QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

DIVISION OF PLANT INDUSTRY BULLETIN No. 748

CONTROL OF BRIGALOW (ACACIA HARPOPHYLLA) IN CATTLE COUNTRY BY TWO AERIAL SPRAYING APPLICATIONS 10 MONTHS APART

by R. W. JOHNSON, M.Sc., Ph.D.; and P. V. BACK, Q.D.A.

SUMMARY

Two sprayings 10 months apart with 1·12 kg acid equivalent (a.e.) 2,4,5-T ester ha^{-1} reduced the brigalow density of 3½-year-old suckers by 72%. Results with two applications of 0·56 kg a.e. 2,4,5-T ester ha^{-1} were greatly inferior.

Results in this experiment, in cattle country, were inferior to those obtained by other workers on sheep properties.

The effectiveness of the individual applications was related to soil moisture conditions at the time of spraying. The better kills, obtained when the soil was moister, were the result of the slightly better initial foliage kill and the markedly reduced coppice and butt suckering.

A study of the pattern of regeneration, following the initial spraying, indicated that the interval between the two sprayings should be at least 10 months. Pasture growth was shown to be important in the timing of the second spraying.

An attempt to establish improved pastures by hand sowing following spraying was a failure, but a 100% increase in the cover of both native and previously established Rhodes grass (*Chloris gayana*) was recorded 2½ years after the initial spraying.

I. INTRODUCTION

Aerial spraying using 2,4,5-T ester in oil has been successfully used to control brigalow suckers (Johnson 1962, 1964). Best results have been obtained where young suckers have been treated in their first season of growth. With age, suckers become more difficult to control by aerial spraying and expected kills decrease from approximately 80 to 90% with suckers less than 1 year of age to less than 50% where suckers are 5 years old.

Pedley (1963) and McDonald (1967, 1970) have shown that, in areas where sheep are grazed, two sprayings 6 to 12 months apart on older suckers will result in kills in excess of 80%, with rates of application as low as 0·28 kg ha^{-1}. Their results suggest that good kills can be obtained irrespective of seasonal conditions at the time of spraying.

Johnson (1964) observed that sheep prefer sprayed to unsprayed suckers and can control root suckers which arise following spraying. McDonald (1970) attributed the excellent control obtained in his experiments partly to the influence of grazing. Regardless of seasonal conditions, aerial spraying with 2,4,5-T will cause considerable leaf drop and one of the reasons why kills have been poor following spraying under dry conditions is because of prolific regrowth. Since this young regrowth is preferred by sheep, grazing could offset the effects of adverse seasonal conditions.

56409—B

The aim of this experiment was to test whether two applications of 2,4,5-T approximately 10 months apart could be used to obtain kills in excess of 80% in country where sheep were absent.

II. MATERIALS AND METHODS

This experiment was established on two adjoining properties, 'Thomby' and 'Oranje', situated approximately 32 km north-west of Theodore. This region receives approximately 700 mm of rain a year, two-thirds of which falls during November to March.

The experimental area was originally covered with a brigalow–wilga (*Geijera parviflora*) forest. The brigalow trees forming the canopy were 12 m high with wilga prominent in the understorey. The soil is mainly a gilgaied uniform grey brown cracking clay (Northcote Ug 5·24) with smaller areas of texture-contrast soil having a shallow, reddish brown sandy clay loam surface. The forest was pulled to the ground in 1963, burnt in November of that year and sown to Rhodes grass. Following pasture establishment, both experimental areas have been used for beef cattle production.

At the time of the initial spraying most suckers were 0·7 to 1·0 m high and much of the sown pasture had been replaced by native species. Brigalow grass (*Paspalidium caespitosum*), belah grass (*P. gracile*), spider grass (*Enteropogon acicularis*) and fairy grass (*Sporobolus caroli*) were the most common native grasses.

Two blocks 360 m x 720 m, one on each property, were subdivided into 18 plots, each 120 m x 120 m. In May 1967, two strips 120 m x 720 m, on each block, were sprayed from the air with 2,4,5-T ester. One was treated with 0·56 kg acid equivalent (a.e.) 2,4,5-T in 28 litres ha^{-1} of diesel distillate, the other with 1·12 kg a.e. 2,4,5-T ester in 28 litres ha^{-1} of diesel distillate. The third strip was left unsprayed.

In March 1968, 10 months after the initial spraying, four strips, each 120 m x 360 m were sprayed on each block at right angles to the previous strips, two with 0·56 kg a.e. 2,4,5-T ha^{-1} and two with 1·12 kg a.e. 2,4,5-T ha^{-1}. Two strips were left unsprayed on each block. At both times of spraying, the treated strips were selected at random. In this way the following treatments were imposed—

1. 0·56 kg 2,4,5-T in May 1967.
2. 1·12 kg 2,4,5-T in May 1967.
3. 0·56 kg 2,4,5-T in March 1968.
4. 1·12 kg 2,4,5-T in March 1968.
5. 0·56 kg 2,4,5-T in May 1967 followed by 0·56 kg 2,4,5-T in March 1968.
6. 0·56 kg 2,4,5-T in May 1967 followed by 1·12 kg 2,4,5-T in March 1968.
7. 1·12 kg 2,4,5-T in May 1967 followed by 0·56 kg 2,4,5-T in March 1968.
8. 1·12 kg 2,4,5-T in May 1967 followed by 1·12 kg 2,4,5-T in March 1968.
9. Control unsprayed.

