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SOME STUDIES ON THE CHEMICAL CONTROL OF DAWSON GUM OR BLACKBUTT (EUCALYPTUS CAMBAGEANA)

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Part III. Basal Bark and Cut Stump Treatment of Multi-stemmed Regrowth

SUMMARY

This paper is the third in a series on the chemical control of Dawson gum (*Eucalyptus cambageana* Maiden). Results of experimental work into the control of multi-stemmed regrowth, 4 to 6 m high, by basal bark and cut stump treatments are discussed.

Basal bark spraying using picloram plus 2,4,5-T at concentrations as low as 0·1% a.i. (active ingredient) picloram plus 0·4% a.i. 2,4,5-T esters in oil resulted in kills in excess of 84% following treatments in August 1968 and December 1969 when the soil was moist. Under similar conditions, 2,4,5-T ester at concentrations of 2% a.i. in oil gave slightly inferior results. Treatments with both chemicals were much less effective at other times when soils were dry.

Cut stump treatments using 0·1% a.i. picloram plus 0·4% a.i. 2,4,5-T both as esters in oil and amines in water resulted in kills in excess of 88% when applied under good soil moisture conditions. Esters at 1% and amines at 1% and 2% a.i. 2,4,5-T gave significantly poorer results. All treatments made when the soil was dry produced unsatisfactory results.

While a trend towards decreasing effectiveness with increasing stem size was noted, particularly with basal bark treatments, this trend appeared to have little influence on the overall experimental results.

I. INTRODUCTION

The first two papers in this series (Johnson and Back 1974a, 1974b) discussed the use of stem injection techniques for the killing of virgin trees and single-stemmed saplings. Regrowth from lignotubers following the destruction of the above-ground parts by fire or mechanical means results in bushy suckers which, in a few years, grow into multi-stemmed saplings. Stem injection is not a practical method of killing this type of growth but basal bark spraying and cut stump applications can be used.

These techniques have been used widely in commercial practice in Queensland against a number of *Eucalyptus* spp. but few research results have been published. Robertson and Pedersen (1973) successfully controlled sprouting stumps of *E. populnea* and *E. largiflorens* using basal bark spraying with 2,4,5-T and picloram plus 2,4,5-T mixtures while Anderson (1974) used both basal bark spraying and cut stump treatments with 2,4,5-T and picloram plus 2,4-D mixtures in experiments aimed at controlling *E. microtheca* regrowth. Beger (1970) also reported on the use of picloram plus 2,4-D, with and without the penetrant dimethyl sulphoxide, as a basal bark treatment of *E. dichromophloia* saplings.

This paper discusses the use of basal bark and cut stump techniques for the control of multi-stemmed regrowth of *E. cambageana*.

II. MATERIALS AND METHODS

Two experiments were established on the 'Rhyddings' block of the Brigalow Research Station, 38 km N.W. of Theodore. The experimental area supported fire-disturbed brigalow (*Acacia harpophylla*)—Dawson gum (*Eucalyptus cambageana*) forest which was pushed to the ground in July 1964 and burnt and seeded to Rhodes grass (*Chloris gayana*) in December 1964. The regrowth at the time of treatment averaged 4 to 6 m high. The average number of stems per plant was three to four while the diameter of the largest stem averaged 3 to 4 cm. The soil is a loamy duplex (Dbl. 43, Northcote 1971).

Rainfall and soil moisture were monitored at a site approximately 5 km from the trial area. The soil at the monitoring point, a dark grey gilgaied cracking clay (Ug5.24, Ug5.25, Northcote 1971) was not the same as at the trial site but the soil moisture data do reflect the relative soil moisture at the various times of treatment. No soil moisture data were available at the time of the December 1969 treatment.

Two methods of control, basal bark spraying and cut stump treatment, were tested.

1. Basal bark spraying

CHEMICALS AND RATES OF APPLICATION. Two chemicals were used, each at three rates of application.

