Fosamine for lantana control in south east Queensland hoop pine plantations: a preliminary evaluation

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Summary

***Lantana* spp. cause land management problems in south east Queensland. Chemical control measures form the mainstay of the lantana control programme in the hoop pine estate of the Queensland Department of Forestry. Fosamine shows promise as a useful adjunct to existing chemical control measures. Environmental conditions need to be considered in making decisions about timing the application of chemical controls.**

Introduction

The common name, lantana, is used to identify a multitude of species and cultivars of the *Lantana camara* group (Everist 1974). Lantana is a multi-branched, evergreen shrub, varying in habit from compact clumps to rampant semi-scramblers which often form dense impenetrable thickets. The branches are square in cross section and in some forms carry backwardly curved spikes along the angles. The growth habit and prickly nature of lantana combined with its vigour and fecundity in the subtropical coastal environment (CSIRO 1972) have created a number of land-management problems in south east Queensland.

In hoop pine (*Araucaria cunninghamii* Ait ex D. Don) plantations, lantana does not noticeably affect tree growth after canopy closure. However, its tangled growth habit severely restricts access in older plantations. Efficiency in harvesting and management operations is thus hindered. Regular lantana control is practised to limit the severity of infestation in plantation areas. In the 1976/77 fiscal year, the cost of this control programme in the 38 500-ha hoop pine estate of the Queensland Department of Forestry exceeded $900 000 (C. Wells, unpubl. data).

A search for biological control agents was not encouraging (CSIRO 1972), though research is continuing following some successful instances of localized control (Wylie 1979). Mechanical control methods such as pushing and slashing are generally ineffective, except for the provision of immediate access. Besides, they are of limited applicability owing to the dissected and steep topography throughout the pine estate. Successful control can be achieved by grubbing or brushing. However, the high cost of these labour intensive methods usually precludes their use other than as a complement to chemical control measures which are the mainstay of the lantana control programme. Repeated doses of chlorophenoxy herbicide formulations are applied with a variety of misting, basal spray and cut stump techniques depending on the age and severity of the infestation.

Fosamine (ammonium ethyl carbonmoylphosphorate) is a herbicide that could contribute to lantana control in the hoop pine estate. It has been used successfully as a brush control agent in both the south east (Hernadez *et al.* 1975) and north west (Gratkowski *et al.* 1978) states of the U.S.A. This chemical demonstrates selective activity with both herbaceous plants (Welch *et al.* 1974) and important plantation forest species (Niehuss and Roediger 1974; Gonzalez 1975).

Fosamine is reported to have characteristics which indicate that it is safe to use in the forest environment. The chemical has a very low acute and chronic oral toxicity for mammals, fish and birds (Gonzalez 1975; Andrews 1973) and is neither an eye nor a skin irritant (Niehuss and Roediger 1974). After feeding fosamine to rats for 90 days at rates up to 10 000 ppm, Niehuss and Roediger (1974) reported that no clinical or pathological changes were attributable to the compound and that no birth abnormalities were observed in the offspring of the subject animals. Fosamine is not likely to contaminate either surface waters or groundwater aquifers because the chemical is readily adsorbed by soil particles and is quickly decomposed by soil microorganisms (Gonzalez 1975; Welch *et al.* 1974). Gonzalez (1975) reported a half-life for fosamine in the soil of 4 to 6 weeks depending on environmental conditions.

This paper presents a preliminary evaluation of two trials that were instigated in the south east Queensland hoop pine estate to determine the efficacy of fosamine at various concentrations for the control of lantana. The fosamine treatments were compared with two current chemical control practices.

Materials and methods

In June 1977, fosamine evaluation trials were commenced on two sites in mature hoop pine plantations (Table 1) infested with lantana. The sites were in the Mary River Valley near Imbil and the Brisbane River Valley near Yarraman (Table 2).

The following treatments were applied and evaluated, each treatment being assigned a code for presentation of the results.

Table 1 Stand characteristics at commencement of the trial

District	Age (years)	Stocking (stems ha^{-1})	Predominant ht^A (m)	Basal area (m^2 ha^{-1})
Imbil	30-36	420-660	27-31	34
Yarraman	48	257	28.1	24.8

[A] Predominant height is defined as the average height of the 50 tallest stems per ha, sampled at the rate of 1 stem per 0.02 ha.

