paint and numbered for ease of relocation during subsequent monitoring. The circumference of stems was also measured near the base to determine the appropriate herbicide dose, using the same approach as that described previously for the intact plant trials. Then the capsules were applied on the stump around <15 cm above ground. In trial 3, most plants were multi-stemmed whilst in trial 4 the plants were mainly single-stemmed. Herbicide capsules were implanted and sealed into the cut stump ends using the Injecta® unit. The benchmark cut stump application of triclopyr/picloram mixed with diesel were undertaken using a 5 L pressurised sprayer with the nozzle adjusted to put out a coarse droplet spray and applied to the point of runoff.

Table 2. Chemical herbicide treatments for cut stump trials.

Treatment	Description	Dose of Product per capsule	a.i. Concentration in product
Control	Cut stumps without implanted herbicide capsule	No chemical herbicide treatment	
TyP-diesel	Cut stumps sprayed with triclopyr/picloram + diesel	Diluted 1:60	Triclopyr 240g/L Picloram 120g/L
G	Cut stumps implanted with Di-Bak G™	350 mg glyphosate / capsule	700 g/kg
AM	Cut stumps implanted with Di-Bak AM™	155 mg aminopyralid 125 mg metsulfuron-methyl / capsule	375 g/kg 300 g/kg
H	Cut stumps implanted with Di-Bak H™	350 mg hexazinone / capsule	750 g/kg
C	Cut stumps implanted with Di-Bak C™	450 mg clopyralid / capsule	750 g/kg

For trial 3, monitoring was undertaken 4 MAT on 20th November 2018, 8 MAT on 29th March 2019 and 15 MAT on 8th November 2019. For trial 4, the assessments were completed 8 MAT on 7th November 2019 and 20 MAT on 24th November 2020. The main parameter for evaluation was stem regrowth and plant mortality. The data was tested following General Linear Model (GLM) ANOVA using Minitab® version 17. Treatment plot means were compared following Tukey's test with 95% confidence.

3. Results

3.1. Intact Plant Trials

In trial 1, significant treatment effects ($P < 0.05$) were recorded for all three monitoring times. Each stem received one capsule as all samples had a circumference less than 15 cm. Stem implantation of capsules containing aminopyralid/metsulfuron-methyl and hexazinone resulted in relatively high canopy mortality (≥ 90%) at 3 MAT, which continued across subsequent monitoring periods (Figure 5). Stem implantation using these encapsulated herbicides was equally as effective as the basal bark treatment (benchmark). Capsules containing only metsulfuron-methyl were not as effective as these treatments 3 MAT, but they were 8 MAT (94%) and thereafter. Clopyralid, glyphosate and triclopyr/picloram treatments all took time (15 MAT) to reach only a moderate level of canopy death 15 MAT, averaging 72%, 65 and 57%, respectively. Control plants remained relatively healthy despite the prolonged dry conditions with <9% canopy death recorded 15 MAT (Figure 5).

