Herbicidal control of *Parthenium hysterophorus* L.

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SUMMARY

Parthenium weed (*Parthenium hysterophorus* L.) is causing increasing concern in Queensland by its invasion of disturbed areas and pastures, its competition with,and contamination of,crops; and by the allergic reactions it causes in susceptible persons and some animals. A containment scheme introduced in 1976 is apparently checking its spread to uninfested areas of Australia. Comprehensive herbicide screening trials have resulted in recommendations for treating *P. hysterophorus* in several situations. Dicamba as the amine salt applied at 0.5 to 1 kg/ha in sufficient volume of water for canopy coverage gives effective knock-down, but will not control subsequent seedlings. Young actively growing parthenium weed is controlled by 2,4-D amine at 4 kg/ha when used for aerial application in pasture as a suppressant. Hexazinone at 1 kg/ha as granules or in aqueous solution from 40 ℓ/ha provides quick knock-down and a significant residual effect although initial suppression of pasture species limits its application. Picloram at 225 g/ha plus 2,4-D at 900 g/ha as amine salts in carrier volumes above 200 ℓ/ha controls parthenium weed and is less damaging to grasses. Atrazine at 2 to 4 kg/ha provides economical pre- and post-emergence control in tolerant crops and other situations where other herbicides may cause damage to desirable species, particularly trees.

INTRODUCTION

Parthenium weed (*Parthenium hysterophorus*) was first collected in Australia from Toogoolawah in the upper Brisbane Valley in 1955 where it still persists. It was subsequently recorded from the central lowlands of Queensland with the comment that it established on an area of gidyea (*Acacia cambagei*) scrub pulled and burnt in 1959 and sown in 1960 with grass seeds imported from Texas, U.S.A. (Everist, 1976a). This infestation was reported in 1964 to be suppressing rangeland species. In the second half of 1973, following above average winter rain, parthenium weed appeared as continuous infestations along roadsides leading south through the Central Highlands (Everist, 1976b). During the good seasons between 1974 and 1977, it continued to spread at an alarming rate and now infests thousands of square kilometers (Anon., 1977).

Parthenium weed can infest virgin scrub and disturbed, degraded or bare soil situations especially on heavily stocked areas and on pulled and burned scrub areas before improved pastures can be fully established. Sheep are the only animals observed to eat any quantity of parthenium weed but this causes tainting of their carcasses. Parthenium weed can cause contact dermatitis to man, and allergic skin reactions in livestock have also been reported (Shelmire, 1939).

Parthenium weed was surveyed, recognized as an official problem, and declared noxious in Queensland in 1975. In 1976 the State Government introduced a containment scheme to subsidize local authorities and landholders in treating marginal infestations. Seeds can be spread from roadsides, headlands, waterways and adjacent pasture or timbered areas by vehicles, mobile machinery, 'whirly winds', running water, animals and farm produce.

Figure 1 shows the current distribution in Queensland of parthenium weed. Gas exchange studies (Doley, 1977) and C.S.I.R.O. phytotron studies have confirmed that this weed has the potential to germinate and grow in any environment in Australia. It has already been identified from the Roper River area of the Northern Territory (Nemestothy, personal communication).

Comprehensive herbicide screening trials were established to provide recommendations for treating parthenium weed. Because of the mass of seed present in the soil, residual as well as knock-down herbicides were considered because parthenium weed can germinate and grow throughout the year.

MATERIALS AND METHODS

The main experimental site was on Cairo Holding, 50 km north of Clermont. This alkaline, self-mulching, black earth supports native grasses and legumes that had been invaded by parthenium weed during 1975. Plants were counted in the centre of each plot on fixed quadrats.

The series of trials outlined below basically differed in the volume of water carrier and timing of application of the herbicides. The herbicides and rates used are set out in the tables numbered to correspond with the following application techniques:

Trial 1 - 12 March 1976. Hand boom sprayed at 300 ℓ/ha

A pneumatic tank sprayer hand pumped to 270 kPa delivered a 2 m swath through four T-jet nozzles attached to a hand boom. Plots of 2 m x 5 m were arranged in a randomized block design with three replications. Dense parthenium weeds ranging from seedlings to flowering plants, the latter from 6 cm to 1.5 m tall, were sprayed.

