Research reports

Chemical control of thunbergia (*Thunbergia grandiflora*)

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Summary

Thunbergia is destroying north Queensland tropical lowland rainforests at the rate of about 0.5 hectare per year. Three experiments involving twenty-five herbicides were trialled at various concentrations as high volume foliar applications for the control of thunbergia (*Thunbergia grandiflora*). Most herbicides produced 100% brown out, but failed to prevent regrowth of underground tubers and allowed complete recovery of treated plants in 3–6 months. Only imazapyr (1.87, 2.5 and 3.75 g L^{-1}) killed both the above-ground growth and the tuberous root system. The three next most effective herbicides, triclopyr/picloram, fluroxypyr and 2,4-D/picloram produced 80–100% foliage reduction and 20–75% regrowth of underground tubers.

Introduction

Thunbergia (*Thunbergia grandiflora* Roxb. ex Rottle), a native of northern India (Ahmad 1974, Kumar and Paliuval 1975), was introduced into Australia as a garden plant. It is widely promoted as an ornamental in many tropical, subtropical and warm-temperate areas (Parsons and Cuthbertson 1992). Thunbergia is frequently found growing as a vigorous and aggressive woody vine in eastern Australian domestic gardens as far south as Melbourne and west to Adelaide. Distribution of thunbergia in north Queensland is patchy; it is found in scattered places along coastal streams from the Tully to Daintree rivers with areas of dense infestation along the Mulgrave River and the lower part of the Mossman River (Humphries *et al.* 1991).

Thunbergia usually does not produce seed but is propagated by vegetative material. Once rooted it spreads by stolons (Bremekamp 1955). The plant develops an extensive tuberous root system with some tubers being as large as 0.5 m in diameter, 3 m in length and weighing 100 kg (N. Tucker personal communication 1994). The root system, when cut, sprouts repeatedly from many dormant buds. However, viable seed-producing plants exist in Cairns, Georgetown and along the Mulgrave River.

Dispersal in north Queensland rainforests can be attributed to transport of stem and tuber pieces down rivers during floods or transport from infested sites by earth-working equipment. Plants grown from stem cuttings are sold by nurseries throughout the eastern states.

Thunbergia has large ovate to broad-ovate leaves (12.5–20 cm long), angle-toothed or slightly lobed towards the base with acuminate tips. The upper and lower surface of leaves is either scabrous or pubescent (Bailey 1949). The pale lavender-blue trumpet-shaped flowers occur in dense racemes or solitary. Each flower has a short broad tube, white on the outside and yellowish inside, which expands to five rounded pale blue lobes, one larger than the others. The flowers are up to 8 cm long and 6–8 cm across. The seed pod, cone-shaped with a rounded base, is 3–5 cm long and 1 cm broad. When dry, it splits in two catapulting seeds several metres. Seeds are 0.5–1.0 cm in diameter, flat with one side curving outwards, and covered with triangular brown scales.

In Australia, thunbergia has become a serious weed in tropical lowland forests of Queensland (3000–4000 mm annual rainfall), and has been highlighted as one of the top priority species of national concern threatening the Wet Tropics World Heritage Areas (Humphries *et al.* 1991). It has an extremely high growth rate and can destroy rainforests at the rate of more than 0.5 ha yr^{-1}, reducing trees to blanketed poles and eliminating understorey species (P. Stanton personal communication 1991). In some sites it maintains 100% groundcover over several hectares.

Several foliar herbicides (2,4-D amine, 2,4-D ester, 2,4,5-T ester, 2,4-DP, glyphosate and triclopyr) have been trialled previously with limited success (J. Mangano personal communication 1987). Our study evaluated the response of thunbergia in the field to foliar applications of 25 herbicides.

Materials and methods

Field experiments to determine the effect of foliar-applied herbicides on thunbergia were conducted between 1987 and 1991 near Innisfail, Queensland (15° 22'S, 146° 01'E). Thunbergia infestations covering 100% of the ground were selected for the experiments, whilst vines climbing trees were excluded for ease of herbicide application. Thunbergia was dense, uniformly lush and actively growing at the time of herbicide application. In February 1992, an untreated 100 m^2 area of densely growing thunbergia was selected to determine the weight of tubers and foliage per unit area. Three randomly selected quadrats were chosen, each 1 m^2, for the study within the 100 m^2 plot. Depth and weight of thunbergia groundcover and number of stoloniferous stems was recorded. Tuber production was determined by hand-shovelling 1 m^3 of soil from each quadrat and separating the top 30 cm. Dry weights for foliage biomass and tubers were determined after air drying for 60 days and then oven drying at 80°C for 4 days.