Each treatment was applied to four 120 m x 120 m plots. In addition to these treatments, a strip 120 m x 240 m was sprayed twice in May 1967 with $0 \cdot 56$ kg ha^{-1} 2,4,5-T in 28 litres of diesel distillate while another strip was sprayed twice in March 1968 with a similar mixture.

A Piper Pawnee aircraft was used in this experiment. The chemicals were applied in swathes $16 \cdot 5$ m wide in the early morning and late afternoon under relatively still air conditions. The aircraft flew at approximately 3 m above the ground.

Three separate but related pieces of data were collected from the trial area.

1. EFFECT OF SPRAY TREATMENT ON BRIGALOW SUCKERS. In each plot, four quadrats 20 m x $1 \cdot 5$ m were pegged out and brigalow suckers were counted before spraying. This was done by driving two steel pegs 40 m apart with a wooden peg half way between and counting suckers in a $1 \cdot 5$ m swathe centred on the pegged line. Two such series of pegs were established in each plot. Where the particular plot was sprayed only once, both pairs of quadrats were aligned at right angles to the line of flight of the aircraft. Where a plot was sprayed twice at right angles, one pair was established across each direction of flying. A buffer area of at least 20 m on all sides was allowed for drift so that the ends of each pair of quadrats were well within the inner plot area.

Final counts were made approximately 18 months after treatment. In this trial, any root suckers separated by more than $7 \cdot 5$ cm were regarded as individuals.

2. RATE OF KILL AND REGENERATION OF BRIGALOW SUCKERS. On the 'Thomby' block, smaller permanent quadrats were established to determine the rate of foliage kill and regeneration of suckers following treatment. Five quadrats were pegged in plots treated with

2. $1 \cdot 12$ kg 2,4,5-T in May 1967.
4. $1 \cdot 12$ kg 2,4,5-T in March 1968.
8. $1 \cdot 12$ kg 2,4,5-T in May 1967 followed by $1 \cdot 12$ kg 2,4,5-T in March 1968.

The quadrats were of varied size and were placed at random. The aim was to include at least 100 suckers in each of the treated plots. Each sucker was tagged.

Regular bimonthly counts were made and records were kept of completely browned suckers and new regrowth. In addition, any new suckers which appeared were tagged. A distance of $7 \cdot 5$ cm between individuals was used to define a sucker as in the 20 m x $1 \cdot 5$ m quadrats. Original suckers, which were completely browned following spraying, were recorded as having regenerated if regrowth appeared from stems or from roots within $7 \cdot 5$ cm of the base.

A final assessment of the quadrats which had been sprayed in May 1967 was made in May 1969 and for the remaining quadrats in January 1970.

3. EFFECT OF SPRAYING ON PASTURES. In an attempt to study the effect of spraying on the pastures, three treatments were selected

2. $1 \cdot 12$ kg 2,4,5-T sprayed in May 1967.
8. $1 \cdot 12$ kg 2,4,5-T in May 1967, followed by $1 \cdot 12$ kg 2,4,5-T in March 1968.
9. Control unsprayed.

The plots were split and one half sown in June 1967 to a mixture of Rhodes grass, buffel grass and green panic, each species at the rate of $1 \cdot 12$ kg ha^{-1}.

The pasture at the time of the initial spraying consisted of six components—

1. Brigalow suckers.
2. Introduced pasture species, mainly Rhodes grass with some green panic and buffel grass.
3. Native grasses.
4. Native forbs.
5. Native woody weeds excluding brigalow.
6. Bare ground.

Information was obtained on—

1. Overall change in the proportion of these components in the pasture after spraying. Data were collected by walking along both diagonals of each plot and recording the dominant component at each step.

2. Changes in dominance within the four main components: brigalow suckers, introduced pasture, native grass and bare ground. Five fixed quadrats, 1 m x 1 m, were established in each plot in each of the following categories.

a. Brigalow—unsown.
b. Brigalow—sown.
c. Bare—unsown.
d. Bare—sown.
e. Native grass—unsown.
f. Rhodes grass—unsown.

The quadrats were positioned to be representative of the main components though minor amounts of the other components were also present. Percentage canopy cover of all components was recorded in each quadrat as well as density of brigalow suckers. In both cases, assessment was made immediately before and 2½ years after the initial spraying.

Both areas were grazed by cattle during the experimental period.

III. RESULTS AND DISCUSSION

Rainfall recorded during the trial is set out in table 1. Rainfall was well below average before the initial spraying in May 1967 and soil moisture was low (table 2).

The second spraying in March 1968 was preceded by a summer of average to above-average rainfall though only 16 mm had been recorded, in three falls, in the 25 days before spraying. Soil moisture at this time was much higher than at the time of the initial spraying as can be seen from table 2. Some rain fell during the night preceding the spraying and a little free moisture was on the foliage when spraying was started.