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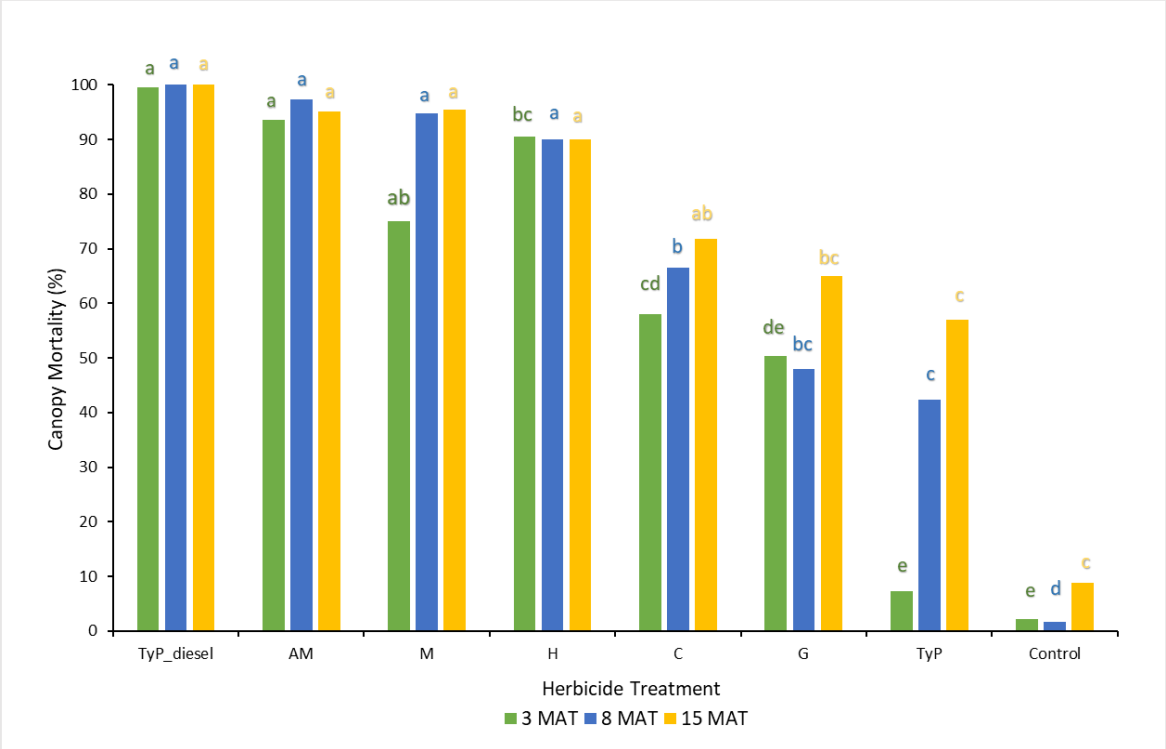

Figure 5. Mimosa bush canopy mortality 3, 8 and 15 MAT following herbicide applications to intact plants in trial 1. For each monitoring time, columns with different letters indicate significant difference by Tukey's Test with 95% confidence.

In trial 2, the mean number of capsules applied was 1.36 ± 0.03 (SE) per plant. Significant treatment effects ($P < 0.05$) were recorded for both the initial (8 MAT) and final assessments (20 MAT). Each time, stem implanted treatments of aminopyralid/metsulfuron-methyl and clopyralid resulted in the greatest canopy mortality (100%) (Figure 6). These treatments were as effective as basal bark application with triclopyr/picloram in diesel (benchmark). Herbicide treatments containing glyphosate and hexazinone took longer to cause maximum canopy mortality, but even 20 MAT it was low averaging only 34% and 52%, respectively. Control plants remained healthy throughout the trial.

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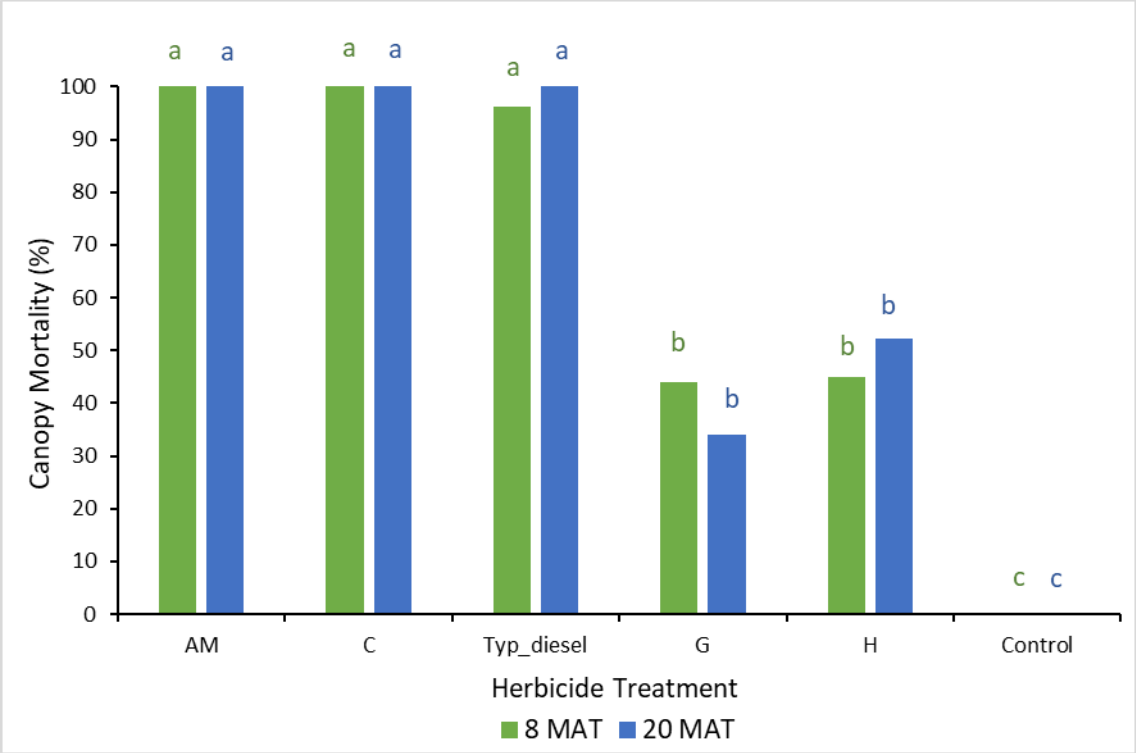