The initial experiment evaluated 25 herbicides between September 1987 and February 1989. Not all herbicides and concentrations were tested at all sites. Plots were 10 × 10 m. The four most effective herbicides (imazapyr, fluroxypyr, triclopyr/picloram and 2,4-D/picloram) having a mean of <50% biomass regrowth were selected for the second experiment and foliar-applied in March 1989. The experimental layout was a completely randomized design with three replicates. Plots were 10 × 10 m.

The final experiment (Experiment 3) was applied in December 1991 and examined the effect of the most effective herbicide, imazapyr, at five concentrations (0.19, 0.42, 0.83, 1.68 and 2.5 g L^{-1}). The experimental design was a completely randomized layout with three replicates. Plots were 4 × 4 m.

Spray equipment and application

A 20 litre, 12 volt electric powered back-carried spray unit with adjustable solid cone nozzle and an operating pressure of 200 kPa was used to apply herbicide treatments for all experiments. At each site the plants were thoroughly sprayed to the point where the spray mixture dripped from the foliage (spray volume 1500 L ha^{-1}). All solutions contained 0.2% (v/v) non-ionic surfactant (Agral 90, a 90% alkyl phenol ethylene oxide condensate).

A twin-diaphragm pump, powered by a 3.7 kW motor was used to respray foliage regrowth in Experiment 3. The handgun was fitted with a D6 nozzle and the operating pressure adjusted to 700 kPa. A positive displacement flowmeter (Manu MEK20LCD4) attached in-line to the spray unit recorded spray volume delivery.

Table 2. Mean foliage reduction (±SE) (assessment date ranging from 35 to 56 days after treatment) and mean foliage regrowth (±SE) 94 to 199 days following treatment with foliar-applied herbicides in Experiment 1.

Trade name	Herbicide (active ingredient)	Rates applied (g a.i. L^{-1})	No. times treatment applied	Biomass reduction (%)	Biomass regrowth (%)
Basal Coat	2,4-D acid	30	1	95	100
D 500	2,4-D amine	5.0	3	50±5	85±5
		10.0	3	45±10	80±5
D-500/Starane	2,4-D amine/fluroxypyr	5.0/3.0	1	95	65
D-500/Round Up	2,4-D amine/glyphosate	5.0/3.6	1	50	100
D-800	2,4-D ester	8.0	1	85	100
D-800	2,4-D ester[A]	5.0	1	95	100
Tordon 50D	2,4-D/picloram	2.0/0.5	1	85	95
		3.0/0.75	2	75±21.2	75±14.1
		4.0/1.0	1	90	100
		5.0/1.25	1	100	10
		6.0/1.5	2	92.5±3.5	30±28.3
MCPA 500	MCPA	5.0	1	25	100
		10.0	1	30	100
Amitrole T	amitrole	2.5	1	75	100
		5.0	1	95	100
AF 420	atrazine/2,4-D	3.2/0.91	1	75	100
		6.4/1.82	1	70	100
Nutrazine Flowable/Starane	atrazine/fluroxypyr	5.0/3.0	1	95	95
Lontrel L	clopyralid	3.0	1	0	100
Banvel 200	dicamba	2.0	1	30	100
		4.0	1	40	100
AF 302	dichlorprop	4.0	4	60±10.8	98.5±2.4
		8.0	4	90±7.1	75±25.5
		12.0	1	80	100
		16.0	1	90	100
DP 600	dichlorprop	6.0	1	45	100
		12.0	1	65	100
Diuron Flowable	diuron	8.0	1	0	100
Starane	fluroxypyr	3.0	2	60±35.6	57.5±60.1
		4.5	1	90	10
		6.0	1	50	100
		7.5	3	95±0	21.7±24.7
		9.0	2	90±7.1	22.5±3.54
		10.5	1	99	15
		12.0	1	90	15
Starane/MCPA 500	fluroxypyr/MCPA	3.0/5.0	1	95	90
Round Up	glyphosate	3.6	4	50±5.8	100±0
		5.4	4	60±8.2	100±0
		7.2	5	65±14.1	95±7.1
Velpar L	hexazinone	2.5	1	0	100
Arsenal 250A	imazapyr	1.25	1	60	20
		1.875	1	95	0
		2.5	5	90.8±12.3	2.2±4.4
		3.75	3	99.3±0.6	3.3±5.8
		5.0	3	98±2.7	0±0
		6.25	1	99	0
Brush-Off	metsulfuron	0.12	2	20±0	100±0
IWD 4046	picloram ester	2.0	1	85	85
		4.0	1	90	90
Garlon	triclopyr	3.36	4	95±4.1	86.3±4.8
		6.72	4	95±7.1	90±4.1
		9.6	1	90	75
		14.4	1	95	55
Grazon DS	triclopyr/picloram	1.5/0.5	3	90±5	96.7±5.8
		3.0/1.0	5	97±2.3	35±16.2
		4.5/1.5	1	95	75
		6.0/2.0	5	96.6±2.2	24±17.8
		7.5/2.5	2	97.5±3.5	12.5±3.5
		9.0/3.0	1	100	10

[A] Diesel used as carrier.

