Research reports

The effect of cutting on the survival *Mimosa pigra* and its application to the use of blade ploughing as a control method

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Summary

Knowledge about how individual plants respond to damage can be applied to help develop more effective physical control methods. To this end the response of mimosa (*Mimosa pigra* L.) to various cutting regimes was observed. Cutting plants off at about 10 cm below ground level was 100% effective in killing plants, however cutting plants off at ground level or 15 cm above ground level resulted in most plants resprouting. This means that physical control methods which cut or break mimosa off at ground level or above (such as slashing or chaining) will not kill a high proportion of plants. Blade ploughing is one method of physical control that cuts plants off below ground level. It was found to be very effective in killing mimosa but some modifications to machinery are required for blade ploughing of mimosa to be an efficient physical control method. The possible role and advantages of blade ploughing in the integrated management of mimosa are discussed.

Introduction

The leguminous woody shrub mimosa (*Mimosa pigra* L.) is a native of tropical America where it is rarely a problem (Heard *et al.* 1997). It was introduced to Darwin in the late 19th Century (Miller and Lonsdale 1987) and spread rapidly during the 1970s so that it now covers more than 800 km^2 in the top end of the Northern Territory. It has become a major weed of wetlands where it forms large dense, thorny, impenetrable, almost monospecific thickets (Lonsdale 1992). Mimosa competes with pastures, hinders mustering, and prevents access to water for livestock (Miller *et al.* 1981). It also restricts access to water for irrigation, fishing and poses a threat to conservation and tourism.

Several control methods have been used for mimosa in the Northern Territory with varying degrees of success (Forno 1992, Miller and Siriworakul 1992, Siriworakul and Schultz 1992, Miller and Lonsdale 1992). To-date the most common form of weed management for mimosa has been through the use of herbicides and biological control.

Chemical control of mimosa is expensive and the effectiveness is variable (Sessional Committee on The Environment 1997). The persistent nature of seeds in the soil (Lonsdale *et al.* 1989) and the variability in the kill rates of herbicides, means that control by herbicides has to be repeated for several years to control new seedlings and regrowth (Cook and Setterfield 1996). This repeated application (especially in wetland environments) is not desirable, neither economically or environmentally (Lonsdale and Braithwaite 1988). In areas where large scale chemical control of mimosa has occurred (such as near Oenpelli, Northern Territory), it is a common sight to see a billabong with a healthy green stand of mimosa growing underneath large dead melaleuca trees which were killed when the mimosa in the billabong was previously treated with chemicals (personal observation).

However the spread of mimosa needs to be controlled and chemicals will continue to play a significant role in this (the main herbicides used against mimosa and the rates at which they are commonly used are: metsulfuron methyl (Brush Off® at 60–75g ha^{-1}), fluoroxypyr (Starane® 0.5% v/v 1.5–2 L ha^{-1}) and tebuthiuron (Graslan® at 7.5 kg ha^{-1}) (Miller and Siriworakul 1992)). It has been recognized for some time that integrating different control methods (such as chemical, physical and biological) is necessary for effective long term control (Miller *et al.* 1992).

It is thought that biological control will be the most cost effective long term solution for managing mimosa (Miller *et al.* 1981). However, current population levels of biological control agents seem to provide better control of smaller plants than the large trees that have been established for many years (personal observation). It would be advantageous for the integrated management of mimosa if there were effective methods other than chemical control available for killing the large trees.

In the past, physical control methods have been regarded as impractical for large areas and have been variable in their effectiveness (Siriworakul and Schultz 1992). Chaining (flattening trees with a large chain pulled between two bulldozers) has been used widely, most commonly to clear mimosa previously treated with herbicides. Techniques such as chaining are regarded as ineffective on green mimosa as plants tend to quickly stand back up after being flattened (i.e. they exhibit a 'whipstick nature' (Siriworakul and Schultz 1992)) or if stems are broken off, they quickly reshoot.