1. Effect of spray treatments on brigalow suckers. Results are set out in table 3. Spraying carried out in May 1967 was markedly inferior to that carried out in March 1968. This difference reflects the relative soil moistures at

TABLE 1

RAINFALL AT BRIGALOW RESEARCH STATION 1967–1969

Year	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec		Year	
	T	D%	T	D%	T	D%	T	D%	T	D%	T	D%	T	D%	T	D%	T	D%	T	D%	T	D%	T	D%	T	D%
1967	182	+78	36	−70	36	−48	9	−81	15	−60	89	+117	0·2	−99	34	+62	0	100	87	+61	18	−72	87	−1	593	−16
1968	137	+33	108	−10	66	−4	119	+150	52	+38	0	−100	56	+65	31	+50	36	+25	4	−93	20	−71	106	+20	735	+ 3
1969	33	−69	73	−38	60	−12	7	−84	48	+27	21	−50	6	−83	10	−54	7	−76	117	+115	73	+8	84	−5	539	−24

T = Total rainfall expressed in mm.
D = Departure from average.

each time of treatment (table 2). The poorer results in May 1967 were associated with much drier soil conditions. Johnson (1964) and Johnson and Back (1973) have shown a strong correlation between soil moisture and percentage kill and this is supported by these results.

TABLE 2

GRAVIMETRIC SOIL MOISTURE AT EACH TIME OF SPRAYING

Depth (mm)	Soil Moisture (%)	
	May 1967	March 1968
0–15	14·83	17·51
15–30	13·12	15·73
30–45	13·54	16·01
45–60	14·45	16·55
60–90	15·38	16·34
90–120	15·93	16·99
120–150	17·38	17·21

TABLE 3

PERCENTAGE REDUCTION OF BRIGALOW SUCKERS FOLLOWING SINGLE AND DOUBLE SPRAY APPLICATIONS OF 2,4,5–T ESTER

May 1967 Treatment (kg ha^{-1} 2,4,5-T)	March 1968 Treatment (kg ha^{-1} 2,4,5-T)			
	0·0	0·56	1·12	0·56 + 0·56*
0·0	1·7	39·9	57·5	82·8
0·56	16·2	51·9	64·5	..
1·12	21·2	61·6	71·8	..
0·56 + 0·56*	37·1	..	..	..

Necessary differences for significance $\begin{cases} 5\% — 10{\cdot}1 \\ 1\% — 14{\cdot}8 \end{cases}$

* Split applications on same date—limited data not used in analysis.

Kills were improved by increasing the rate of application of 2,4,5-T from 0·56 to 1·12 kg ha^{-1} in both May 1967 and March 1968. With the poorer kills which followed the May spraying, the difference was not significant but, in March 1968, spraying with 1·12 kg 2,4,5-T was significantly better than spraying with 0·56 kg 2,4,5-T. Besides causing an increase in percentage kill the stronger spray solution also resulted in markedly greater defoliation of unkilled suckers.

These results suggest that it is more important to increase the rate of 2,4,5-T when spraying under moist soil conditions than under dry conditions. This is at variance with the authors' past experience. With the particular method of assessment used, sampling error tends to obscure the result when there is little change in density following treatment and it is thought this may have been responsible for the failure of the May results to achieve significance. This is supported by the interim counts made in March 1968 on the 24 plots sprayed in May 1967 with either 0·56 kg or 1·12 kg 2,4,5-T per acre. The respective kills at that time were 15% and 27%.

With the double application 10 months apart, the best kill, 72%, was recorded where 1·12 kg 2,4,5-T was followed by 1·12 kg 2,4,5-T. This treatment was significantly better than the other double applications in consecutive years. No difference was noted between the treatments in which 0·56 kg 2,4,5-T was followed by 1·12 kg 2,4,5-T and 1·12 kg 2,4,5-T was followed by 0·56 kg 2,4,5-T. Had seasonal conditions been equally good at each time of application, the result might have been different because in the latter treatment two-thirds of the chemical was applied under unfavourable conditions compared with only one-third in the former treatment. Greater defoliation caused by a higher initial rate of application followed by a lower rate on the more susceptible young regrowth may have resulted in better kills with the 1·12 kg 2,4,5-T followed by the 0·56 kg 2,4,5-T. This, however, can only be postulated.

Kills following the application of 0·56 kg 2,4,5-T followed by 0·56 kg 2,4,5-T were much lower than those obtained by McDonald (1970) and, on the results of this trial, it would appear unlikely that an 80% kill could be achieved with this combination in cattle country. It would also appear that both applications should be undertaken when the soil is moist. In this trial, the initial spraying was relatively ineffective. Although a 72% kill followed the two applications of 1·12 kg 2,4,5-T, a theoretical kill of 84% might have resulted if conditions had been as favourable in May 1967 as in March 1968.