Table 2 Trial sites: location, elevation and mean temperatures

Location	AMG reference map. no.	AMG reference coordinates	Elevation (m)	Mean annual temp. max.	Mean annual temp. min.
Imbil	9445-3	666 730	80	26.0	13.0
Yarraman	9244-2	590 504	427	29.4	4.8

D50: amine salt of 2,4-dichlorophenoxyacetic acid (2,4-D amine): commercial formulation 50% a.i. Applied at 1.5% a.i. concentration with TEN/27 wetting agent at 1.25%.

DP60: 2-(2,4-dichlorophenoxy) propionic acid (dichloroprop): commercial formulation 60% a.i. including surfactants. Applied at 1.5% a.i. concentration.

F1: ammonium ethyl carbonmoylphosphorate (fosamine): 48% a.i. liquid. Applied at 1% a.i. concentration.

F2: fosamine at 2% a.i.

F3: fosamine at 3% a.i.

F4: fosamine at 4% a.i.

All applications of fosamine included TWEEN 20 surfactant at 0.125%. A water carrier was used for all treatments.

A Solo 423 mister was used to apply the herbicide, misting two rows at each pass. Inter-row spacing was 2.7 m Application rates are shown in Table 3. Generally, they varied directly with the density of the lantana plants. Fine weather with light winds prevailed at both locations while the treatments were being applied (7-9 June 1977). Midday temperatures and relative humidities were in the vicinity of 20°C and 50% respectively.

Table 3 Volume of herbicide mixtures applied

Treatment	Application rate (l ha^{-1}): Yarraman	Imbil
D50	126	67
DP60	96	60
F1	90	59
F2	87	56
F3	85	55
F4	110	48

Long-term mean monthly rainfall data and the actual rainfall, by month, for the 6 months preceding and following treatment application are presented in Table 4. The first rains (24 mm at Imbil and 7 mm at Yarraman) occurred 17 days after spraying.

The basic test unit was a plot containing at least 75 individual lantana plants (stools). The Imbil trial was laid out as a randomized complete block with five replications. In the Yarraman trial, five plots were located in each of the six treatment blocks.

Table 4 Rainfall data (mm)

Type	J	F	M	A	M	J[A]	J	A	S	O	N	D
Yarraman												
Mean	117	104	86	50	39	45	51	30	39	70	82	112
1977	23	100	61	23	59	9	2	9	3	25	53	12
Imbil												
Mean	195	176	156	90	65	65	59	37	43	82	103	140
1977	34	144	152	27	59	26	19	8	4	48	135	20

[A] June, month when treatment was applied.