The use of physical methods of control (such as chaining, slashing, rolling and hand cutting) in the past has generally been done in an *ad hoc* manner without a good knowledge of how mimosa plants respond to the damage caused by such treatments. The aim of this experiment was to observe how mimosa plants respond to various cutting regimes, and to apply this knowledge to practical techniques for mimosa control.

Observations of the response of mimosa to cutting in nursery experiments (N. Rea and T. Schatz, unpublished results) have shown that following cutting, plants reshoot from leaf axils or leaf scars (leaf abscission sites). Even when mimosa is cut off quite low to the ground leaving a stump with no leaves remaining on the plant, it can initiate new branches from old leaf scar sites within a few weeks.

The observation that mimosa plants only send out new branches from leaf axils or leaf scars, led to an initial hypothesis that if the plant was cut off at a point below all its leaf scars (at ground level) it would not be able to initiate any new branches and would die as a result. Preliminary experimentation showed that this was the case with potted plants in the nursery. However when it was done in the field, plants grew new shoots from a couple of centimetres below the soil surface, and produced a considerable amount of regrowth within a month.

The fact that this regrowth appeared to come from the first one to two centimetres below the soil surface prompted a further experiment (reported here) to determine if cutting at a lower depth would kill mimosa. This was followed by a field trial of a practical clearing technique in which a blade plough was used to cut mimosa plants off below ground level.

Materials and methods

Cutting experiment

The experiment was undertaken at six sites. Three sites were in dry soil (average soil moisture content of 3.9%) on the Adelaide River flood plain (12° 40' 10.0"S Lat. and 131° 27' 26.7"E Long.), and three were in wet soil (average soil moisture content of 54.0%.) near the Finniss River (sites four and five at 12° 50' 04.2"S Lat. and 130° 38' 01.3"E Long., and site six at 12° 52' 51.9"S Lat. and 130° 33' 07.2"E Long.).

The experiment began on 7/8/97 (in the dry season) and treatments at all sites were completed by 15/8/97. The treatments at each site were:

- Plants were cut off at 15 cm above ground level (n=10).
- Plants were cut off at ground level (n=10).
- Plants were cut off at 10 cm below ground level (n=10).
- Plants were selected and marked as controls (n=5).

Before cutting, the diameter at the base of each plant (or the diameter of each stem coming from the ground if the plant had several stems) was measured with vernier calipers. The maximum diameter of a main stem (the largest stem on the plant) cut was 85.6 mm and the minimum was 16.8 mm. Most commonly the plants had a main stem diameter of between 30 and 50 mm (and thus would be at least two years old (personal observation)).

The plants were cut using a chainsaw. A crow bar and mattock were used to dig soil from around the base of the plants to be cut at 10 cm below ground level to enable them to be cut off at the desired height. As a result of this treatment, all that was left of plants cut in this way was the top of a severed taproot protruding from a depression in the ground (Figure 1).

Plants that were cut off at ground level, or at 10 cm below ground level had a tagged metal stake driven into the ground near the stump to mark their position, while plants cut off at 15 cm had flagging tape tied around their stump. Five control plants were also marked with flagging tape.

Soil samples were taken at each site when the plants were cut. These were weighed and oven dried (for 48 hours at 105°C) to determine soil moisture content.

Regular visits were made to check if and when plants resprouted. Final recordings of plant mortality were taken on the 14/10/97 approximately two months after the plants were cut. By this time it was obvious that plants had either died or resprouted vigorously (Figure 1).

Analysis was performed using the GLIM statistical package (McCullagh and Nelder 1983). An analysis of codeviance (covariance) was performed to study variation in the proportion of plants that failed to resprout following cutting. The factor 'cutting treatment' and the variable 'soil moisture' were included in the analysis to test whether this affected the probability of mimosa resprouting. Analysis was performed after arcsine (angular) transformation of the proportion data. Where the analysis revealed a significant effect of cutting treatment on the proportion of plants resprouting a least significant difference (LSD) multiple-range test was performed to compare treatment pairs (according to Crawley 1993).