(1) Picloram (4-amino,3,5,6-trichloropicolinic acid) + 2,4,5-T (2,4,5-trichlorophenoxyacetic acid) ester (marketed as Tordon 255*) containing 10% a.i. (active ingredient) picloram as the isooctyl ester and 40% a.i. 2,4,5-T present as the propylene glycol ethyl ester.

(2) 2,4,5-T ester (Farmco T80**) containing 80% a.i. mixed butyl and isobutyl esters.

Details of rates of application are given in table 1.

METHOD OF APPLICATION. The chemical was applied in distillate to the basal 40 cm of each stem using an Oxford Precision sprayer. The stems were sprayed until run-off occurred. From 60 to 90 mL of spray was used on each plant.

*Tordon is a trade name of the Dow Chemical Company—Tordon 255 is now registered as Tordon 1040.
**Farmco is a trade name of Farm Chemicals Pty Ltd.

TIMES OF APPLICATION. Applications were made at five times. These were—

(1) 9 April 1968 — moderately dry autumn
(2) 9 August 1968 — wet winter
(3) 12 November 1968 — dry spring
(4) 16 April 1969 — dry autumn
(5) 1 December 1969 — wet early summer

EXPERIMENTAL DESIGN. A split-plot design involving two blocks was used, with time of application being the whole-plot treatment. Eight sub-plot treatments (six chemical treatments, distillate plus unsprayed control) were allocated at random within each whole-plot. The size of the sub-plots was varied to ensure that at least 10 plants were included in each plot. Actual numbers per plot varied between 10 and 29 with an average of 16.

DATA COLLECTION. All plants were tagged at the time of treatment and the diameter of each stem on each plant at 5 cm from the soil surface was recorded. Two interim counts were made 6 months and 12 months after treatment and a final assessment was undertaken at 18 months. Dead and living plants were noted and the percentage defoliation on all living trees.

2. Cut stump treatments

CHEMICALS AND RATES OF APPLICATION. Four chemicals were used each at two rates of application. The chemicals were—

(1) Picloram plus 2,4,5-T amine (Tordon 105) containing 5% a.i. picloram and 20% a.i. 2,4,5-T both present as triethylamine salts.

(2) Picloram plus 2,4,5-T ester (Tordon 255) containing 10% a.i. picloram as the isooctyl ester and 40% a.i. 2,4,5-T present as the propylene glycol ethyl ester.

(3) 2,4,5-T amine (Farmco TA20) containing 20% a.i. 2,4,5-T present as the dimethylamine salt.

(4) 2,4,5-T ester (Farmco T80) containing 80% a.i. 2,4,5-T present as the butyl and isobutyl esters.

Details of rates of application are given in table 1.

TABLE 1

CONCENTRATIONS OF PICLORAM AND 2,4,5-T

Method of Application	Chemical	Formulation	Carrier	Concentrations (% a.i.)
Basal bark ..	Picloram + 2,4,5-T	ester	oil	{0·1, 0·2, 0·5 {0·4, 0·8, 2·0
	2,4,5-T	ester	oil	1·0, 2·0, 5·0
	Picloram + 2,4,5-T	amine	water ..	{0·1, 0·2 {0·4, 0·8
Cut stump ..	Picloram + 2,4,5-T	ester	oil	{0·1 {0·4
	2,4,5-T	amine	water ..	1·0, 2·0
	2,4,5-T	ester	oil	1·0

METHOD OF APPLICATION. The plants were cut off between 20 mm and 100 mm above ground level using a motorized brush cutter (Stihl 08). The chemical was then applied to the cut surfaces using an Oxford Precision sprayer. The surface of the cut was completely covered with spray solution and some chemical was intercepted by the bark of the stump. Very small horizontal uncut stems were also sprayed. The latter stems were very spindly, and with the self-pruning growth of multi-stemmed regrowth it was anticipated most of these branches would eventually die. An average of 40 ml of solution was applied to the cut stems of each individual.

TIMES OF APPLICATION. Applications were made at four times. These were—

(1) 9 August 1968 — wet winter
(2) 14 November 1968 — dry spring
(3) 16 April 1969 — dry autumn
(4) 26 November 1969 — wet early summer

These times coincided closely with the last four times used for the basal bark treatments.

