Preliminary studies on control of *Mimosa pigra* in Vietnam

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Abstract

The noxious exotic weed mimosa, *Mimosa pigra* L., infests many locations in Vietnam. In the past, it has invaded wet and sunny areas such as flooded pasture, canals, river banks and along roadsides causing problems to traffic, irrigation and cultivation activities of farmers. More recently, mimosa has invaded some national parks. One of them, Tram Chim National Park, is a Ramsar Wetland, and the biggest wetland conservation zone in Vietnam. It is facing serious threat from mimosa. At Tram Chin National Park, unmanaged mimosa has increased in area from 150 ha in 1999 to 490 ha in 2,000 and 1,000 ha in 2001. Other national parks and lakes in the north, like Cuc Phuong and Thac Ba, are threatened due to the spread of mimosa in the flooding season. These infestations are causing a decline in plant and animal populations. In response to invasion by mimosa, the National Institute of Plant Protection has conducted research on physical, manual, biological and chemical control measures since 1995. This paper reviews the current status of mimosa invasion, its impact on the ecosystem, and the control measures employed, with the emphasis on herbicide application, in Vietnam.

Keywords: mimosa, invasion, manual control, biological control, herbicide application, control costs, impacts.

Introduction

Stretching from 8°N to 23°N with a variable topography and climate characteristics, Vietnam has favourable conditions for the development of tropical weeds. *Mimosa pigra* L., mimosa, is considered to be one of the most noxious exotic weeds on both agricultural and natural land. When mimosa was first introduced into Vietnam, probably before the 1970s, it mainly grew along the roadsides, and farmers often used it as a fence plant or for firewood. Mimosa then spread and invaded different ecosystems, especially along riverbanks and wetland national parks.

On agricultural land, the invasion by mimosa has not been of much concern because farmers have to apply seasonal weed control practices like hand-pulling or using pre–emergence herbicides to manage this and other weeds. However, there have been almost no promising or feasible measures to control and to prevent the spread of mimosa in national parks. Although the serious dominance of mimosa has been mainly confined to national parks, it will sooner or later be a threat to agricultural land, especially in the Mekong River Delta of Vietnam.

The studies conducted by the National Institute of Plant Protection (NIPP), beginning in 1995, have focused on surveying the status of the

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mimosa invasion and on control measures aiming to effectively manage the plant.

Materials and methods

Surveyed area

Surveys were conducted in eight provinces – Quang Nam, Quang Ngai, Binh Dinh, Phu Yen, Khanh Hoa, Gia Lai, Kon Tum, Darlak — and included three national parks and one river system.

Experiments

Three control methods; manual (cutting and hand pulling), application of herbicides (including the use of paraquat, metsulfuron methyl, triclopyr butoxyethyl ester and glyphosate), and biological control, were used in experiments to evaluate their level of control, costs, and impact on the environment. The tests were conducted on a small scale, with three replicates and 50 to 100 m^2 plot sizes, or in large scale demonstrations, in 500 to 1,000 m^2 plots without replicate at different growing stages of mimosa. Measurements recorded were: changes in fresh weight over time, ability to re-sprout, cost of treatment, and changes in abundance of fishes and beneficial insects.

Results and discussion

Present status of the mimosa invasion

Although mimosa was first introduced into Vietnam before the 1970s, it has continued to spread along the roadsides and fallow highland areas in the northern and central provinces. The surveillance conducted by NIPP, in 89 districts and 1,169 villages of eight central coastal and Tay Nguyen highland provinces, showed that there were only 31.3% of surveyed sites at district level and 18.1% at village level infested, with the total area of mimosa being 680 ha. It was mainly concentrated along the roadsides in Quang Nam and in highland areas of Gia Lai Province (Table 1) (Cam *et al*. 1997). It has nearly the same status in the Northern Province, where mimosa was occasionally found growing in a few locations. The major concentration was observed around some lakes, such as Dong Mo, Nui Coc, Ba Be, Thac Ba, Dai Nai and others. Recently mimosa was reported to have spread to a large area of fallow highland in Quang Binh Province.