An interesting feature of these results was the relatively good kills obtained where two applications of 0·56 kg 2,4,5-T in 28 litres of diesel distillate were made on the same day. Only a limited area was sprayed and the significance of these results could not be tested. However, both in May 1967 and in March 1968, the split applications of 0·56 kg and 0·56 kg resulted in markedly better kills than the single application of 1·12 kg ha^{-1} on the same day. The best kills obtained were following two sprayings of 0·56 kg 2,4,5-T in March 1968.

Two reasons could be suggested for this increased kill. First, the volume of carrier per hectare was increased from 28 litres to 56 litres of diesel distillate. However, experience from past trials and observations (Johnson 1964) has indicated that no benefit is gained by increasing the amount of carrier above 28 litres ha^{-1}. The second and more likely reason is that coverage of the leaves by the spray solution has been more complete. With aerial spraying of dense suckers, basal branches away from the direction of travel of the aircraft tend to be shielded from the spray and by covering the same flight path in the reverse direction better coverage can be obtained. If the better coverage alone has been responsible for the much better kills, it would appear that improvements in methods of application could result in significant improvements in results.

2. Rate of kill and regeneration of treated suckers. One of the main differences between the two times of spraying was the difference in soil moisture. The study of plots sprayed with 1·12 kg ha^{-1} 2,4,5-T gives an indication of the comparative effects of spraying under dry and average conditions on the suckers themselves. Because spraying was undertaken 2 months earlier in 1968 than in 1967, this comparison is confounded by a difference in time of year. However, Johnson and Back (1973) showed that soil moisture status had a much greater influence on the effectiveness of spraying than the time of the year. Study of the time pattern of regeneration of sprayed suckers also provides a guide to the timing of the second spraying.

(a) EFFECT OF TIME OF SPRAYING ON FOLIAGE KILL. Details are given in figure 1. Percentages used to plot the curve for the March 1968 (second spraying) in this and subsequent figures were calculated using the number of suckers in March 1968, which survived the initial spraying, as the initial density. The immediate foliage kill was much more rapid following the March 1968 spraying with the foliage of 38% of the treated suckers being completely browned 16 weeks after treatment compared with only 8% after the May 1967 spraying. Of all the suckers which eventually were completely browned, 95% were in this state within 32 weeks of the May spraying. In contrast, following the March spraying, this stage was not reached until 48 weeks after spraying. Virtually no further browning occurred after January-February in both cases. Only 45% of the suckers sprayed were completely browned following the May spraying compared with 55% of the suckers following the March spraying.

(b) EFFECT OF TIME OF SPRAYING ON REGENERATION FROM STEMS AND ROOTS. Of the 45% of the suckers which were completely browned following the May spraying, 49% produced regrowth from the stem or within a 7·5 cm radius of the stem compared with only 13% of the 55% which were completely browned following the March spraying. However, 27% and 22% of the browned suckers which produced regrowth following spraying in May and March respectively eventually died.

New root suckers were produced following both sprayings (figure 3). The number of root suckers was 7 to 8% of the original density in both cases and of these 42% did not survive (figure 4).

The better kills in March 1968, as against May 1967, were a reflection of the slightly better foliage kill recorded (figure 1) and more importantly the much smaller number of browned suckers which regenerated (figure 2). This could be attributed to the better translocation of 2,4,5-T with spraying under higher soil moisture conditions (Coaldrake, 1965).

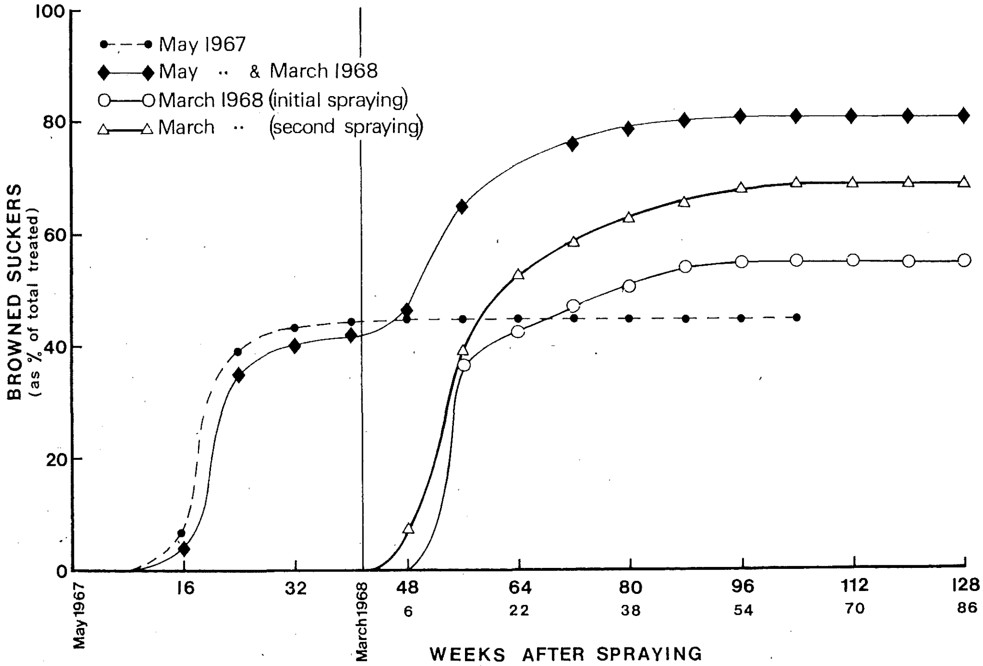

Figure 1.—Percentage of suckers completely browned following spraying.