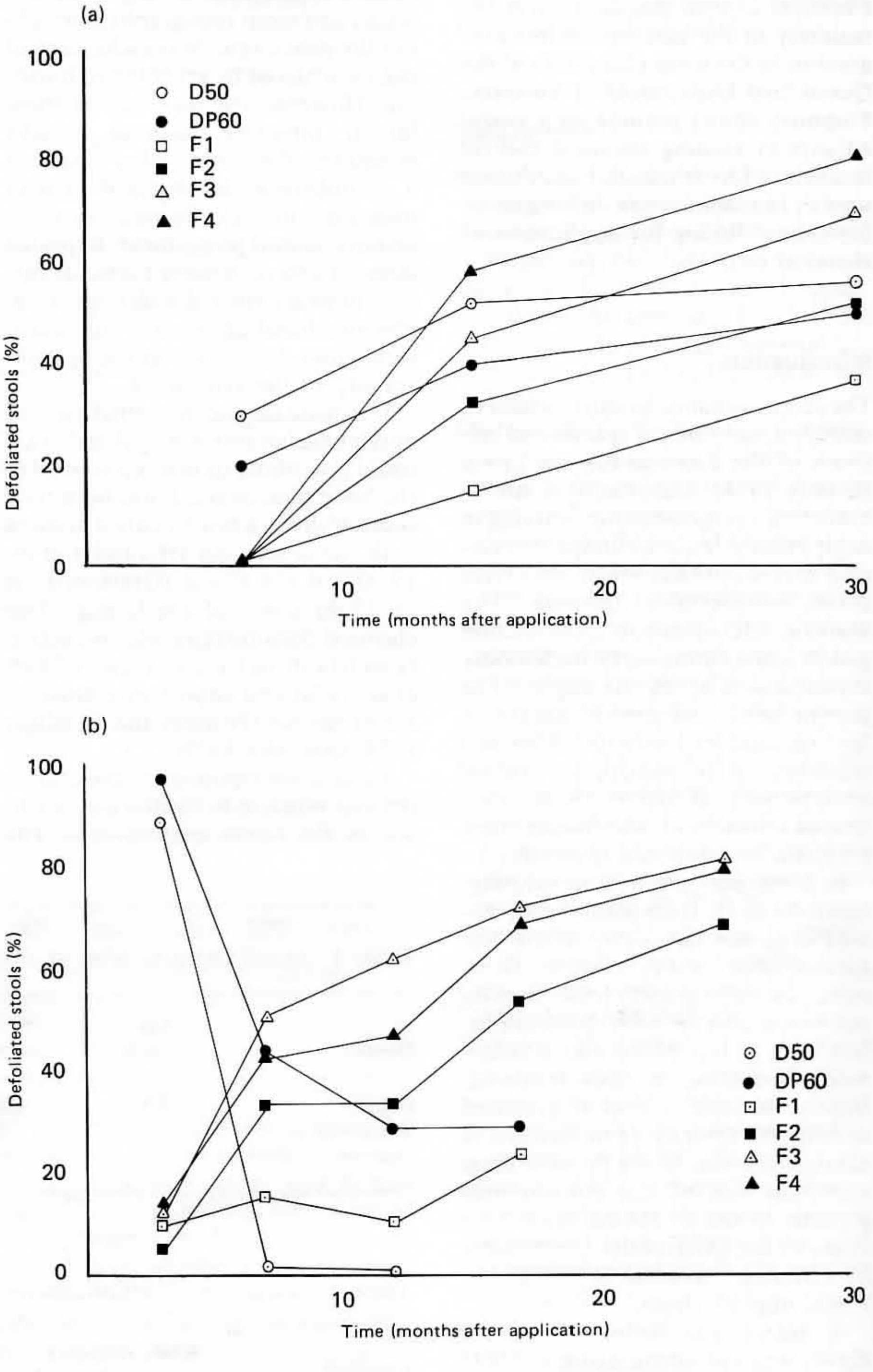

Figure 1 Defoliation of lantana with time under various herbicide treatments. (a) Imbil site, (b) Yarraman site.

Heights of the lantana stools were estimated before spraying, the number of stools being tallied according to four height classes: (i) < 1 m, (ii) 1-2 m, (iii) 2-3 m, and (iv) > 3 m.

The presence or absence of green foliage was assessed periodically for up to 30 months. Defoliation and reshooting of the lantana precluded interpretation of absence of green foliage as death until after the 15-month assessment. In the Yarraman trial, the number of canes with green foliage on each stool were counted at the commencement and periodically for up to 17 months.

Results

Fosamine was generally more effective than the chlorophenoxy herbicides in killing lantana (Table 5). The highest mortalities were achieved with fosamine at 3% (Yarraman) and 4% (Imbil). At Imbil, the chlorophenoxy treatments and the lower fosamine concentrations caused markedly less mortality than the 4% fosamine treatment. On the Yarraman site, the 2,4-D amine treatment did not achieve any long-term control. The dichloroprop and lowest fosamine concentration did not achieve substantial mortalities.

Table 5 Death of lantana stools by treatment

Treatment	% Dead	
	Imbil	Yarraman
D50	54.4	0.8
DP60	48.5	28.8
F1	35.3	23.2
F2	50.6	68.0
F3	68.0	80.5
F4	79.1	78.9

At last assessment at Imbil site (30th month); at Yarraman site for F2, F3, F4 (25th month), for F1 (17th month) and for D50 and DP60 (12th month).