Trial 2 - 12 to 13 March 1976. Power sprayed at 4000 ℓ/ha

A brush gun orifice of 1.6 mm diameter from a twin piston pump at 1000 kPa was used to spray plots of 1 m x 5 m with six herbicides each at three rates replicated three times.

Trial 3 - 16 October 1976. Hand boom sprayed at 280 ℓ/ha

Similar equipment to Trial 1 was used at 1 m/sec walking pace to spray 2 m x 100 m plots. Parthenium weed rosettes had just recovered from dry weather wilting and many new seedlings had emerged after recent rain.

Trial 4 - 21 November 1976. Knapsack sprayed at 1000 ℓ/ha

A hand pumped knapsack sprayer with a fan spray nozzle was used to treat 5 m x 2 m plots.

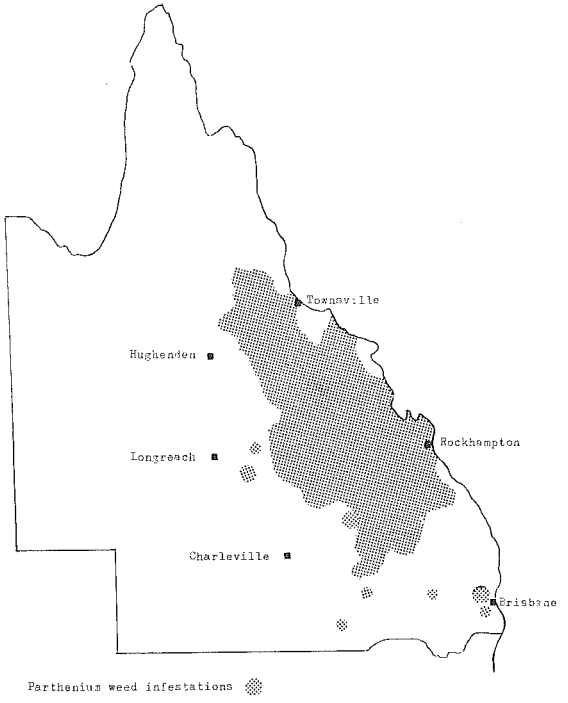

Figure 1. Occurrence of parthenium weed in Queensland

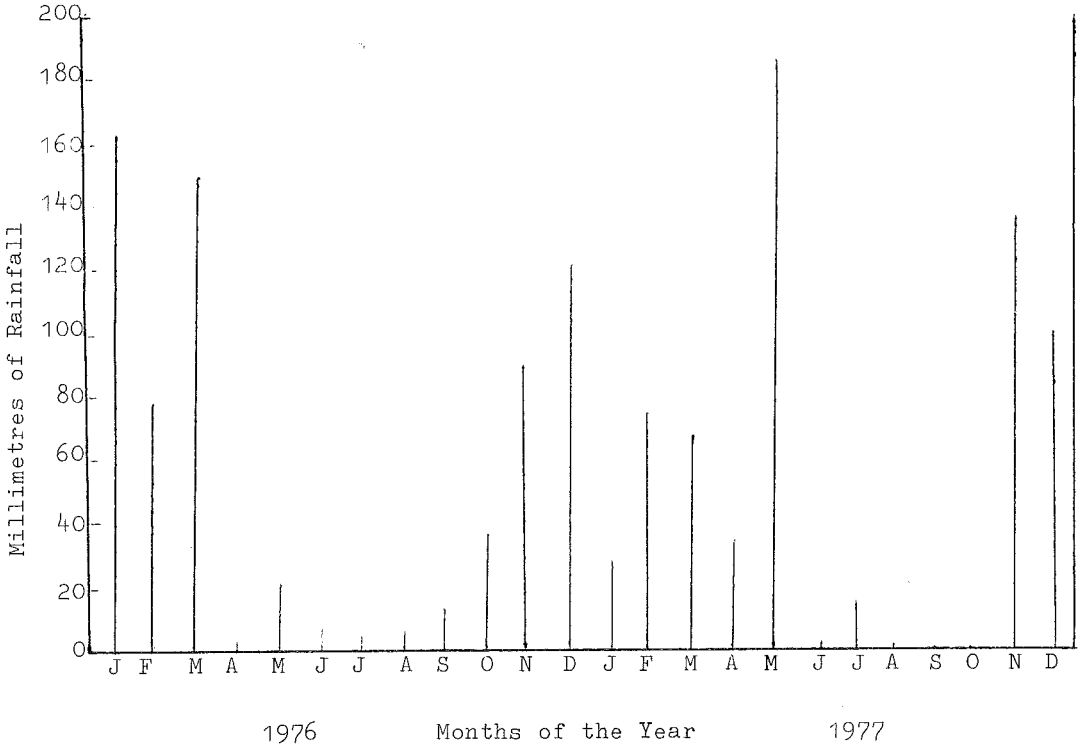

Figure 2. Monthly rainfall near parthenium weed trials (source : R. Clarke, Kilcummin)

Trial 5 - 22 November 1976. Power sprayed at 5000 ℓ/ha

A brush gun orifice of 1.6 mm diameter from a diaphragm pump at 1000 kPa was used to spray 5 m x 2 m plots.

Trial 6 - 13 January 1977. Hand boom sprayed at 300 ℓ/ha

This area was sprayed similarly to Trial 1 with extra (0.1%) wetting agent added to half the 20 m x 2 m plots of each rate of herbicide applied. The parthenium weed plants ranged from seedlings to the flowering stage.

RESULTS AND DISCUSSION

The results of the above trials are given in the correspondingly numbered tables below. The parthenium weed population recorded in the check plots is positively correlated with the rainfall recorded in Figure 2 due to germinations following soaking rains.

In Trial 1 karbutilate initially looked promising but its detrimental effect on pasture and trees along with uncertainty of supply ruled it out for recommendation. Table 1 shows 2,4-D amine controlled only young actively growing parthenium weed while mature plants survived at 3 kg/ha. Dicamba from 450 g/ha controlled most of the existing parthenium weed but gave no significant residual effects. A rate of 225 g/ha picloram plus 900 g/ha 2,4-D controlled parthenium weed but also killed legumes. The 3 kg/ha or higher rates of bromacil required to control mature parthenium weed, detrimentally affected non-target species. Check plots carried heavy infestations of parthenium weed except where dense pasture was present during dry periods.