Blade plough experiment

A trial was undertaken to observe the effectiveness of blade ploughing as a method of clearing large mimosa plants. A blade plough is a large single tine (4 m wide in this case) that is pulled behind a bulldozer (Figure 2) and is used to cut the taproots of trees and suckers to clear land. The tine was set to be pulled through the soil at a depth of about 10–20 cm.

On 17/10/97 the blade plough was pulled through a stand of mature mimosa at 'Tortilla Flats' (13° 5' 5.1"S Lat. and 131° 13' 24.1"E Long.), for a distance of 200 m and three passes of this length were made side by side, producing a ploughed area of approximately 200 × 12 m.

Two quadrats (4 × 4 m) were set up within the ploughed area and two control quadrats adjacent to these within the stand of unploughed mimosa. On 13/11/97 visual estimates were made of the percentage of mimosa plants killed in the whole blade ploughed area, and photographs were taken. On 3/12/97 the diameter of all live mimosa plants greater than 50 cm in height within the quadrats was measured.

Results

Cutting experiment

Of the 60 plants cut at each height only one plant (1.3%) died that was cut off at

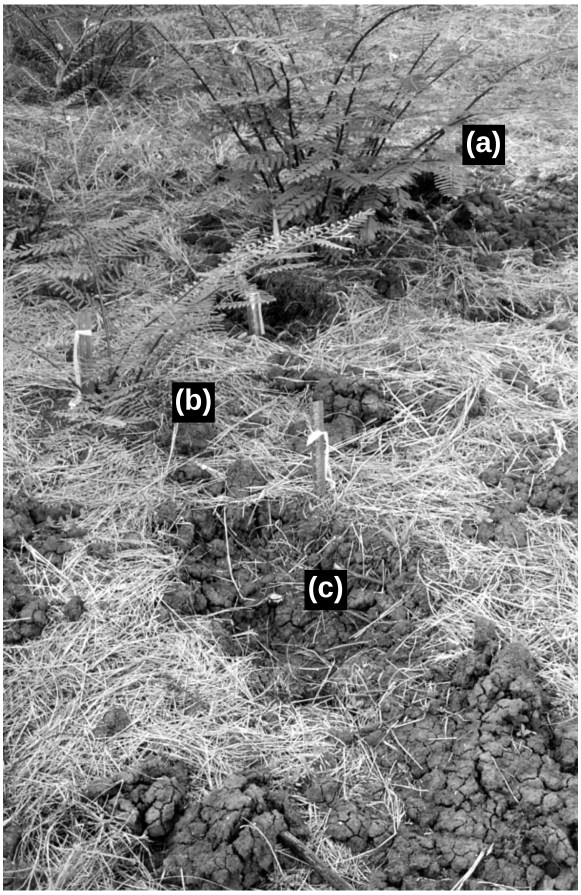

Figure 1. Mimosa two months after being cut at (a) 15 cm above ground level, (b) ground level, (c) 10 cm below ground level.

Figure 2. The blade plough and bulldozer used in this experiment.

15 cm above ground level, eight plants (13.3%) died that were cut off at ground level, and all 60 plants (100%) died that were cut off at 10 cm below ground level. All of the control plants survived (Table 1).

The analysis of codeviance revealed a highly significant treatment effect (P<0.001). Cutting mimosa plants below ground level was a much more effective way of killing them than cutting them at or above ground level (Table 2, Figure 3). Cutting plants off at ground level did have a significant effect on survival (P<0.05), but the proportion of plants killed was not high enough to consider using it as a control method (Figure 3).

The plants cut off at 15 cm above ground level resprouted from leaf scars on the stumps. Those plants cut off at ground level which resprouted, put out new shoots from a few centimetres below the soil surface (no more than 5 cm but usually about 2–3 cm below ground level). On digging up these plants it was found that these new shoots came from the area between the base of the stump and the top of the taproot.