In assessing the efficacy of the treatments, improvement in accessibility needs to be considered along with mortality. The 6-month assessment on the Imbil trial (Figure 1a) and the 3-month assessment on the Yarraman trial (Table 6, Figure 1b) indicated that the chlorophenoxy treatments were superior for short-term access. However, this superiority did not persist (Figure 1). The higher fosamine concentrations were superior in providing longer term access. The chlorophenoxy herbicides, failing to kill the lantana at Yarraman, may exacerbate the problem of accessibility through stimulated cane production (Table 6). This does not appear to be the case for fosamine treatments. Seed regeneration of lantana did not occur during the assessment period.

Table 6 Number of green canes at original assessment (vi.77) and number at subsequent assessment as a percentage by treatment for the Yarraman trial site

Treatment	vi.77	Months after spraying: 3	7	12	17
D50	2952	10.9	94.6	382.2	–
DP60	2970	1.6	20.8	75.8	168.6
F1	2241	74.0	60.2	86.9	94.7
F2	2847	64.2	46.6	86.6	71.8
F3	2952	48.5	23.5	31.4	31.4
F4	3183	53.3	24.7	31.8	31.0

The mortality of lantana was directly related to fosamine concentration up to 3 or 4% (Figure 2). This was generally the case for all height classes (Figure 3), though actual mortality appears to be size dependent (Figure 4). Greater than 80% mortality of lantana bushes up to 2 m high was achieved with fosamine concentrations of 3 and 4%. Mortality for these treatments declined slightly for bushes 2-3 m high and substantially for bushes taller than 3 m.

Discussion

Mist spraying of lantana with 2,4-D amine often achieves better control in routine operations than is indicated by this trial, although a second application is frequently required to secure satisfactory results. The timing of this trial in relation to season and the rainfalls received, which were below average (Table 4), probably contributed to the poor performance of the 2,4-D amine and dichloroprop sprays because, according to Ashton and Crafts (1981) the light, temperature and moisture conditions which favour high rates of photosynthesis and growth are required for maximum translocation of the chlorophenoxy herbicides. Richardson (1977) presented evidence that moisture stress, while not significantly affecting uptake of 2,4-D, severely reduces translocation of the herbicide.

Environmental conditions and thus the physiological state of the target plants in this trial could have had a similar inhibitory effect on the activity of the fosamine treatments, and hence the relativity among treatments is considered reliable. Thonke (1977, cited by Richardson 1980) demonstrated that the herbicidal effect of fosamine against *Sinapsis alba* L. increased with increasing temperature and humidity. Both absorption and translocation are inferred as the operating mechanisms for this observation.

The increasing efficacy of fosamine with concentration observed in this

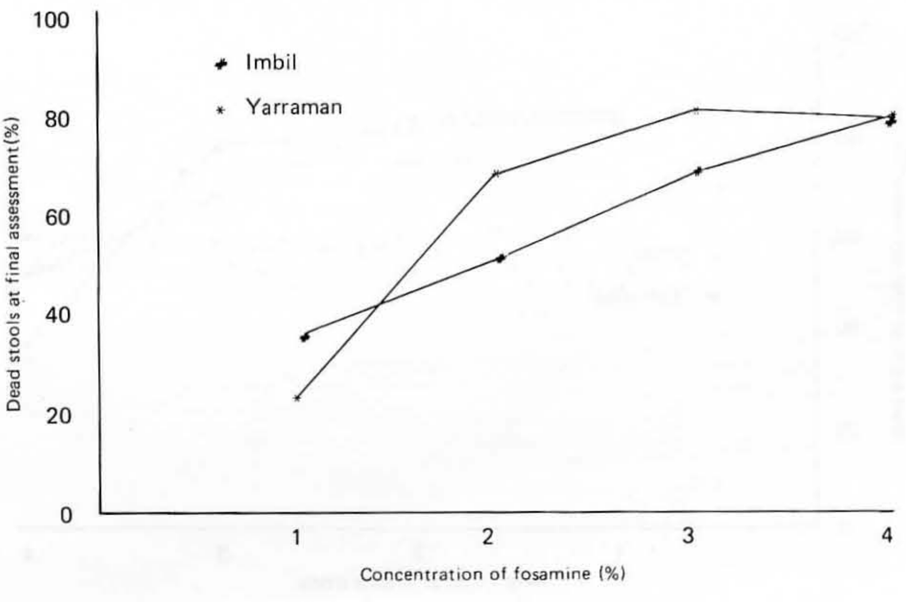

Figure 2 Death-dosage response for fosamine.