In Trial 2 where higher herbicide rates in more water per ha were used there were more effective results (Table 2) than that recorded in Trial 1. Hexazinone gave quick knock-down of parthenium weed but did not immediately affect grasses. Later root absorption killed most vegetation on plots where heavier applications were used although legumes and grasses on the 0.9 kg/ha plots recovered. Diuron at 3.2 kg/ha and above killed all existing parthenium weed but its residual life was limited. Bromacil at 4 kg/ha and above controlled parthenium weed but also stopped growth of useful species for a year. Dicamba was effective in reducing the parthenium weed problem in favour of grasses. Mature parthenium weed with sparse foliage required high rates of 2,4-D and other foliage-absorbed herbicides for suppression. Picloram which can be root absorbed controlled all stages of parthenium weed growth.

Trial 3 followed a pilot trial which demonstrated that atrazine and hexazinone could persist during 2 months of dry weather and give acceptable control when rain finally allowed root absorption of the herbicides by parthenium weed. Table 3 shows knock-down of existing parthenium weed occurred within a month of treatment. Residual control from hexazinone lasted 4 months while atrazine at rates of similar cost per ha controlled parthenium weed for the rest of the season. However where high rates of both herbicides eliminated other vegetative competition, the parthenium weed a year later, without further treatment, grew to be larger plants. This trial demonstrated that residual effects could be achieved with boom spray volumes.

Trial 4 was set out to compare the most promising herbicides and the results are given in Table 4. Parthenium weed usually took longer than a month to die as shown on the picloram and 2,4-D plots although dicamba, hexazinone at 0.9 kg/ha and atrazine at 4 kg/ha gave the best control in the first and second months.

Trial 5 was similar except that the herbicide rate was lowered while the water volume was increased. Table 5 shows that this resulted in 1 kg/ha dicamba giving the best initial kill while picloram and atrazine gave the best residual effects after 5 months.