More plants died following cutting off at ground level in the wet soils (7 plants) than in the dry soils (1 plant) however this difference was not statistically significant (Tables 1 and 2).

Blade ploughing experiment

On examining the treated area about a month (13/11/97) after the blade ploughing had been done it was found that the technique was very effective in killing large mimosa plants. A visual estimate was that close to 100% of all large mimosa plants that had been ploughed were dead (Figure 4).

When reassessed on 3/12/97 it was confirmed that all large mimosa plants in the marked quadrats had been killed by the blade ploughing. There were some live seedlings present but they were shorter than 50 cm. Some of these were present at the time of ploughing and their root systems were shallower than the depth of the plough. As a result they survived if they remained rooted in sufficiently large clods of soil. Also some seedlings may have germinated after the treatment was applied (therefore seedlings of this size (0–50 cm) were not counted). None of the large plants died in the control quadrats and the growth of mimosa in them seemed to be normal (Table 3).

Table 1. Effect of cutting *Mimosa pigra* plants at three different heights. (Plants were cut in August 1997 and mortality was assessed in October 1997).

Site number	Soil moisture (%)	% Mortality of *M. pigra* plants			
		Cut at 15 cm above ground (n=10)	Cut at 0 cm above ground (n=10)	Cut at -10 cm below ground (n=10)	Control (not cut) (n=5)
1	5.44	0	0	100	0
2	3.20	0	10	100	0
3	3.01	0	0	100	0
4	58.30	10	30	100	0
5	50.40	0	0	100	0
6	53.28	0	40	100	0

Table 2. Analysis of codeviance of the percentage of *Mimosa pigra* stems that survived cutting.

Source	SS	d.f.	*F*-ratio	*P*-value
Soil Moisture	0.08	1	3.07	0.1
Treatment	9.89	3	129.79	<0.001
Error	0.496	19		

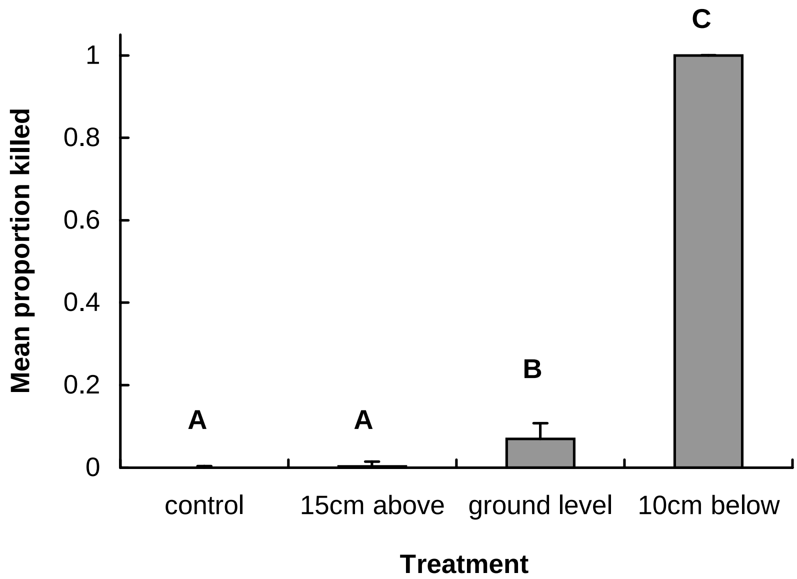

Figure 3. The proportion of *M. pigra* plants killed by treatment. Treatment means with different letters are significantly different (LSD, P<0.05%).

Table 3. Measurements of live *Mimosa pigra* plants in marked quadrats on 3/12/97. (Blade ploughing of treated quadrats occurred on 17/10/97).