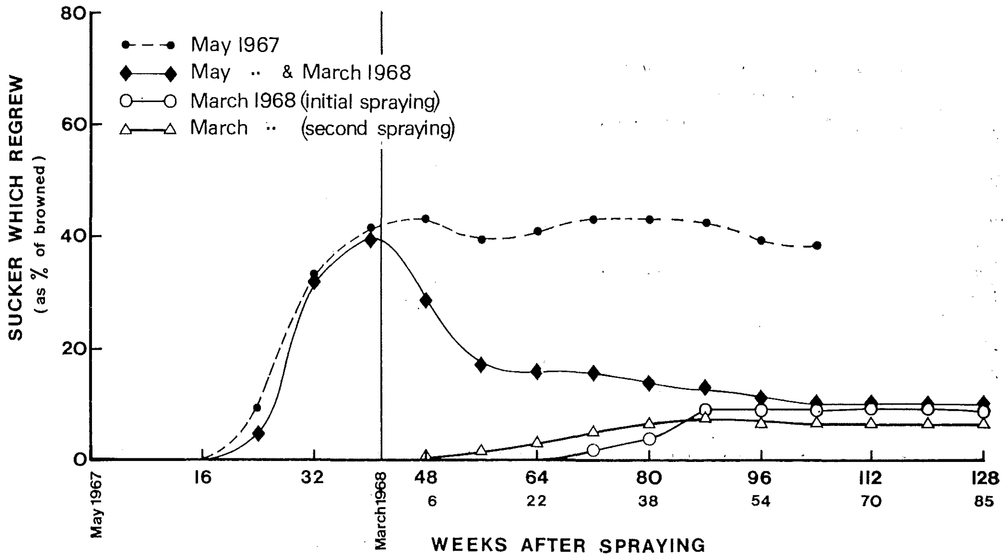

Figure 2.—Percentage of completely browned suckers which regrew.

(c) THE TIME PATTERN OF REGROWTH FOLLOWING SPRAYING AND THE TIMING OF THE SECOND SPRAYING. Regrowth from browned suckers first appeared between September and November regardless of the time of spraying. This was between 16 and 24 weeks after the May spraying and between 24 and 32 weeks after the March spraying. McDonald (1967) found that, in most cases, irrespective of season, percentage kills following double spraying improved as the time interval between treatments increased from 2 to 6 months. In this trial, the 2 to 6-month period was one of increasing leaf (phyllode) browning and defoliation. Little regrowth was produced within 24 weeks of spraying. Of the browned suckers which eventually regrew, only 17% had commenced regrowing within 24 weeks of the May spraying and no regrowth was recorded in a similar period after the March spraying. With spraying at this time suckers would have a minimum of foliage and most regrowth from the first spraying would emerge after respraying. McDonald (1967) also found there was little difference between results where a 6-month and an 8-month delay were imposed. Browned suckers continued to regrow for up to 80 weeks after spraying in both cases, but most had regrown within 40 to 49 weeks of spraying. In this trial, only about 5% of the suckers at the final count emerged more than 10 months after spraying.

(d) THE RELATIVE EFFECTS OF THE SECOND SPRAYING. At the time of the second spraying, three types of regrowth were present on the trial area—

1. Suckers which were not completely browned following the initial spraying, carrying old leaves and new regrowth.
2. Suckers which were completely browned and carrying only new regrowth from branches and at the base.
3. New root suckers.

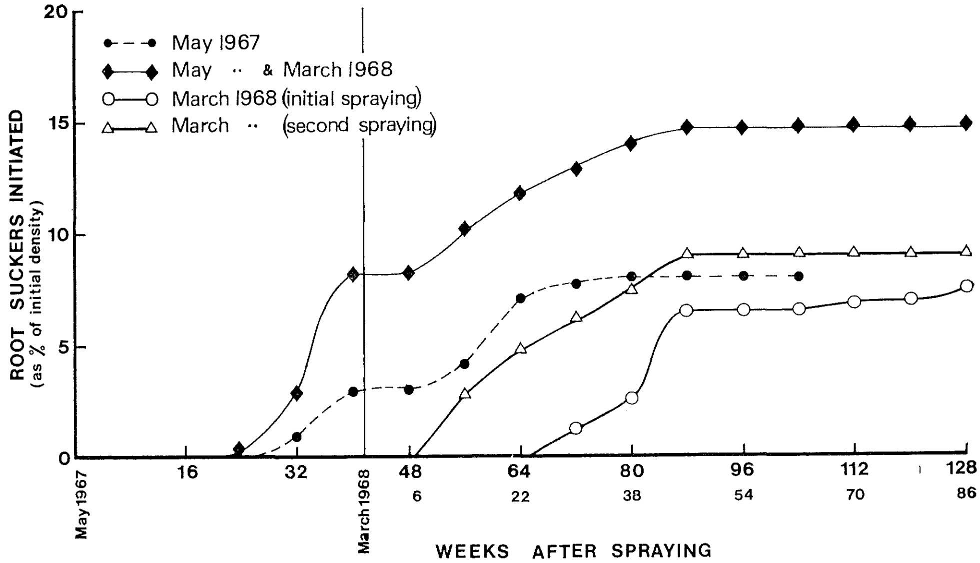

Figure 3.—Root suckers initiated following spraying.