Figure 6. Mimosa bush canopy mortality 8 and 20 MAT following herbicide applications to intact plants in trial 2. For each monitoring time, columns with different letters indicate significant difference by Tukey's Test with 95% confidence.

3.2. Cut Stump Trials

In trial 3, significant treatment effects ($P < 0.05$) were recorded for all three monitoring times (Figure 7). Similar with trial 1, each stump received one capsule as all samples had a circumference less than 15 cm. The traditional cut stump application using triclopyr/picloram with diesel gave significantly greater control of mimosa bush, with no regrowth recorded at any monitoring period. Treatment with encapsulated herbicides was most effective using clopyralid and aminopyralid/metsulfuron-methyl, with stem regrowth across the three monitoring periods ranging between 2 and 4 stems. Hexazinone and glyphosate were least effective with plants having an average of more than 11 stems at 15 MAT (Figure 7 and Figure 8).

Plant mortality displayed a similar trend to that of stem regrowth, with clopyralid and aminopyralid/metsulfuron-methyl giving the best results, although only moderate mortality (44% to 54%) was recorded 15 MAT (Figure 9). Hexazinone and glyphosate exhibited even lower efficacy, with plant mortality 15 MAT averaging only 2% and 13%, respectively.

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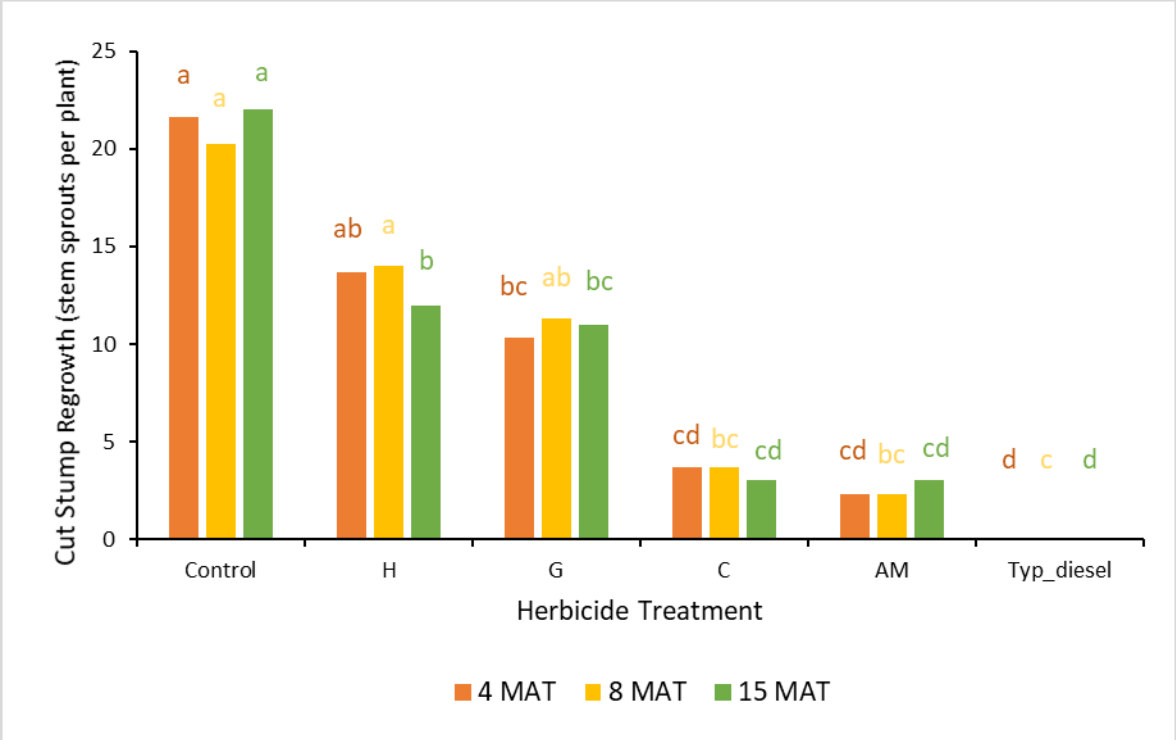