	Control 1	Control 2	Ploughed 1	Ploughed 2
Seedlings 0–50 cm	na[A]	na[A]	na[A]	na[A]
Number of seedlings (50–130 cm)	119	19	0	0
Number (separate) large plants	34	19	0	0
Number stems (on large plants)	70	72	0	0
Maximum diam. of large plants (mm)	45.6	52.2	0	0
Minimum diam. of large plants (mm)	8.1	5	0	0

[A] Seedlings were present in all quadrats but were not counted (see text for explanation).

Discussion

The cutting experiment showed that *Mimosa pigra* (mimosa) can be killed by cutting plants at approximately 10 cm below ground level. Cutting at ground level or 15 cm above resulted in most plants (86.7 and 98.3% respectively) reshooting rapidly due to the large root system still intact below the ground (Figure 1).

The resprouting from just below the soil surface that occurred in most of the plants cut off at ground level, could have been because some leaf scars were below the soil surface due to soil movement associated with seasonal flooding. By cutting plants off at 10 cm below ground level, the area of the plant able to reshoot was removed and all plants cut in this way died.

From this result it is evident that methods of physical control that do not cut plants off below ground level (such as chaining, slashing, cutting by hand etc.)

Figure 4. A strip of blade ploughed mimosa.

may temporarily retard growth, but will not provide effective lasting control of mimosa as plants will regrow rapidly. A method of physical control that cuts mimosa plants off below ground level (by at least 10 cm) should be a very effective means of killing mature mimosa. A technique that achieves this should be very useful in an integrated management program as it will kill the large plants while the seedlings which germinate subsequently are more likely to be able to be controlled through methods such as burning and biological control.

In situations where the stands of mimosa are small or where labour is plentiful, mimosa could be killed effectively by cutting in this way by hand. Extensive situations where large areas are infested with mimosa (such as in the Northern Territory) would require a less time consuming and more efficient method of cutting such as blade ploughing.

Blade ploughing produced the effect required to kill large mimosa plants (i.e. cutting them off below ground level), however some modifications to machinery are required for this to become an efficient clearing method. The trial work reported in this paper was stopped as the thorny mimosa branches kept tangling up between the plough and the bulldozer during ploughing, resulting in many delays to clear it. These preliminary problems could be overcome by some simple modifications to equipment such as fitting a 'V' shaped implement to the front of the bulldozer to split the tangled mimosa to either side of the plough. Another option is a small 'skimming tine' mounted in front of the blade plough. This has been used successfully to overcome similar problems with rubber vine (*Cryptostegia grandiflora*) in Queensland (Barry Homan (Homan Industries Pty. Ltd.) personal communication).

Should the modifications to machinery prove to be successful, blade ploughing would be a valuable control method in combating mimosa. The advantages it has over control through herbicides are that it reduces the amount of chemicals applied to sensitive wetland environments, and it is a less expensive means of control. The cost of blade ploughing at the required depth has been estimated at approximately $90–100 per hectare by the manufacturers of one type of blade plough (Barry Homan personal communication). This compares favourably with the costs of chemical control which are about $200 per hectare per application (Sessional Committee on The Environment 1997). Furthermore, this study has shown that one treatment with a blade plough can effectively kill mature plants whereas more than one application of herbicide is often required as kill rates can be quite variable (Cook and Setterfield 1996, Miller and Siriworakul 1992).

While blade ploughing would be a viable alternative to chemical control in many situations, it would not be suitable for all types of terrain. Some environments such as creek banks or areas with many large trees growing close together would be unsuitable for efficient clearing by blade ploughing. Also blade ploughing on some soil types may only be able to be done at times when the soil moisture is suitable (for example some clays when dry, may set too hard for ploughing).

As with any method of killing mature mimosa plants, control by blade ploughing would be one part of an integrated management program and it is envisaged that inexpensive control methods such as burning and/or biological control would play a significant role in managing subsequent seedling establishment. Burning would be a logical next step to follow blade ploughing. The mimosa killed by blade ploughing would make an excellent fuel load after drying for three to four weeks (Figure 4). The burning of the debris should be strategically timed to kill any mimosa seedlings that become established. Burning also kills mimosa seeds on the soil surface (Lonsdale and Miller 1993).