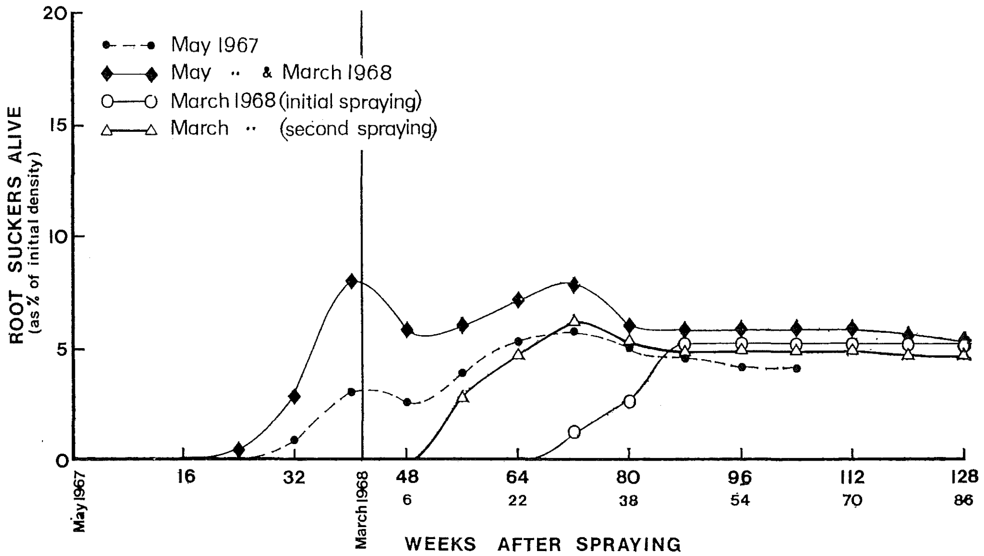

Figure 4.—Survival among root suckers initiated by spraying.

After the second spraying, kills of suckers of the above types of approximately 63%, 70% and 77% respectively were recorded. These kills are considerably better than those recorded among original suckers treated for the first time in March 1968 when the average kill in these selected plots was approximately 44%. However, in plots which were not resprayed, 23% and 40% respectively of types 2 and 3 died more than 10 months after the initial spraying. When account is taken of these deaths, the kill after respraying (61%) was only 37% better than the single March 1968 spraying. In assessing the effectiveness of the second spraying from the overall trial results in table 3, the spraying in March 1968 of previously unsprayed suckers resulted in a 57% reduction in density compared with 64% where the suckers had been previously sprayed.

In other trials, regrowth following burning has been significantly more susceptible to spraying than unburnt suckers, and it was expected that the respraying would have been much more effective than the initial spraying at the same time. Pasture growth was prolific following the first spraying and, at the time of the second spraying, many of the small suckers were covered by grass and forbs which the existing number of cattle were unable to graze sufficiently to prevent shielding. Hand clipping of many of the quadrats was found necessary before the second spraying and, though shielding might be a serious problem, in practice it is not thought to have affected the results in this trial.

Vigorous pasture growth following the initial spraying poses a practical problem in applying this method on a broad scale. This problem is likely to be most acute if the second spraying is timed for the midsummer and early autumn as it was in this trial.

TABLE 4

PERCENTAGE COVER OF VARIOUS COMPONENTS OF PASTURE BEFORE AND AFTER SPRAYING (LINE TRANSECT)

Treatment	Sampling Time*	Brigalow	Native Grass	Rhodes Grass	Forbs	Woody spp.	Bare
Single Spraying ..	Before ..	40·55	15·00	8·81	0·67	1·82	33·32
	After ..	17·50	26·02	15·53	2·05	2·74	36·18
Double Spraying ..	Before ..	34·52	16·35	12·50	1·61	0·66	34·49
	After ..	6·62	35·08	22·17	2·10	1·10	32·70
Control—Unsprayed ..	Before ..	35·26	8·76	7·60	1·77	5·25	42·21
	After ..	35·15	9·70	4·53	1·93	5·12	43·60

* Sampling dates—Before: May 1967, After: December 1969.

3. EFFECT OF SPRAYING ON PASTURE. Data from line transects set out in table 4 revealed little change in any of the pasture components in the control plots in the 2½ years after spraying. The only marked change was a reduction in Rhodes grass cover from 7·6% to 4·5%.