Figure 7. Cut stump regrowth (stem sprouts per plant) of mimosa bush 3, 8 and 15 MAT following cut stump herbicide application in trial 3. For each monitoring time, columns with different letters indicate significant difference by Tukey's Test with 95% confidence.

Figure 8. Plant response 15 MAT following cut stump applications in trial 3, clockwise: (A) Control (untreated sample), (B) triclopyr/picloram_diesel treatment, (C) aminopyralid/metsulfuron-methyl treatment, (D) hexazinone treatment, (E) glyphosate treatment and (F) clopyralid treatment. Photo credit: Dr. Shane Campbell.

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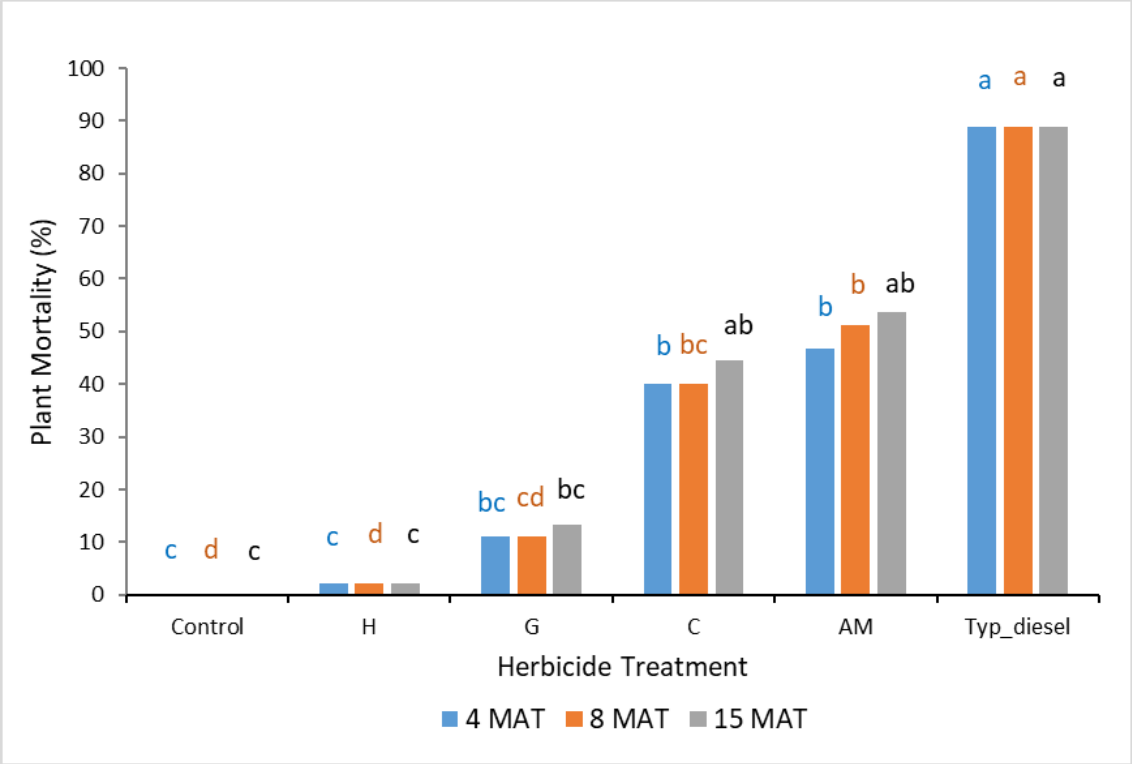