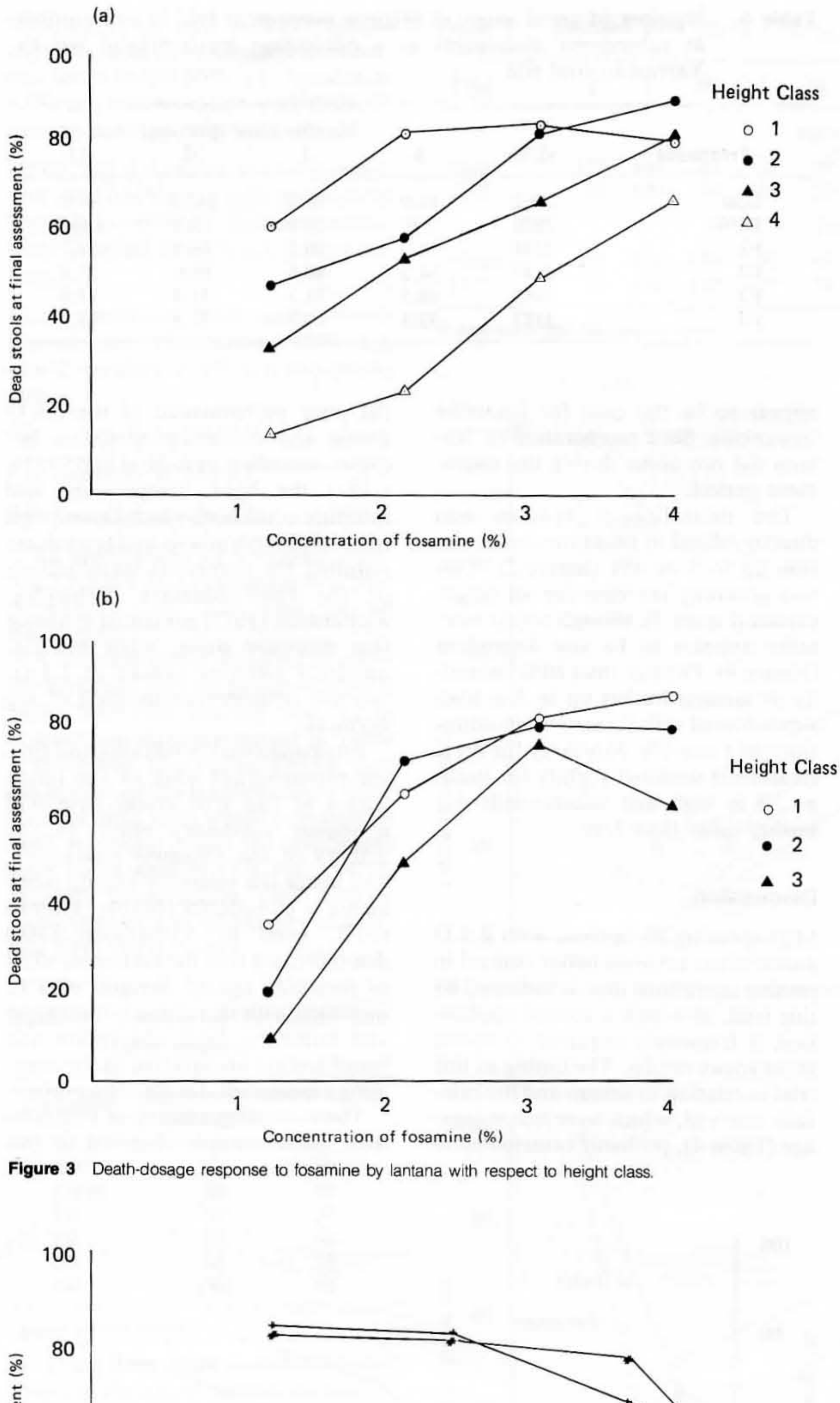

Figure 3 Death-dosage response to fosamine by lantana with respect to height class.