Trial 6 was set out to screen other herbicides likely to be useful in controlling parthenium weed. Table 6 gives the results of normal formulations compared with 0.1% extra wetting agent. Only cyanazine gave significantly better knock-down from the addition of wetting agent but gave no residual control. MSMA at 2 kg/ha and above killed the existing parthenium weed and pasture but resulted in greater parthenium weed germination and growth than on the untreated areas. Thiazafluron at 0.8 kg/ha gave poor knock-down but allowed pasture competition which resulted in the lowest parthenium weed populations after one year. Ethidimuron at 0.8 kg/ha kept the parthenium weed population lowest most consistently. Ametryne and prometryne were ineffective on parthenium weed. Simazine controlled only the seedlings. Metribuzin managed both knock-down and residual control of parthenium weed but not as effectively as the recommended atrazine at 4 kg ($20)/ha or hexazinone at 750 g ($30)/ha or 225 g picloram plus 900 g 2,4-D ($30/ha).

ACKNOWLEDGEMENTS

The assistance of I.C.I., Du Pont, Shell, Ciba-Geigy, Velsicol, Schering and Bayer for supply of herbicides and I. Francis, Cairo lessee, is greatly appreciated.

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Table 1. Results of Trial 1 showing numbers (per m^2) of parthenium weed plants and assessments at various times after application of herbicides by boom spraying at 300 ℓ/ha on 12 March 1976

Herbicide a.i.	12/5/76	21/7	17/11	12/1/77	20/4	21/7	9/11
						Ps-r	Pr
Karbutilate							
0.6 kg/ha	25	AP	51	34	Pr-f	>100	10
1.2 kg/ha	2	AP	3	2	SP	>100	50
2.4 kg/ha	0	DP	o/q	0	SP	>100	5
4.8 kg/ha	0	DP	0	0	Pr-f	>100	>100
2,4-D amine							
0.75 kg/ha	104	AP	15	9	SP	>100	>100
1.5 kg/ha	133	AP	21	12	SP	>100	50
3 kg/ha	4	AP	7	2	SP	>100	10
Dicamba							
225 g/ha	60	AP	9	9	SP	>100	10
450 g/ha	8	DP	o/q	0.3	Pr	>100	3
900 g/ha	25	DP	9	5	SP	>100	10
Picloram + 2,4-D							
56 g + 225 g/ha	69	AP	1	1.3	SP,Pr	>100	5
112 g + 450 g/ha	18	SP	4	0.7	Pr	>100	>100
225 g + 900 g/ha	0	DP	o/q	0.3	Pr-f	>100	50
Bromacil							
0.75 kg/ha	58	AP	11	5	SP,Pr	>100	50
1.5 kg/ha	78	DP	33	4	Pr-f	>100	>100
3 kg/ha	9	DP	o/q	1	Pr	>100	50
Check	175	AP	91	31	SP,Pr	>100	>100

o/q = nil parthenium weeds (P) per m^2 quadrat counts, but P present on plot.

Pr-f = Parthenium rosettes to flowering stage. AP = Alive parthenium weeds.

Ps-f = Parthenium seedlings to rosettes. DP = Dead parthenium weeds.

SP = Senescing parthenium weeds.

Table 2. Results of Trial 2 showing numbers (per m^2) of parthenium weed plants and assessments at various times after application of herbicides by power spraying at 4000 ℓ/ha on 12 and 13 March 1976