Figure 9. Plant mortality of mimosa bush 3, 8 and 15 MAT following cut stump herbicide application in trial 3. For each monitoring time, columns with different letters indicate significant difference by Tukey's Test with 95% confidence.

In trial 4, significant treatment effects ($P < 0.05$) were also recorded for the initial assessment 8 MAT. The number of capsules applied was 1.57 ± 0.04 (SE) per stem. As for trial 3, stem implantation treatments of aminopyralid/metsulfuron-methyl and clopyralid resulted in the least stem regrowth, which was not significantly different to the traditional cut stump treatment using triclopyr/picloram with diesel (benchmark). All three treatments had no new stem regrowth from the cut stump 8 MAT. On the contrary, hexazinone was the least effective treatment with plants having an average of 12 stems (**Error! Reference source not found.**).

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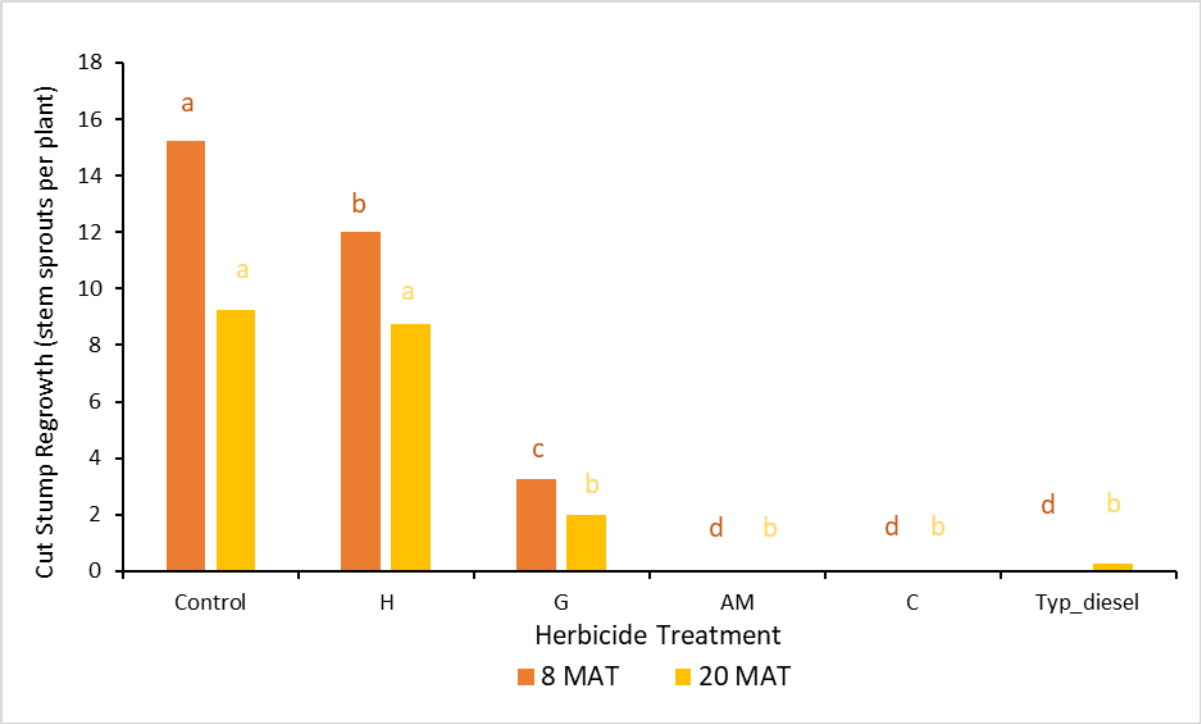