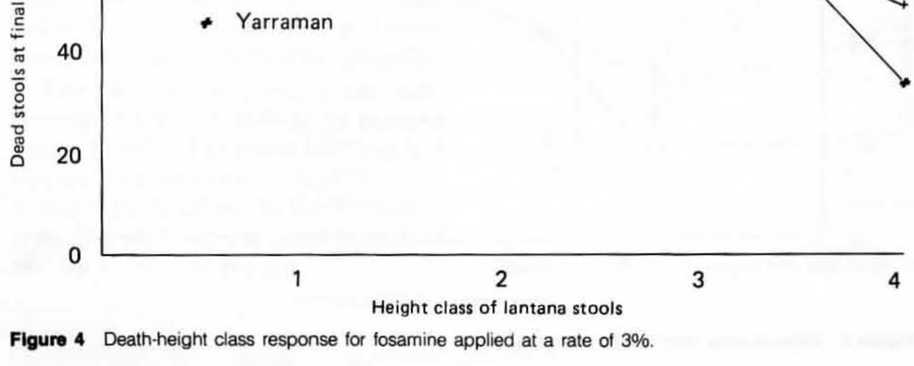

Figure 4 Death-height class response for fosamine applied at a rate of 3%.

trial may result from increased absorption of the herbicide owing to the improved diffusion gradient across the boundary layer. Richardson (1980) found that maximum uptake (35%) by blackberry (*Rubus procerus*) took 4 days with no further uptake to 7 days. Kitchen *et al.* (1980) found that maximum uptake (20%) by black cherry (*Prunus serotina*) took up to 14 days with the greatest uptake occurring after day 7. They suggested that fosamine activity is limited by the rate of translocation because absorption of fosamine through the leaf surface occurred readily, replacing that removed by translocation. Other data from the Imbil trial, still being analyzed, indicate that the concentration rather than the amount of active ingredient applied determines the effectiveness of fosamine (P. Ryan, pers. comm.). More efficient use of the herbicide may be obtained by using higher concentrations and by reducing the total amount of spray mixture applied.

However, this trade-off should only be made to the point where good coverage of the target plant with the spray mixture is still possible. Welch *et al.* (1974) found that applications designed to get the spray into the canopy of the target plants appeared to be most effective. Niehuss and Roediger (1974) observed optimum mortality with plants 1.2 to 1.5 m high because good foliage cover was readily apparent. The declining efficacy of fosamine with increasing height of lantana over 2 m, was probably due to a shading effect of plant size on foliage coverage. It is also possible that larger plants may have physiological characteristics that make them less susceptible to fosamine.

Lantana has been shown to be partially susceptible to fosamine applied in early winter in south east Queensland. Andrews (1973) concluded that the most effective time to apply fosamine is late summer to early autumn in temperature latitudes. This critical time of application is associated with the onset of leaf senescence and a possible basipetal translocation of fosamine into the wood of the plant and acropetal translocation into the next years bud (Niehuss and Roediger 1974). Welch *et al.* (1974) warn that in more tropical climes, where complete dormancy may not be attained, the response to the time of application of fosamine may need to be more critically defined.

Being an evergreen plant, lantana may be susceptible to fosamine over a wide seasonal range in tropical climates. The slow rate of uptake of fosamine (Kitchen *et al.* 1980), which has been directly related to temperature and humidity (Thonke 1977, cited by Richardson 1980), restricts suitable times of application in south east Queensland. Since the normal weather pattern in this region ranges from seasonal drought in early spring to storm activity in late spring and early summer to reasonably persistent rain in late summer, these periods could be considered to be generally unsuitable for the application of fosamine. The most appropriate time of application is probably autumn. During this season rain events and rainfall intensity have diminished but the lantana should still be physiologically receptive prior to the temperature- or drought-induced dormancy of winter. A higher rate of wetting agent than the 0.125% used in this trial may partially reduce losses of fosamine from the leaf surface during falls of rain. Hernandez *et al.* (1975) used 0.25% of a non-ionic surfactant in their trials with fosamine.

Conclusion

In prescribing herbicide treatments for a particular area infested with lantana, managers need to take cognizance of environmental conditions in making decisions about timing the application. Chlorophenoxy herbicides should be used only when plants are growing actively and when the likelihood of rain for several days after application is minimal. This trial and the literature indicate that, ideally, fosamine should be applied at 3% active ingredient with 0.25% by volume of a surfactant in autumn in south east Queensland.

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