Herbicide a.i.	12/5/76	21/7	18/11	13/1/77	20/4	21/7	9/11
						Ps-r	Pr
DPX 3674 ♯							
0.9 kg/ha	0	o P	0	0	Pr	>100	50
1.8 kg/ha	0	o P	0	0	Pr	>100	>100
3.6 kg/ha	0	o P	0	2	SP + Pr-f	>100	>100
Diuron							
1.6 kg/ha	11	Ps	107	36	SP + Pr	>100	>100
3.2 kg/ha	0	Ps	o/q	o/q	SP + Pr	>100	>100
6.4 kg/ha	0	o P	o/q	0.1	SP	>100	>100
Bromacil							
4 kg/ha	0	o P	0	0	Pr-f	>100	>100
8 kg/ha	0	o P	0	0	Pr-f	>100	>100 Pf
16 kg/ha	0	o P	0	0	Pr-f	>100	1 Pf*
Dicamba							
1 kg/ha	5	Ps	89	9	SP + Pr	>100	>100
2 kg/ha	0	Ps	19	1	SP + Pr	>100	50
4 kg/ha	0	o P	31	1	Pr	>100	2
2,4-D amine							
4 kg/ha	36	Ps	19	5	SP + Pr	>100	>100
8 kg/ha	3	Ps	76	23	SP	>100	50
16 kg/ha	0	Ps	32	7	SP + Pr	>100	>100
Picloram + 2,4-D							
0.2 kg/ha + 0.8 kg/ha	0	Ps	3	0	Pr	>100	10
0.4 kg/ha + 1.6 kg/ha	0	o P	0	0	Pr	>100	50
0.8 kg/ha + 3.2 kg/ha	0	o P	0	0	Pr	>100	10
Check	170	Ps	138	21	SP + Pr	>100	>100

♯ = hexazinone

o P = nil parthenium weeds SP = Senescing parthenium.

o/q = nil parthenium (P) per m^2 quadrat counts but P present on plot.

Ps = Parthenium seedlings to 4 leaf stage. Pr-f = Parthenium rossettes to flowering.

Pf* = Affected parthenium weed flowering.

Table 3. Results of Trial 3 showing numbers (per m^2) of parthenium weed plants and assessments at various times after application of herbicides by boom spraying at 280 ℓ/ha on 16 October 1976

Herbicide a.i.	17/11/76	14/1/77	20/4/77	9/11/77
Atrazine 1.5 kg/ha	O/q AG	3 P	0.1 P AG.AL	7 Pr
Atrazine 3 kg/ha	O/q AG	1 P	0.3 P AG.AL	14 Pr
Atrazine 6 kg/ha	o P L* & G*	o P	6 Pr A & DG, L*	1 Pr
Atrazine 12 kg/ha	o P L* & G*	o P	0.1 Pr A & DG, L*	o P DG
Checks O	87 Pr AG.AL	126 Ps-f	60 SPf AG.AL	>100 Pr
DPX 3674 ⸗ 0.225 kg/ha	O/q AG.AL	40 Pf	100 Pr AG.AL	>100 Pr
DPX 2674 0.45 kg/ha	1 P* A & DG	Ps*	100 P AG.AL	>100 Pr
DPX 3674 0.9 kg/ha	O/q A* & DG	o P	50 Pr D & AG.AL	>100 Pr
DPX 3674 1.8 kg/ha	o P DG	1 P	50 Pr D & AG.AL	>100 Pr-f

⸗ = hexazinone

* Plants affected by herbicide. o P = nil parthenium weeds (P) O/q = nil parthenium weed/m^2 quadrat but present on plot. L = Legumes. G = Grasses. A = Alive. D = Dead. Pr = Parthenium rosettes. Pf = Parthenium flowering. SP = Senescing parthenium. Ps-f = Parthenium seedlings to flowering. Pr-f = Parthenium rosettes to flowering.

Table 4. Results of Trial 4 showing numbers (per m^2) of parthenium weed plants and assessments at various times after application of herbicides at various rates applied by knapsack at 1000 ℓ/ha on 21 November 1976

Herbicide a.i.	16 Dec 76	13 Jan 77	4 Mar	20 Apr	21 July	9 Nov
	kg/ha			Pr-f	Ps-r	Pr
Ametryne	4	39*	25	Ps-f	24	>100	>100
Diquat	1	4	21	Ps-f	13	>1000	>100
VEL 5026	0.8	5	5	Ps-f	5	>1000	10
Dicamba	2	o/q	0	Ps-r	410 Ps	>100	73
2,4-D-amine	4	5	0.1	Ps-r	SP.0	>100	25
2,4-D amine	8	7	1	Ps-r	SP.0	>100	>100
Picloram + 2,4-D	0.225 0.9	12*	0.4*	Ps-r	132 Ps	>100	>100
DPX 3674 ⸗	0.45	6	1*	Ps-f	0.1	>100	>100
DPX 3674	0.9	0	0	Ps-r	420 Ps	>100	>100
Atrazine	4	o/q	0.1	Ps*-f	SP.0	>100	>100
Check	0	71	91	Ps-f	67 Pf + SP & Pr	2500	>100

⸗ = hexazinone

* Parthenium weeds (P) affected.

o/q = Nil parthenium weed alive per m^2 quadrat.