Figure 10. Average stem regrowth of mimosa bush 8 and 20 MAT following cut stump herbicide application in trial 4. For each monitoring time, columns with different letters indicate significant difference by Tukey's Test with 95% confidence.

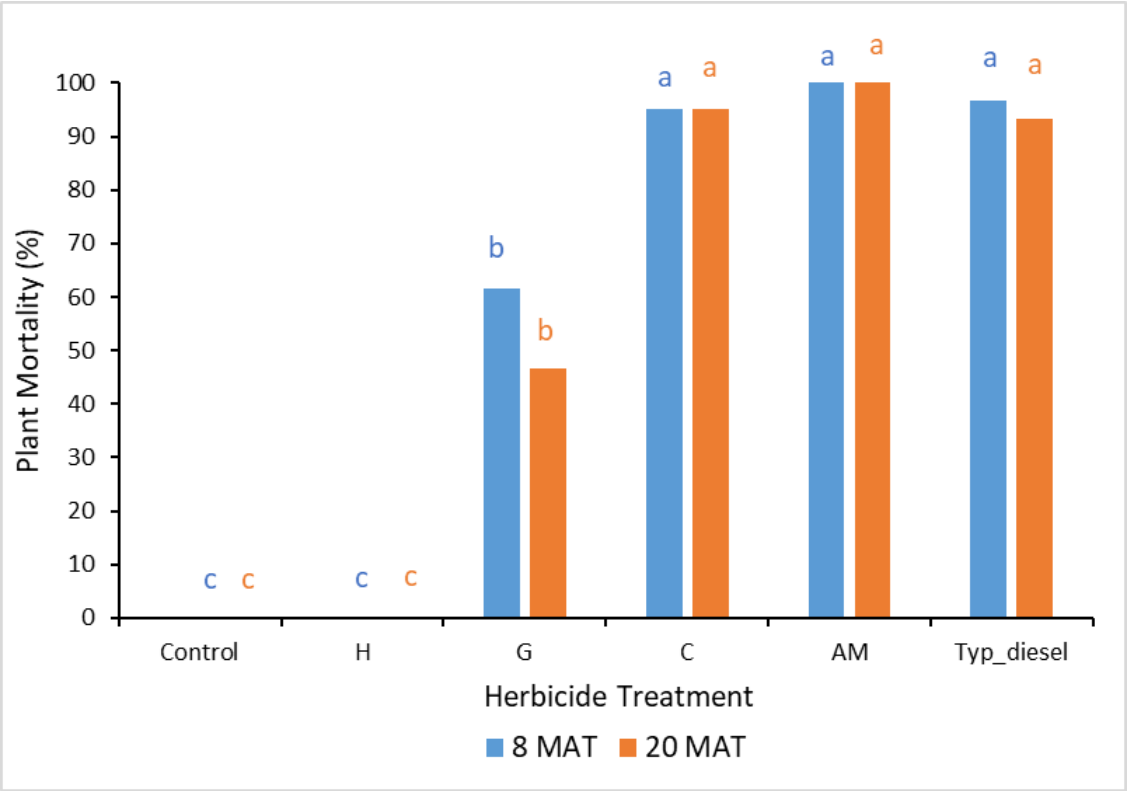

Figure 11. Plant mortality of mimosa bush 8 and 20 MAT following cut stump herbicide application in trial 4. For each monitoring time, columns with different letters indicate significant difference by Tukey's Test with 95% confidence.

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The final assessment 20 MAT displayed similar results to the 8 MAT for most treatments, with stem implantation of aminopyralid/metsulfuron-methyl and clopyralid remaining not significantly different ($P > 0.05$) to the benchmark treatment. A slight change occurred with the glyphosate treatment which had significantly more stems than the benchmark treatment 8 MAT but not 20 MAT (Figure 10).