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Environmental weeds of Christmas Island (Indian Ocean) and their management

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Abstract

The environmental weeds of Christmas Island (Indian Ocean) are mostly exotic tropical rainforest trees, shrubs and vines that persist in areas that have been rehabilitated after being mined for phosphate but which now form part of the Christmas Island National Park. Other environmental weeds occur within the rainforests, along rainforest margins and in other situations throughout the island.

The major environmental weeds of Christmas Island are *Adenanthera pavonia, Aleurites moluccana. Castilla elastica, Clausena excavata, Cordia curassavica, Delonix regia, Ficus elastica, Hevea brasiliensis, Mikania micrantha, Mucuna albertisii, Pithecellobium dulce, Pterocarpus indicus, Schefflera actinophylla, Spathodea campanulata* and *Tecoma stans*. Minor environmental weeds of the island include *Antigonon leptopus, Barringtonia asiatica, Ceiba pentandra, Imperata cylindrica, Leucaena leucocephala, Muntingia calabura, Nephrolepis biserrata, Nephrolepis multiflora, Pluchea indica, Psidium guajava, Ricinus communis, Senna sulfurea* and *Syzigium* spp.

An integrated system of environmental weed control is being developed on the island. It includes strict quarantine, the eradication of major weeds of limited distribution, the development of local legislation to prohibit the growing of certain plants, the encouragement of competition by native rainforest plants, limited physical and biological control, and progressive chemical control of the remaining weeds followed by rehabilitation with native rainforest seedlings.

Introduction

Christmas Island is a small (135 km^2) isolated Australian Overseas Territory in the Indian Ocean, about 400 km south of the western tip of Java. The island arose from the depths of the Indian Ocean, and consists of a basaltic core overlaid by limestone shelves originating from raised coral reefs. It has an undulating summit plateau 300–360 m high, surrounded by cliffs and terraces. The island has never been part of a larger land mass, and its flora is therefore restricted and includes many endemics (Australian Biological Resources Study 1993).

Christmas Island was uninhabited prior to European settlement in 1888, at which time it was covered by primary rain forest on the deeper soils of the plateau and by marginal rainforest on the shallower soils of the cliffs and terraces. The area has a strongly monsoonal tropical climate, dominated by southeast trade winds throughout much of the year.

Soon after settlement several areas were cleared and planted with potential rubber bearing trees, but the industry was not pursued and most of these areas were subsequently destroyed by mining. About 25% of the original vegetation has since been cleared for phosphate mining and other purposes. The post-mining landscape consists of tall coralline pinnacles and deep pits, and is initially almost sterile biologically.

Some of the exhausted mine fields have been rehabilitated by bulldozing the pinnacles and resoiling with phosphate rich subsoil. The surfaces were then ripped and planted with a range of exotic trees, shrubs and forage legumes.

Mining, rehabilitation, clearing for other purposes and natural regeneration have left a complex mosaic of vegetation types on Christmas Island. Primary rainforest is still dominant on the deeper soils of the plateau, as is marginal rainforest on the shallower soils of the cliffs and terraces. Extensive rainforest margins exist along linear disturbances such as roads and railway lines, as well as around the edges of abandoned and rehabilitated mine fields.

Much of the island is now national park, including much of the remaining rainforest and several partly or wholly rehabilitated mine fields. Largely as a result of this change in ownership and management the exotic trees within the rehabilitated areas of the national park are now perceived to be environmental weeds (Swarbrick 1997). Parks Australia North is actively removing competitive and invasive environmental weeds and replacing them with native rainforest trees.

This paper lists and discusses the actual and potential environmental weeds of rainforests, rainforest margins, rehabilitated areas and other parts of Christmas Island (Table 1), and considers their integrated control and management.

Environmental weeds of rainforests

Relatively undisturbed primary rainforest