EXPERIMENTAL DESIGN. The design used was similar to that used in the basal bark treatments. There were four whole-plot and seven sub-plot treatments, six chemical plus a cut but unsprayed control. The number of individuals per plot varied between 10 and 34 with an average of 16.

DATA COLLECTION. The data collection method was similar to that used in the basal bark trial except that at the interim and final inspections the results were assessed by the presence or absence of regrowth.

III. RESULTS

Soil moisture data for all times of treatment except November-December 1969 are given in table 2. In the 2 months before the latter treatment, 190 mm of rain were received. This was approximately 70% above the expected average for the period and compares with 16 mm received in the 2 months before the comparable November treatment in 1968. It is therefore reasonable to assume that soil moisture at the time of the final treatment was high.

TABLE 2

GRAVIMETRIC SOIL MOISTURES (%) AT VARIOUS DATES OF TREATMENT

Date of Treatment	Date of Sampling	Soil depth (mm)						
		0–15	15–30	30–45	45–60	60–90	90–120	120–150
9 Apr. 1968 ..	9 Apr. 1968[1] ..	12·0	14·7	15·6	16·3	17·0	17·3	18·5
9 Aug. 1968 ..	6 Aug. 1968 ..	19·8	25·1	22·8	21·9	20·5	20·0	20·1
12 Nov. 1968 ..	12 Nov. 1968 ..	11·2	14·2	14·5	15.4	16·1	17·8	18·7
16 Apr. 1969 ..	15 Apr. 1969 ..	15·8	15·6	15·1	15·5	16·5	16·6	18·4
1 Dec. 1969 ..	.. [2]	..	..	..	..	..	..	..

[1] Average of readings on 2 Apr. 1968 and 16 Apr. 1968. No rain was recorded during that period.
[2] No sampling was undertaken at this time.

TABLE 3

EQUIVALENT MEAN PERCENTAGE KILLS FOLLOWING BASAL BARK APPLICATIONS

Date of Treatment	2,4,5-T				Picloram (+2,4,5-T)				Dates (means)
	1%	2%	5%	Means	0·1%	0·2%	0·5%	Means	
9 Apr. 1968	8·8 (0·301)*	33·5 (0·618)	57·6 (0·862)	31·3 (0·594)	38·8 (0·672)	25·8 (0·533)	73·6 (1·031)	46·0 (0·745)	38·5 (0·669)
9 Aug. 1968	49·5 (0·780)	82·8 (1·143)	90·2 (1·253)	76·0 (1·059)	84·5 (1·166)	94·3 (1·330)	100·0 (1·571)	95·4 (1·356)	87·4 (1·207)
14 Nov. 1968	19·9 (0·462)	23·4 (0·505)	60·1 (0·887)	33·6 (0·618)	9·1 (0·306)	25·8 (0·533)	55·6 (0·841)	29·2 (0·560)	30·9 (0·589)
16 Apr. 1969	7·2 (0·271)	39·7 (0·681)	51·5 (0·800)	30·4 (0·584)	19·4 (0·456)	57·1 (0·857)	70·0 (0·991)	48·2 (0·768)	39·1 (0·676)
1 Dec. 1969	65·3 (0·940)	71·8 (1·101)	87·0 (1·202)	75·3 (1·051)	87·8 (1·214)	98·2 (1·436)	97·0 (1·396)	95·1 (1·348)	86·9 (1·200)
Conc. .. .. .. (means)	27·4 (0·551)	50·6 (0·792)	70·9 (1·001)		47·7 (0·763)	65·0 (0·938)	84·5 (1·166)		
Chemicals .. .. (means)	..	..	..	49·6 (0·781)	..	..	..	66·7 (0·955)	

* Inverse sine transformation used for analysis.

—	Dates	Chemicals	Conc.	Treatments
Necessary Differences 5%	(0·107)	(0·073)	(0·127)	(0·284)
for Significance 1%	(0·144)	(0·099)	(0·171)	(0·382)

BASAL BARK SPRAYING. An analysis of variance using an inverse sine transformation on the percentage kill data produced highly significant time of application and chemical treatment effects.