As for the plant mortality (Figure 11), samples treated with clopyralid and aminopyralid/metsulfuron-methyl as well as the benchmark displayed the highest plant mortality at 20 MAT, averaging 95%, 100% and 93%, respectively. Glyphosate displayed moderate mortality (47%), whilst hexazinone failed to kill any mimosa bush plants.

4. Discussion

The results suggest that the application of encapsulated dry formulation herbicides using the Injecta® capsule delivery technique can provide control of mimosa bush that is comparable to basal bark and cut stump treatments using triclopyr/picloram mixed with diesel. However, not all the encapsulated herbicides performed equally as well as each other and efficacy appears to have been better in the second round of trials (trial 2 and trial 4) compared to the initial screening experiments (trial 1 and trial 3). The plants in trial 1 and trial 3 were generally small in size (circumference less than 15 cm) but multi-stemmed, which appeared to affect herbicide efficacy. Given the size of plants and the method used to determine the number of capsules to apply (see Section 2.3) not all stems were injected with a capsule. Consequently, the herbicide tended to affect the stem which was treated with a capsule, but it did not always affect the whole multi-stemmed plant. In contrast, plants in trial 2 and trial 4 were mostly single-stemmed, which resulted in a compatibility between the circumference of the stem and the dose applied[23]. This finding suggests that herbicide capsules might need to be applied into each stem of multi-stemmed plants in order to achieve the best result.

As expected, minimal mortality (<10%) occurred if mimosa bush plants received no herbicide treatments, whilst the benchmark basal bark treatment of triclopyr/picloram (Access®) mixed with diesel provided excellent control (>89%). Diesel is a very efficient carrier which simplifies the application of the liquid herbicide into the target plant and reduces evaporation of spray droplets after they leave the sprayer[27]. Compared to the liquid formulation of triclopyr/picloram mixed with diesel, the encapsulated formulation of triclopyr/picloram was ineffective for mimosa bush control.

When applied to the stem of intact plants, aminopyralid/metsulfuron-methyl consistently gave the best results. Metsulfuron-methyl, hexazinone and clopyralid individually also performed well in at least one of the trials. Aminopyralid/metsulfuron-methyl was also one of the best performing herbicides when applied to the cut stump of plants. Clopyralid was the only other herbicide that performed to a satisfactory level using this technique.

Based on its Mode of Action (MoA), aminopyralid acts as a synthetic auxin which triggers tissue elongation through plant cell division, resulting in vascular tissue destruction (Group 4)[28-30]. Metsulfuron-methyl inhibits acetolactate synthase (ALS) or acetohydroxy acid synthase (AHAS) which leads to the inhibition of amino acid production for plant defence mechanism activation[30, 31] (Group 2). In trial 1 efficacy was similar for both the aminopyralid/metsulfuron-methyl and metsulfuron-methyl treatments. Therefore, instead of using both metsulfuron-methyl and aminopyralid/metsulfuron-methyl as the treatments, aminopyralid/metsulfuron-methyl was selected in order to disrupt mimosa bush cell growth and to inhibit its ALS. Considering that mimosa bush is a fast-growing weed, the combination of these modes of action is expected to be more efficient.

Clopyralid is another synthetic auxin herbicide which displayed satisfactory results when applied to the cut stump or intact plants. However, it was less effective in the first round of trials (1 & 3) compared to the second round (2 & 4). As described in 2.3, most of the plants in the first round of trials were multi-stemmed while plants in the second round were predominately single-stemmed or had only a couple of stems. This suggests that plants with fewer stems were easier to kill and that multi-stemmed plants may require higher dosage rates. Overall, the aminopyralid/metsulfuron-methyl treatment was more effective on both multi-stemmed and single-stemmed plants than

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clopyralid, probably because of a synergetic relationship MoA of aminopyralid and metsulfuron-methyl that facilitated higher mortality.