TABLE 5

PERCENTAGE COVER OF VARIOUS COMPONENTS OF PASTURE BEFORE AND AFTER SPRAYING (FIXED QUADRATS)

Component	Spray Treatment	Sowing Treatment	Sampling Time*	Brigalow		Native Grass	Introduced Grass	Forbs	Woody Plants	Bare
				Density	Cover					
Brigalow	Single Spraying	Unsown	Before	124	84·5	14·4	1·2	5·3	0·5	11·3
			After	84	37·1	31·8	5·6	16·7	1·3	32·9
	Double Spraying		Before	112	82·5	16·1	0·2	3·8	0·2	14·0
			After	34	3·3	36·7	7·3	19·8	0·5	40·4
	Control—Unsprayed		Before	97	85·5	10·9	0·9	4·8	3·5	12·3
			After	92	81·5	18·0	0·2	8·3	5·6	16·6
Brigalow	Single Spraying	Sown ..	Before	114	87·0	10·5	0·1	3·6	0·4	10·8
			After	85	41·4	26·5	1·6	16·9	0·6	35·8
	Double Spraying		Before	119	84·8	9·3	0·3	3·7	0·2	14·0
			After	48	10·2	42·3	10·8	16·7	0·4	33·2
	Control—Unsprayed		Before	90	86·3	6·1	0·2	3·3	3·5	11·5
			After	87	85·7	7·1	0·3	8·0	4·5	13·2
Bare ..	Single Sprayed	Unsown	Before	4	10·8	4·5	0·5	4·3	0·5	83·0
			After	6	3·1	20·0	5·5	12·8	0·7	62·6
	Double Spraying		Before	0	6·4	5·5	0·4	3·6	0·1	85·1
			After	2	0·8	25·2	2·7	19·5	0·1	56·7
	Control—Unsprayed		Before	4	8·5	5·5	0·2	3·7	1·3	84·2
			After	6	10·5	7·3	0·1	4·8	1·8	79·1
Bare ..	Single Spraying	Sown	Before	1	9·2	2·9	0·7	2·2	0·5	86·3
			After	2	2·6	14·8	3·9	18·7	1·1	61·8
	Double Spraying		Before	2	7·6	3·2	0·9	3·8	0·1	85·8
			After	5	1·5	36·4	5·9	22·9	0·2	43·1
	Control—Unsprayed		Before	2	8·6	2·8	0·2	4·3	0·7	87·1
			After	2	13·0	2·4	0·1	5·5	0·5	81·8
Native	Single Spraying	Unsown	Before	11	10·3	57·2	1·0	5·4	0·1	35·1
			After	7	2·9	46·5	1·2	7·8	0·2	45·8
	Double Spraying		Before	6	6·9	57·2	0·1	12·9	0·8	32·3
			After	2	0·6	46·7	1·0	13·4	1·5	37·6
	Control—Unsprayed		Before	10	6·1	54·3	0·3	5·0	0·5	39·3
			After	10	9·1	35·9	0·4	5·6	0·9	55·8
Rhodes	Single Spraying	Unsown	Before	3	3·8	2·8	44·3	16·1	0·5	38·8
			After	1	2·5	11·7	43·5	18·0	0·6	39·9
	Double Spraying		Before	1	4·1	2·3	38·5	15·4	0·1	46·3
			After	3	0·7	15·0	57·4	27·7	0·1	21·9
	Control—Unsprayed		Before	4	4·9	2·0	15·1	13·0	0·1	66·5
			After	5	7·8	5·4	0·5	13·0	0·1	76·9

* Sampling dates—Before: May 1967 After: December 1969

In plots sprayed once in May 1967, the cover of brigalow suckers was reduced by 57% while, in the double-sprayed plots, a reduction of 81% was recorded 2½ years after the initial spraying. Marked increases in native grass cover of 73% and 115% and in Rhodes grass cover of 76% and 77% also resulted from the spraying. Little change in the amount of bare ground occured in treated and untreated plots. It would appear that the reduction in cover of brigalow following treatment was balanced by the increase in native and Rhodes grass.

A more detailed picture of the relative changes in the cover of the various pasture components can be obtained from a study of data from the permanent quadrats. Details are given in table 5.

Establishment of improved pasture species, buffel grass, green panic and Rhodes grass, was a failure. Plants of buffel grass and green panic were extremely rare and the increase in Rhodes grass cover was partly due to vegetative growth of old plants. Rhodes grass seedlings were present at the final count but these could have originated from the existing population equally as readily as from the introduced seed.

This failure could be attributed either to the unfavourable time of sowing or to the known difficulty of establishing pasture on self-mulching clay soils without some cultivation treatment.

Though the trial paddocks were grazed almost continuously from the time of the initial spraying, mass germination of sown grasses was not noticed at any of the regular bimonthly inspections. Establishment might have been helped if pasture seed had been broadcast in the midsummer at the time of expected wet season and preferably if spraying could also have been carried out at this time, but this remains a speculation. The response of Rhodes grass to the spraying indicates that, where sown grasses are present, spraying should be undertaken while they are still a major component of the pasture.