Table 1. Thunbergia grandiflora foliage biomass from a 1 m² area and tuber biomass from a 1 m³ soil volume, near Innisfail in February 1992. Mean and standard error of the mean are based on three samples.

	Fresh weight (kg)	Dry weight (kg)	Depth of groundcover (cm)	No. Stems at ground level (number)
Groundcover biomass	10.5 ± 3.0	1.3 ± 0.2	57 ± 12	23.3 ± 5.6
Tuber[A]	51.2 ± 5.5	5.0 ± 0.3	–	

[A] 75 ± 5.8% of tubers located in the upper 30 cm of the soil.

Table 3. Percentage foliage reduction 31 days after treatment (DAT) and foliage regrowth 145 DAT of thunbergia following foliar-spraying with imazapyr, fluroxypyr, triclopyr/picloram and 2,4-D/picloram in Experiment 2.

Herbicide	Rates applied (g a.i. L^{-1})	Biomass reduction (%)	Biomass regrowth (%)
Imazapyr	1.87	100 a	0.0 e
	2.5	100 a	0.6 e
	3.75	100 a	0.0 e
Fluroxypyr	6.0	95.8 bc	66.8 ab
	7.5	99.4 ab	43.2 c
	9.0	100 a	26.2 d
Triclopyr/picloram	3.0/1.0	87.4 cd	26.4 d
	7.5/2.5	92.2 cd	19.8 d
2,4-D/picloram	4.0/1.0	80.2 d	75.1 a
	5.0/1.25	88.4 cd	55.0 bc

Means followed by same letter do not significantly differ (P=0.05, Duncan's MRT).

Table 4. Percentage foliage reduction 51 days after treatment (DAT), foliage regrowth 140 DAT and volume required to spray regrowth 140 DAT of thunbergia foliar-sprayed in December 1991 with imazapyr in Experiment 3.

Rates applied (g a.i. L^{-1} solution)	Biomass reduction (%)	Biomass regrowth (%)	Volume to respray regrowth (L per 16 m²)
0	0.0 e	100.0 a	5.0 a
0.19	10.9 d	91.0 b	4.1 a
0.42	67.2 c	49.9 c	2.4 b
0.83	91.0 b	9.0 d	1.4 bc
1.68	98.3 ab	6.5 d	0.7 c
2.5	100.0 a	0.0 e	0.0 d

Means followed by same letter do not significantly differ (P=0.05, Duncan's MRT).

Herbicide evaluation

Assigning treatments to individual thunbergia plants was extremely difficult due to its stoloniferous nature and its rooting system, therefore no assessments of individual mortality were possible. Instead a visual estimate of the percentage biomass reduction and a visual estimate of percentage biomass regrowth was used. In Experiment 1, a biomass reduction assessment date ranged from 35 to 56 days after treatment (DAT), and a final biomass regrowth assessment ranged from 94 to 199 DAT. Biomass reduction for Experiments 2 and 3 were at 31 and 51 DAT, and a final regrowth assessment at 145 and 140 DAT for Experiments 2 and 3, respectively. As a cross check on the accuracy of the visual method of estimating the percentage biomass, treatments in Experiment 3 were resprayed with water on final assessment (140 days after treatment (DAT)), the volume of water used being a measure of the regrowth present. This method of assessment is time consuming, but allows a quantitative comparison to the visual percentage biomass method. The tubers in plots with no foliage regrowth (in all experiments) or requiring no respray with water at final assessment (Experiment 3) were randomly sampled to ensure no live tissue remained.

Statistical analysis

As application of treatments in Experiment 1 was spread over 17 months, using various degrees of replication each time, no realistic test of significance was possible. Treatment means are presented in Table 2. Percentage biomass reduction, biomass regrowth and volume respray were subjected to a one-way analysis of variance (ANOVA) after an arcsine transformation for Experiments 2 and 3. Differences between means were separated using Duncan's multiple range test. A Bonferroni pairwise comparison between herbicides (based on regrowth) was also used in Experiment 2.