In the tropical south of Vietnam, where flooding occurs annually, mimosa is easily spread and grows quickly. Infestations are thick in wet and flooded areas such as riverbanks, lakes and wetland national parks. In Tri An hydro-electric Lake, mimosa covers 800 ha of 32,400 ha of total lake area. Along the banks of the La Nga River the weed infested almost 7,000 ha at a high density of two to eight plants m^{-2}. In the Mekong River Delta, at locations such as An Giang, Kien Giang, Dong Thap, Long An, and others, mimosa has invaded thousands of hectares. The weed is also threatening to spread into agricultural land in the Delta. It is alarming that mimosa will sooner or later spread to agricultural land, especially in the buffer zones of national parks and the floodplains of the Mekong River Delta. It has already spread to a big area of agricultural land in Cat Loc District which is in the buffer zone of Nam Cat Tien National Park.

Mimosa tends to be more serious in wetland national parks where it is unmanaged. In Tram Chim National Park, mimosa has increased in area from 150 ha in 1999 to 490 ha in 2000 and 1,000 ha

Table 1. The invasion of mimosa in some of the central coastal and Tay Nguyen highland provinces of Vietnam (Cam *et al*. 1997).

Location	Number of districts surveyed	Number of infested districts	Number of villages surveyed	Number of infested villages	Infested area (ha)
Quang Nam	16	6	250	12	221.7
Quang Ngai	12	3	162	21	38.6
Binh Dinh	11	3	144	9	25.0
Phu Yen	7	5	96	25	74.7
Khanh Hoa	7	2	129	5	0.8
Gia Lai	11	4	148	27	224.6
Kon Tum	7	6	70	35	71.7
Darlak	18	6	170	48	22.9
Total	89	35	1,169	212	680
Percentage infestations		31.3		18.1	

in 2001. Nam Cat Tien, in the south-east, has been listed as a Wetland Conservation Area under the Ramsar Convention, and presents a similar situation. Not only has mimosa covered 30 ha of the total 50 ha of Bau Chim (Bird Pond), but it has also spread into thousands of hectares of the buffer zone.

The invasion of mimosa is causing negative impacts to the economy, biodiversity and the environment, requiring the special attention of scientists, government and society in Vietnam.

Impact on the economy

Invasion by mimosa not only obstructs farm practices but also increases the costs of farming due to control (see below). Although farmers in the Mekong River Delta have applied physical measures annually to control mimosa, thousands of hectares of alluvial land are now occupied by the weed.

Impact on biodiversity

The presence of mimosa has caused a decline in both the population size and number of species of plants and animals. In Tram Chim National Park its occupation may reduce the density of Poaceae and Cyperaceae plants, such as creeping panic grass (*Panicum repens* L.), wrinkled grass (*Ischaemum rugosum* Salisb.) and Chinese water chestnut *(Eleocharis dulcis* (Burman f.) Henschel), as well as some broadleaf weeds like water lettuce (*Pistia stratiotes* L.), water hyacinth (*Eichhornia crassipes* (Mart.) Solms-Laub.) and creeping water primrose (*Ludwigia adscendens* (L.) H. Hara). The invasion of mimosa in *E. dulcis* pasture is threatening the precious water bird the Brolga (*Grus antigone sharpii*), one of 16 species that are highly protected around the World (Triet and Dung 2001).

In Nam Cat Tien National Park different bird species often reunite after migration during the flooding season. They use plant material and seeds of various grasses and sedges like *P. repens*; *Brachiaria mutica* (Forssk.) Stapf, *Phragmites karka* (Retz.) Trin. ex Steud., *I. rugosum*, *E. dulcis* and *Cyperus* spp., as well as broadleaf plants for food. Under dense infestations of mimosa, the populations of these plants have declined sharply causing the disappearance of many bird species.

Social impact

Farmers living along the La Nga River are concerned about the pollution, due to the mimosa leaf fall to water sources used for drinking and fish feeding.

Management of mimosa

To cope with the spread of mimosa, some institutions in Vietnam have focused on the most effective measures for immediate control and long-term prevention of its spread. Some primary results of studies undertaken by NIPP since 1995 on manual, biological and chemical control of mimosa are presented below.