There was also a highly significant chemical x dates interaction, but this was largely due to the results from the distillate alone treatment. The latter treatment resulted in a kill of 34% following the August 1968 application but at the other times only a few plants were affected. Results are presented in table 3. There was also a weak but significant dates x (2,4,5-T v. picloram) interaction reflecting a reversal in trend in the dry spring of 1968 when 2,4,5-T was slightly more effective than picloram. The kills obtained from all treatments at this time were poor and the difference between 2,4,5-T and picloram was not significant.

The treatments imposed in August 1968 and December 1969 were significantly better ($p < 0.01$) than treatments in April 1968, November 1968 and April 1969. At the rates used, the picloram plus 2,4,5-T treatments were superior to the 2,4,5-T treatments at the high, medium and low rates of application.

In general, a significant improvement in effectiveness was achieved with both picloram plus 2,4,5-T and 2,4,5-T alone by increasing the concentration of active ingredient. Following treatments in August 1968 and December 1969 with picloram plus 2,4,5-T, no significant improvement was noted by increasing the concentration from 0.1% to 0.5% picloram. Percentage kills obtained using 0.2% and higher exceeded 94%.

At the other times of application, kills improved a further 13 to 48% by increasing the concentration from 0.2 to 0.5%. Similarly, increasing the concentration of 2,4,5-T resulted in significantly improved kills, though the improvement in kill by increasing the concentration from 2% to 5%, when expressed as a percentage of the 2% result, was lowest following August 1968 and December 1969 treatments.

Correlation coefficients were calculated between three attributes of individual plants—the number of stems, the diameter of the largest stem and the sum of the diameters of all stems—and the percentage defoliation, for all treatments at all times of applications. The most highly correlated attributes were in almost every case those involving stem size and correlations with the size of the largest stem generally had the highest coefficients. With increase in diameter, the percentage defoliation obtained decreased. The mean diameter of the largest stem of dead and alive plants was calculated for each plot, where sufficient numbers of alive plants were available, and with only one exception the mean diameter of alive plants was larger than that of dead plants.

Analyses of variance of these data revealed the difference was significant in about 30% of the plots. Using the same three attributes in multiple linear regression revealed that the relationship was in general significant, but the percentage of the variation accounted for by the relationship was low, usually less than 40%.

CUT STUMP TREATMENTS. An analysis of variance using an inverse sine transformation on the percentage kill data produced a significant time of application effect and a highly significant chemical treatment effect. The interaction was not significant. Results are presented in table 4. None of the cut but unsprayed control plants was killed at the first three times of application. However, following treatment in November 1969, 29% of the control plants did not regrow.

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TABLE 4

EQUIVALENT MEAN PERCENTAGE KILLS FOLLOWING CUT STUMP TREATMENT

Date of Treatment	2,4,5-T				Picloram (+ 2,4,5-T)				Dates (means)
	1% as amine	2% as amine	1% as ester	Means	0·1% as amine	0·2% as amine	0·1% as ester	Means	
9 Aug. 1968	56·0 (0·846)*	58·8 (0·873)	70·7 (0·998)	61·9 (0·906)	88·8 (1·230)	96·4 (1·381)	96·1 (1·372)	94·2 (1·328)	80·8 (1·117)
14 Nov. 1968	28·4 (0·562)	14·6 (0·393)	47·8 (0·763)	29·4 (0·573)	21·1 (0·477)	44·7 (0·733)	56·6 (0·851)	40·2 (0·687)	34·7 (0·630)
16 Apr. 1969	29·1 (0·570)	31·6 (0·598)	22·0 (0·488)	27·5 (0·552)	32·8 (0·610)	67·6 (0·965)	66·0 (0·948)	55·5 (0·841)	41·1 (0·696)
26 Nov. 1969	41·3 (0·698)	83·7 (1·155)	84·0 (1·159)	71·2 (1·004)	90·8 (1·263)	100·0 (1·571)	97·4 (1·410)	97·6 (1·415)	87·5 (1·209)
Conc. .. .. .. (means)	38·4 (0·669)	46·9 (0·755)	56·6 (0·852)		60·9 (0·895)	84·2 (1·162)	83·0 (1·145)		
Chemical .. .. (means)	..	..	..	47·4 (0·759)	..	..	..	76·7 (1·067)	

* Inverse sine transformation used for analysis.