Results

The average depth of matted thunbergia groundcover was 57 cm (Table 1). A mean of 23 stoloniferous stems per m² was observed at ground level following removal of the foliage. The fresh and dry weights of foliage sampled were 10.5 and 1.3 kg respectively, and a 1 m³ of soil yielded 51.2 kg of tubers (fresh weight), 75% of which were in the upper 30 cm (Table 1).

Experiment 1

Most herbicides produced 100% brown out. Both foliage reduction and biomass regrowth ranged from 0–100% over all treatments (n=60) tested (Table 2). Percentage biomass regrowth was considered the most reliable indicator for determining herbicide effectiveness. The trial set-up did not permit the presentation of meaningful significant difference in Table 2. An arbitrary point of <50% per cent biomass regrowth was used to select herbicides warranting further testing. Of the 25 herbicides trialled in Experiment 1 only four herbicides, imazapyr, fluroxypyr, triclopyr/picloram and 2,4-D/picloram, met this criterion (Table 2).

Experiment 2

Two herbicides in Experiment 2 (Table 3)—imazapyr (1.87, 2.5 and 3.75 g L^{-1}) and fluroxypyr (7.5 and 9.0 g L^{-1})—produced foliage reduction levels (>99%) that were significantly better than those achieved by triclopyr/picloram and 2,4-D/picloram. Foliage regrowth for imazapyr was approximately 0% at all concentrations tested and the least effective treatment 2,4-D/picloram (4.0/1.0 g L^{-1}) had 75% regrowth. A Bonferroni pairwise comparison between herbicides of the regrowth values indicated that imazapyr was significantly better (P<0.0005) than triclopyr/picloram, fluroxypyr and 2,4-D/picloram. Triclopyr/picloram was significantly better than both fluroxypyr (P=0.02), and 2,4-D/picloram (P<0.0005). The order of decreasing efficacy of the herbicides trialled in reducing regrowth was imazapyr > triclopyr/picloram > fluroxypyr > 2,4-D/picloram.

Experiment 3.

Imazapyr at 2.5 g L^{-1} was the most effective concentration trialled (Table 4) on thunbergia. It produced a complete kill of both foliage and roots, with a 100% biomass reduction, no foliage regrowth and no regrowth spray required. Imazapyr as low as 0.83 g L^{-1} would allow acceptable control levels in the field, producing

biomass reduction of 91%, and biomass regrowth of 9%.

Discussion

The field experiments indicated that, of the 25 foliar-applied herbicides, only imazapyr at 1.87, 2.5 and 3.75 g L^{-1} killed actively growing thunbergia. Imazapyr is readily absorbed by foliage, is translocated throughout the plant and accumulates in meristematic plant tissue (Orwick *et al.* 1983). It has a residual effect in the soil, and consequently may also enter the plant through the roots. The biological activity of imazapyr in the soil persists for three months to one year, depending on dosage and soil moisture content (Peoples 1984). Under drought conditions, the herbicide may persist for more than one year (Peoples 1984). The residual effect is short-lived in the wet tropics, as the plots treated with imazapyr had *Panicum* sp. and *Brachiaria* sp. re-establishing 3–6 months following treatment.

The susceptibility of thunbergia tubers to imazapyr was confirmed when tubers from treated plots were examined, and no live tissue was found. Results indicate that 4.5 mg imazapyr is able to kill 1 kg of live thunbergia (imazapyr 1.87 g L^{-1} at a spray volume of 0.15 L m^{-2} on a total biomass of 61.7 kg m^{-2}). Imazapyr has also effectively controlled above ground parts and tubers of the sedge, *Cyperus rotundus* (Zaenudin 1988), which has been described as one of the world's worst weeds (Holm *et al.* 1991), and one of the most difficult weeds to control effectively (Hawton *et al.* 1992).

Following registration of imazapyr for use on thunbergia in Queensland at a rate of 1.87 g L^{-1} on 23 December 1991, several large scale commercial spray applications along the Mulgrave River and on Dunk Island controlled all the thunbergia plants sprayed. In these areas thunbergia smothered vegetation 10–12 m above ground, and was sprayed from ground to 5 m. One hundred per cent control, minimal non-target damage and natural revegetation of native plant communities previously smothered by thunbergia has been observed up to 1996.

Treating isolated thunbergia plants with imazapyr is a priority, thereby reducing the risk of further weed expansion. The plant can also be successfully removed from North Queensland tropical lowlands rainforests by foliar-spraying with imazapyr at 1.87 g L^{-1}. However, caution must be exercised in the widespread application of imazapyr as desirable native species may be killed. Only treating areas blanketed with thunbergia would minimize non-target damage.

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