Manual control

Stem cutting

Due to the long flooding season, farmers can cultivate only from April to July in alluvial soil areas along La Nga River. Just after harvesting time, mimosa starts to grow and quickly increases in biomass. To enable sowing of the next crop, farmers have to cut mimosa plants before flooding with a hope to drown regrowth and seedlings. Roots of the first year plants may be inundated and die during the seasonal flooding while roots of older plants can survive. These older plants hinder ploughing during the next season and the weed regrows together with the planted crop. Over several years, mimosa can completely prevent farming. Manual control costs farmers 46 days of labour ha^{-1}, equal to US\$100 ha^{-1}.

In our experiments, carried out during the dry season mimosa re-sprouted seven days after cutting. One or more shoots sprouted from a basal stem and reached 50 cm in height after three weeks. In the case of shallow flooding (less than 30 cm), mimosa plants re-sprouted, but the development of new shoots was less than under no flooding. The cost of labour for cutting depended on the age of plants and level of plant cover. With low density and newly invaded sites, it was around 30 days of labour ha^{-1}. In contrast, in high density areas labour may be up to 60 days ha^{-1}. Farmers' practice and experiments showed that stem cutting followed by flooding only impacted on new plants.

Pulling

It was shown from experiments conducted in Nam Cat Tien National Park that pulling could achieve complete control of mimosa. However, it is feasible only with seedlings at an early stage. The cost for pulling depends on the height and age of the plants. Plants younger than two months and less than 100 cm high cost US\$150 ha^{-1} to control, while the control of older plants may require more than US\$200 ha^{-1}. The pulling method was successfully applied in Nam Cat Tien National Park to control mimosa in some critically important areas liked the Bau Chim (Bird Pond). However, it must be done annually due to the new germination of mimosa from seed.

Biological control

In a co-research project between NIPP and CSIRO Entomology, funded by the Australian Centre for International Agricultural Research (ACIAR), we imported two insect biological control agents between 1995 and 1997 for rearing and releasing in Vietnam. They were the mimosa stem borer, *Carmenta mimosa* Eichlin & Passoa, and the seed bruchid, *Acanthoscelides quadridentatus* (Schaeffer), which had been released and were established in Australia. Both species were subjected to host-specificity tests on different leguminous plants, food plants and fruit trees before releases were approved. They did not affect any of the test plants and *C. mimosa* was released in six locations in the north and four in the south of Vietnam. *Carmenta mimosa* established at the release sites, infected 50–80% of the mimosa stems and spread 2 km after four years. However, *C. mimosa* killed only new shoots and young plants. The insects are now mass-reared and released in combination with other methods such as cutting or pulling. The seed bruchid was released in 1987. It has established but has had no impact on seed production.

In 1998, also as part of the ACIAR project, a strain of the fungus, *Phloeospora mimosae-pigrae* Evans & Carrion, was imported from Australia for evaluation under Vietnamese conditions. The fungus showed a high host-specificity to mimosa and did not attack any of the 25 tested plant species belonging to Mimosaceae, Fabaceae, Gramineae, Cruciferaceae, Rosaceae, Solanaceae, Amaranthaceae, Compositae, Basellaceae, Convolvulaceae and Rutaceae. Spore germination and colony development of *P. mimosae-pigrae* proved to be better in improved PDA medium (PDA + 20% V8 juice) than in single PDA. The potential of the fungal pathogen to control mimosa was evaluated in a greenhouse with high humidity. Disease incidence (the percentage of the plant diseased) and disease index (the level of infection) increased with higher temperatures (Table 2). In these tests, plants were inoculated once only in summer, the most favourable period for development of the fungus (Thanh *et al*. 1998).

Chemical control

Although herbicides, especially non-selective herbicides, are not encouraged for use in protected areas such as national parks, they are an effective control method when mimosa spreads over a large area and other control methods are difficult to implement. Our experiments were done with two non-selective herbicides, paraquat and glyphosate, and two selective chemicals for broadleaf weeds, metsulfuron methyl and triclopyr butoxyethyl ester. All tested herbicides were used at 1.5 times the standard dosage. At that rate, leaf-drop occurred 7–15 days after treatment. Plants treated with paraquat quickly recovered 15 days after treatment while the other herbicides remained active for up to three months. After three months, new regrowth occurred (Table 3).

Table 2. The infection of *Phloeospora mimosae-pigrae on* mimosa under greenhouse conditions (Thanh *et al*. 1998).