—		Dates	Chemicals	Conc.	Treatments
Necessary Differences for Significance	5%	(0·385)	(0·138)	(0·240)	(0·479)
	1%	(0·706)	(0·189)	(0·327)	(0·654)

The treatments imposed in August 1968 and November 1969 were significantly better ($p < 0 \cdot 05$) than those imposed in November 1968 and April 1969. The 0·2% picloram plus 0·8% 2,4,5-T amine treatment and the 0·1% picloram plus 0·4%, 2,4,5-T ester treatment were significantly superior to the other treatments. With both picloram plus 2,4,5-T and 2,4,5-T alone, ester formulations in distillate were more phytotoxic than amine formulations in water and it appeared that by using esters only half the concentration of chemical is needed for similar results.

With the brushcutter, one or more small spindly shoots were not severed on about 20% of the multi-stemmed regrowth. However, these shoots still received the spray application and a check revealed kills of 62·6 and 63·8, as equivalent percentages, respectively for the completely and the partially severed plants over all treatments, with no significant interaction effect with treatments.

Correlation coefficients were calculated between four attributes of individual plants—the number of stems, the squared diameter of the largest stem, the number of uncut stems and the sum of the squares of all diameters—and the kill of individual plants for all treatments at all times of application.

No clear-cut pattern emerged, the attribute providing the highest correlation varying greatly from treatment to treatment and from time to time. Using the same attributes in multiple linear regression against kill indicated that these attributes in general were having little influence on the effectiveness of the treatments at the various dates. In general, the percentage of the variation accounted for by the relationship was very low, usually less than 30%. Where a highly significant relationship was revealed, attributes associated with stem size were making the greatest contribution.

IV. DISCUSSION

The most significant feature of the experiment was the influence of time of application on the result. Treatments in April 1968 and November-December 1969 were significantly superior to treatments at other times. This appears directly related to the higher soil moisture conditions, inferred from the rainfall data in the December 1969 treatments, at the time of treatment. This applied to both the cut stump and basal bark treatments. In the previous paper in the series (Johnson and Back 1975), we showed that kills using stem injection techniques were greater, particularly with 2,4,5-T treatments, following application in the July 1968 during a moderately wet winter, than in November 1968 during a dry spring and April 1969 during a dry autumn.

Though we suggested in that paper that soil moisture conditions were the dominant influence, the suggestion of Robertson and Moore (1972), following trials on use of stem injection, that high temperatures might depress results, could not be discounted. Our treatments in November 1968 were imposed during heat wave conditions. The maximum daily temperature between 12 and 24 November varied between 32°C and 38°C and these high temperatures may have contributed to the poor results obtained at that time.

However, temperatures were much lower in April 1968 and April 1969 when percentage kills were also low. It would now appear, in the case of *E. cambageana,* that soil moisture is the critical factor. Under good soil moisture conditions, excellent results can be expected using either basal bark or cut stump treatments.

With basal bark application, kills in excess of 94% were obtained with picloram plus 2,4,5-T at concentrations of both 0·2% and 0·5% picloram while kills in excess of 84% were obtained with 2,4,5-T at 5% and 0·1% picloram plus 2,4,5-T. When soils were relatively dry following below-average rainfall, the best kill obtained was 70% following treatment with 0·5% picloram plus 2,4,5-T.

Though there was an overall trend for kills with both 2,4,5-T and picloram plus 2,4,5-T to improve with increasing concentration of the active ingredient, the significance of this trend was affected by the soil moisture conditions at the time of treatment. If we assume that kills in excess of 80% are acceptable, then, when soil moisture is high, concentrations of picloram as low as 0·1% can be used. In contrast 2,4,5-T should be used at rates between 2% and 5%. Under dry conditions the best kills were less than 75% and picloram at 0·5% was the only treatment which led to kills in excess of 70%. Even so, all kills following all treatments in November 1968 were unsatisfactory.