Hexazinone (Group 5) has a MoA which inhibits photosynthesis, particularly photosystem II which occurs in the chloroplast [28, 30-32]. For the intact plant experiments, it was slower acting than the other herbicides, until sufficient rainfall occurred between October to December 2018 to fully activate it. In trial 1, hexazinone showed similar results with the benchmark. However, in trial 2 hexazinone displayed the least canopy mortality compared to the other treatments. The plants treated with hexazinone might have recovered from hexazinone treatment effect as low rainfall occurred a few months before the assessment at 20 MAT. For the cut stump method, efficacy of hexazinone was minimal in both trials (trial 3 and 4) and not significantly different to the untreated control. With removal of the canopy of the mimosa bush plants during the cut stump process, the MoA of hexazinone would have been prevented from disrupting photosynthesis through photosystem II[32, 33]. Cut stumped plants managed to sustain life by concentrating on cell division and elongation and stimulated more stem regrowth from the vegetative buds.

Overall, Group 4 herbicides were the most effective for mimosa bush control across all intact and cut stump trials. This herbicide group is comprised of the chemical family: benzoic acid, phenoxycarboxylic acid, pyridine carboxylic acid and quinoline carboxylic acid[29]. The Group 4 herbicides applied in these trials are categorised as pyridine carboxylic acids (pyridines)[28-30]. Synthetic auxin herbicides mimic the natural auxins in plant cells and induce abnormal auxin concentration and activity that disrupts the plants growth[34, 35]. In plant tissue, this process consists of a stimulation phase (activation of metabolism), inhibition phase (growth malformation) and accelerated senescence phase[34, 36].

The findings of this study suggest that this technique is worth progressing further as an effective control option for mimosa bush, using those herbicides that demonstrated high efficacy across the four trials. While efficacy was greatest on infestations containing predominately single stemmed plants or those with only a few stems, the exploration of increasing dosage or reviewing dose placement for multi-stemmed plants should increase efficacy. Once refinements to the technique have been made, cost:benefit comparisons with other techniques would be recommended to assist land managers to decide on the most cost effective techniques for their situation.

5. Conclusions

This study demonstrated the ability to control mimosa bush through implantation of encapsulated herbicides into either the stem of intact plants or into cut stumps. Several herbicides proved capable of causing high mortality of mimosa bush in at least one of the four trials undertaken (aminopyralid/metsulfuron-methyl, hexazinone, metsulfuron-methyl and clopyralid). However, aminopyralid/metsulfuron-methyl consistently gave the highest mortality across all intact plant and cut stump trials, achieving comparable results to basal bark or cut stump applications using triclopyr/picloram mixed with diesel. Overall, highest efficacy was achieved on single stemmed plants, but with some further refinement of the technique it should be possible to achieve similar results for multi-stemmed species.

Further research is now needed to determine the situations where this technique would be a cost-effective option for control of mimosa bush compared to other available options. Key factors to consider include infestation (size and density) and plant characteristics (size and number of stems), but in some situations the usefulness of this technique for minimising spray drift and non-target damage may also be an important consideration.

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Author Contributions: Conceptualization, Ms. Limbongan, Prof Galea and Dr Campbell; methodology, Ms. Limbongan, Prof Galea and Dr Campbell; formal analysis, Ms. Limbongan; resources, Ms. Limbongan, Dr Campbell and Prof Galea; writing—original draft preparation, Ms. Limbongan; writing—review and editing, Dr Campbell and Prof Galea; visualization, Ms. Limbongan; supervision, Dr Campbell and Prof Galea; project administration, Prof Galea; funding acquisition, Prof Galea. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by North West Local Land Services, New South Wales, grant number NW00064 and the APC was funded by Indonesia Endowment Fund for Education.

Acknowledgments: We thank Dr Kenneth Goulter (Bioherbicide Australia Pty Ltd) for manufacturing the encapsulated chemical herbicides; we thank Peter Dawson, Sara Chapman, Pip Bagshaw, Keith Walker (Local Land Services, New South Wales) and Mr. Lachlan Fowler (University of Queensland) for their full support during this trial.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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