Date of inoculation	Average temperature (°C)	Disease incidence (%)	Disease index (%)
28 March 1998	20.7	94.1	37.5
7 April 1998	26.3	100	80.9
12 May 1998	28.6	80.3	23.6
1 June 1998	30.3	56.2	70.4
13 July 1998	30.7	64.2	77.8

Table 3. Effect of herbicides on leaf-drop of mimosa.

Herbicide[a]	Dosage (gal/ha)	Efficacy (%) leaf drop after treatment			
		15 DAT[b]	30 DAT	60 DAT	90 DAT
Glyphosate	2,250	55.3	100	100	96.7
Paraquat	900	100	23.7	0	0
Metsulfuron methyl	9	33.7	85.3	100	90.0
Triclopyr butoxyethyl ester	1,800	50.0	100	100	94.3
Untreated control	–	–	–	–	–

[a] Sprayed at 800 L water volumetric ha^{-1}.
[b] DAT = days after treatment.

While calculating efficacy, we adjusted for number of leaves in both treated and untreated using the Henderson Tilton method as follows:

$$\text{Efficacy (\%)} = 1 - \frac{\text{Ta Cb}}{\text{Ca Tb}} \times 100$$

where:

Ta = number of leaves in treated plot after treatment

Tb = number of leaves in treated plot before treatment

Ca = number of leaves in untreated plot after treatment

Cb = number of leaves in untreated plot before treatment

With the exception of paraquat, the herbicides started to kill branches of mimosa 15 or 30 DAT. Glyphosate provided the highest efficacy (90.6% at 90 DAT), followed by triclopyr butoxyethyl ester (68.7% at 90 DAT). Metsulfuron methyl killed 44.7% of branches (Table 4). While glyphosate killed both old and young branches, triclopyr butoxyethyl ester and metsulfuron methyl could kill only young ones.

Following the death of branches, all herbicides, except paraquat, started to kill parts of plant including main and basal stems and roots. However, glyphosate killed whole parts of plants at all ages and sizes and gave 89.3% control of mimosa at 90 DAT (Table 5). Triclopyr butoxyethyl ester and metsulfuron methyl did not kill basal stems of old plants and they controlled only 48.0% and 15.3%, respectively, of mimosa plants.

It was concluded that glyphosate, a non-selective herbicide, provided the best control of mimosa. However, at the standard dosage it also killed plant communities under the mimosa canopy. When used at standard dosage (1,500 gal ha^{-1}) glyphosate caused necrosis at 15 DAT but it killed only young plants. The efficacy sharply increased when the dosage was increased to 2,250 gal ha^{-1} while the effect on non-target plants was still very high. This means that to control mature mimosa, glyphosate cannot be applied at a lower dosage than 2,250 gal ha^{-1} and will have undesirable consequences to other plants. When glyphosate, at 2/3 standard dosage, was mixed with either triclopyr butoxyethyl ester or metsulfuron methyl at half their standard dosages, the efficacy was improved compared with a single use of glyphosate at its standard dosage, but it was still not sufficient to control mimosa. The mixture of triclopyr butoxyethyl ester and metsulfuron methyl at half their standard dosage also provided a far lower efficacy than their single use at standard dosage (Table 6).

Aiming to achieve a more effective and economical use of glyphosate, different volumes of water were tested using two low-volume sprayers; ULVA Plus and a hand knapsack sprayer. The results with the knapsack sprayer

Table 4. Efficacy of herbicides to kill branches of mimosa.

Herbicide	Dosage (gal/ ha)	Percentage of branches dead after treatment			
		15 DAT[b]	30 DAT	60 DAT	90 DAT
Glyphosate	2,250	15.7	45.3	88.3	90.6
Paraquat	900	0	0	0	0
Metsulfuron methyl	9	0	20.7	39.4	44.7
Triclopyr butoxyethyl ester	1,800	0	28.7	65.3	68.7
Untreated control	–	–	–	–	–

[a] Sprayed at 800 L water volumetric ha^{-1}.

[b] DAT = days after treatment.

Table 5. Efficacy of herbicides to control whole plants of mimosa.