Similarly with cut stump treatments, kills in excess of 95% were recorded with 0·2% picloram plus 0·8% 2,4,5-T amines in water and 0·1% picloram plus 0·4% 2.4,5-T esters in oil, under average to above average soil moisture conditions. Kills in excess of 88% followed the use of 0·1% picloram plus 0·4% 2,4,5-T amines in water under similar conditions. Under relatively dry soil moisture conditions, the best kills recorded were less than 70%. As with basal bark treatments, kills in excess of 80% can be achieved when the soil is moist using concentrations as low as 0·1% picloram plus 0·4% 2,4,5-T ester. With 2,4,5-T, kills were less consistent and rates of 2% and higher are needed. No treatments were satisfactory under dry conditions, but concentrations in excess of 0·2% picloram may have proved satisfactory.

Though there was a negative relationship between the size of the saplings and the effectiveness of the basal bark treatments, within the range of sizes treated in these trials this was of little practical importance. Within the range of diameters of regrowth used in the cut stump trial, the size of the individuals also had little effect on the kill achieved. In addition, the presence of uncut spindly horizontal stems did not appear to influence the results.

Results following basal bark applications of picloram plus 2,4,5-T and 2,4,5-T alone to the stems of other species of *Eucalyptus* have been reported by Anderson (1974) and Robertson and Pedersen (1973). The latter authors obtained consistently good kills of 80% or better on *E. populnea* regrowth using concentrations of 0·2% and 0·4% picloram in mixed picloram and 2,4,5-T esters. Kills in excess of 93% were achieved on regrowth of *E. largiflorens* at rates as low as 0·05% picloram.

Particularly at the lower concentrations of picloram, the time of treatment in their experiment on *E. populnea* appeared to influence the results but they indicated there were too few data to draw any firm conclusions. Similar indications appear in the results with both species where 2,4,5-T butyl ester was the active ingredient. No clear seasonal effect was shown in their paper to support the trends towards poorer results in the warmer months as shown by Robertson and Moore (1972) in trials using stem injection techniques or towards superior results in the warmer months as shown by Beger (1970) following basal bark spraying of *E. dichromophloia* with and without a penetrant. Neither was a soil moisture relationship indicated. Kills following treatment of *E. cambageana* indicate it is more difficult to control than *E. populnea,* but the large difference in the rate of application of the spray solution in both experiments confounds the results. In trials on *E. populnea,* Robertson and Pedersen (1973) used an average of more than 300 mL of solution per plant compared with 60 to 90 mL in our trial. Individual plants were taller in our trial though there may have been more stems per individuals in theirs. Assuming most of the solution was absorbed in both experiments, the amount of active ingredient received by each plant in the experiments of Robertson and Pedersen (1973) was three to five times that used in our experiment. This difference in rate might explain why *E. cambageana* appears more difficult to control than *E. populnea* and why the noted seasonal trend in effectiveness in the former experiment appears to be evident only at lower concentrations.

Comparisons with the results obtained by Anderson (1974) with basal bark spraying of *E. microtheca* are more difficult because he used an amine of picloram plus 2,4-D and an ester of 2,4,5-T, both in water. He did, however, show at his lower concentrations of picloram and of 2,4,5-T that plants with larger stems were more difficult to kill than smaller plants.

Anderson (1974) also reported on the effectiveness of cut stump treatments for the control of *E. microtheca.* His results using picloram plus 2,4-D were comparable with those obtained on *E. cambageana* using picloram plus 2,4,5-T in August 1968 and November 1969 under good soil moisture conditions. In contrast, his kills following the use of 2,4,5-T alone were markedly better than ours. This would indicate that *E. microtheca* may be more susceptible to 2,4,5-T than *E. cambageana* though the large seasonal differences in effectiveness indicated in this trial make comparisons with other experiments difficult when soil moisture conditions are unknown.

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