Ps-f = Parthenium seedlings to flowering stage.

SP = Senesced parthenium.

Pr = Parthenium rosettes stage of growth.

Table 5. Results of Trial 5 showing numbers (per m^2) of parthenium weed plants and assessments at various times after application of herbicides by boom spraying at 5000 ℓ/ha on 22 November 1976

Herbicide	a.i.	16 Dec 76	13 Jan 77	4 Mar	20 Apr	21 July	9 Nov
	kg/ha				Pr-f	Ps-r	Pr
Ametryne	1	9	32	Ps-f	12	>1000	>100
Ametryne	2	18	26	Ps-f	23	>100	100
Diquat	0.5	81	131	Ps-f	45	>1000	>100
VEL 5026	0.4	3	3	Ps-f	2 + Ps	>1000	>100
Dicamba	1	94*	0	Ps	12 Ps	>100	>100
2,4-D amine	2	215	115	Ps-f	40	>100	>100
Picloram + 2,4-D	0.225 0.9	6	2	Ps	0	>100	>100
DPX 3674♯	0.18	8	5	Ps-f	8	>100	>100
Atrazine	1	5	6	Ps & f	3	>100	>100
Atrazine	2	15	4.5	Ps & f	o/q	>100	>100
Check	0	71	91	Ps-f	67 Pf + SP & Pr	2500	>100

♯ = hexazinone

* Parthenium weeds (P) affected.

Ps-f = Parthenium seedlings to flowering stage.

Pr = Parthenium rosettes.

o/q = Nil parthenium weed alive per m^2 quadrat.

SP = Senesced Parthenium.

Table 6 Results of Trial 6 showing numbers (per m^2) of parthenium weed plants and assessments at various times after application of herbicides by boom spraying at 300 ℓ/ha on 13 January 1977

Herbicide	a.i.	4 March		21 July		13 Jan '78	
	kg/ha	N	X	N	X	N	X
Simazine	2	Pr-f 8	22	Ps 100	25	Pr-f AG 100	100
Simazine	4	Ps-f 22	11	Ps-r Ps 100	19	AG 10	10
Prometryne	2	Ps-f 99	28	Ps-r Ps 100	100	AG 100	100
Metribuzin	0.35	Ps 10	11	Ps-r Ps 100	5	AG 100	1
Metribuzin	0.7	Ps-f Ps 20	3	Ps-r 100	100	AG 50	50
Ametryne	2	Ps-f 6	34	Ps-r 100	100	AG 100	100
Ethidimuron	0.4	Ps-f 9	28	Ps-r 88	100	AG 10	10
Ethidimuron	0.8	Ps-f Ps 12	6	Ps-r Pr 28	1	AG 10	10
Thiazafluron	0.4	Ps-f 53	117	Ps-r Ps 100	100	AG 50	50
Thiazafluron	0.8	Ps-f 59	21	Ps 100	20	AG 0.1	0.1
Cyanazine	1	Ps-f 21	o/q	Ps-r 100	37	AG 100	100
Cyanazine	2	Ps-f 40	o/q	Ps-r 100	4	AG 100	20
M.S.M.A.	1	Ps-f Ps-r 32	32	Ps-r 100	100	A & DG 100	100
M.S.M.A.	2	Ps 30	5	Ps-r 100	100	DG 100	100
M.S.M.A.	4	Ps 203	17	Ps-r 100	100	DG 100	100
Check	0	Ps-f 108	60	Ps-r 100	100	AG 100	100

N = Normal formulation with no extra wetting agent

X = Extra wetting agent at 0.1% added

Ps = Parthenium seedlings to 4 leaf stage

Pr-f = Parthenium rosettes to flowering adults

SP = Senescing parthenium weed

DG = Dead Grass

AG = Alive Grass

o/q = Nil P per m^2 quadrat