Herbicide[a]	Dosage (gal/ ha)	Percentage of plants dead after treatment			
		15 DAT[b]	30 DAT	60 DAT	90 DAT
Glyphosate	2,250	6.3	32.7	80.3	89.3
Paraquat	900	0	0	0	0
Metsulfuron methyl	9	0	13.7	13.7	15.3
Triclopyr butoxyethyl ester	1,800	0	18.3	35.7	48.0
Untreated control	–	–	–	–	–

[a] Sprayed at 800 L water volumetric ha^{-1}.

[b] DAT = days after treatment.

showed that glyphosate supplied an equal efficacy when reducing the spray volume from 800 L to 600 L ha^{-1}. However, 400 L ha^{-1} was not adequate for efficient surface coverage of the plant, therefore the efficacy of the product sharply decreased (Lam *et al*. 2001).

The recommended use of ULVA is 5 L ha^{-1}. However, the efficacy of the product was remarkably improved when sprayed at 10 and 15 L ha^{-1} (Table 7). By using ULVA, farmers save 4–5 days labour ha^{-1}, which is equal to US$8 to $10 ha^{-1} for spraying practice.

Summary

Mimosa occurs scattered across northern, central coastal and central highland locations in Vietnam. However, the weed is widely spread and is invading various wet and seasonally flooded areas in the south. Of them, Tri An hydroelectric lake, the banks of the La Nga River, and Tram Chim and Nam Cat Tien National Parks are facing a serious invasion requiring special attention from Vietnamese and international scientists.

The invasion of mimosa is causing a negative impact to the economy and the environment, especially to the diversity of plants and animals in conservation zones.

Although manual control methods of cutting or pulling, as well as biological control, can suppress the development of mimosa, they are not able to prevent the regrowth of plants, or the growth of new generations. Stem cutting is successful when applied to young plants just before the flooding season. Manual control methods require a high cost for labour that is less feasible for use on large areas. However, manual and biological control methods are proposed to control young plants or where the density of mimosa is low. They may also be utilized with herbicides.

Glyphosate showed the best control among the herbicides tested when applied at 1.5 times the recommended standard dosage. It controlled approximately 90% of the treated mimosa plants. The efficacy was sharply decreased when applied at its standard dosage but it was appreciably improved when mixed with either triclopyr butoxyethyl ester or metsulfuron methyl at half their recommended standard dosages. The highest efficacy was achieved when glyphosate was applied at a rate of 600 L ha^{-1} with a hand knapsack sprayer or at 10 L ha^{-1} with an ULVA sprayer. The ULVA sprayer was equal in efficacy to the hand knapsack sprayer and also significantly reduced costs.

Table 6. Efficacy of glyphosate and its mixtures to control mimosa.

Herbicide[a]	Dosage (gal/ ha)	Percentage of plants dead after treatment			
		15 DAT[b]	30 DAT	60 DAT	90 DAT
Glyphosate	1,500	10.3	18.7	59.7	66.7
Glyphosate + metsulfuron methyl	1,000 + 4.5	3.3	20.7	65.3	77.7
Glyphosate + triclopyr butoxyethyl ester	1,000 + 900	0	15.7	25.3	80.9
Triclopyr butoxyethyl ester + metsulfuron methyl	900 + 4.5	0	10.7	15.7	28.3
Untreated control	–	–	–	–	

[a] Sprayed at 800 L water volumetric ha^{-1}.
[b] DAT = days after treatment.

Table 7. Efficacy of glyphosate[a] applied using different sprayers and in various water volumes to control mimosa.

Sprayer type	Water volume (L ha^{-1})	Percentage of plants dead after treatment			
		15 DAT[b]	30 DAT	60 DAT	90 DAT
Hand knapsack	800	10.3	30.7	76.8	85.3
	600	8.7	32.3	77.3	84.0
	400	3.3	18.7	69.7	73.7
ULVA	5	0	13.7	45.7	56.5
	10	6.7	29.3	74.3	82.7
	15	11.7	33.3	76.7	86.3
Untreated control	–	–	–	–	–

[a] Used at 2,250 gal ha^{-1}.
[b] DAT = days after treatment.

Although glyphosate controls mimosa it also burns plant communities living under the mimosa canopy. Therefore, it is recommended only where non-target effects are tolerable and it should be combined with manual control methods by spraying in bands, to minimize its negative effects. It may be spot sprayed on new shoots of mimosa to reduce the total treated area, to reduce non-target damage and to make it more effective.

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