Because of the extremely contagious distribution of brigalow suckers, the vegetation on the trial area was a mosaic of three kinds of patches. Dense patches of brigalow suckers were separated by relatively bare areas where the patches were close and by grassy areas where they were further apart. In both these bare and grassy areas, some scattered suckers and very small patches of suckers occurred.

In all three patches, there was a marked reduction in the cover of brigalow suckers following both single and double spraying, with reductions of 50 to 70% being recorded following the single spraying and 80 to 90% following the double spraying. A marked reduction in sucker density also occurred, except on the relatively bare patches where new root suckers caused an increase in density. So, although the overall density was reduced, distribution of the suckers after spraying was more even.

The behaviour of the vegetation in each of these patches following spraying is detailed below—

BRIGALOW DOMINANT PATCHES. Spraying caused a marked increase in both native and Rhodes grass cover and in the cover of forbs. Excluding bare ground, native grass was by far the most common of the non-brigalow components in these patches before spraying and became the major component after the double spraying. Two-and-a-half years after the single spraying, brigalow was again the main component. Spraying also resulted in a marked increase in the amount of bare ground in these patches from 10 to 15% at the time of spraying to 30 to 40%.

PREDOMINANTLY BARE AREAS. Spraying resulted in a reduction in bare ground and a marked increase in native and Rhodes grass and in forbs. The main vegetation in these patches was brigalow suckers, native grasses and forbs before spraying while, after spraying, native grasses and forbs were dominant. Both were relatively more common on the double-sprayed areas. Even with double spraying Rhodes grass covered less than 6% of these patches after spraying.

NATIVE GRASS PATCHES. Where native grasses were dominant, spraying maintained this dominance. The cover of native grass was reduced following spraying but to a much smaller degree than in control plots. Many of these grassy areas would appear fairly stable and variations in cover could be due to grazing and seasonal conditions.

RHODES GRASS PATCHES. At the time of the initial spraying, Rhodes grass patches were defined by the cover of both dead and alive Rhodes grass. Conditions were particularly dry at sampling time and the dead material was of recent origin. Plots in all three treatments had an 85 to 90% cover of Rhodes grass though the cover of live Rhodes grass was much less. In the control plots, there was little Rhodes grass alive at the final count. In contrast, the cover of live Rhodes grass was maintained in plots sprayed only once and increased markedly with a consequent reduction in the amount of bare ground following the double spraying. The proportional increase in native grass in these Rhodes grass patches was, however, greater in all sprayed plots.

Soil moisture appears to be the main factor controlling growth in a mixed brigalow-grass pasture. The bare patches appear to be maintained in this state by a moisture deficit and are vegetated only during periods of above-average rainfall. Spraying reduces the cover of brigalow and reduces transpiration loss through brigalow suckers. This has resulted in increases in grass cover on these relatively bare patches. Even in these areas, however, less than half of the original bare ground was revegetated after double spraying.

While bare ground was reduced in these predominantly bare areas, there was a marked increase in bare ground in the brigalow-dominant patches. In these areas, without treatment, the native species seem able to survive the competition with brigalow suckers better than Rhodes grass and were better able to recolonize the bare areas which resulted from the death of brigalow suckers. The reduction in bare ground in the bare patches and the increase in the brigalow patches has resulted in little overall change in the amount of bare ground following spraying.

Field experience indicates that recolonization by improved pastures is easier where soils are not self-mulching clays and the effects of spraying on grass establishment and regeneration may be different on texture-contrast brigalow soils particularly where green panic and buffel grass were present in the original pasture. Good establishment has been achieved following the spraying of whipstick brigalow on cracking clay soils (Johnson 1964) but in sucker brigalow where native grass is prominent establishment is more difficult.

In this trial, defoliation in the brigalow-dominant patches left bare areas covered with leaf litter and this situation would appear suitable for green panic establishment. If the sowing time had been more favourable, establishment in these areas may have been possible.

Native grass thickened up considerably following spraying. Because the proportion of bare ground at sampling was similar in sprayed and unsprayed plots while brigalow cover was greatly reduced in the former, it is likely a further increase in native grass cover can be expected on the sprayed plots in the future.

4. **Practical consideration.** From the results outlined above and from observations made during the course of the trial, a number of practical considerations arise in implementing this technique in the real property situation. Results showed the importance of spraying under good soil moisture conditions only and for maximum results the timing of both applications should be related, where possible, to soil moisture status. In this trial, the time interval between spraying was set at 10 months so it was not possible to assess the effect of varying the time interval between sprayings. If the pattern of regeneration following the initial spraying is a critical factor in the timing of the second spraying, then the second spraying should be delayed for at least 10 months. This time delay would appear necessary to ensure that at least 95% of the damaged suckers had green shoots when resprayed.

Shielding of suckers by pasture species is generally of little concern during the initial spraying when the brigalow suckers are dominant and pasture growth is suppressed. It could, however, be important in the second spraying because of increased growth of grass following the first spraying. No work has been undertaken to measure the effect of various amounts of shielding on the kill following spraying, though the authors have witnessed very effective spraying in well-grassed pastures. However, if the spray solution is intercepted by herbage before it can be absorbed by the suckers, then the effectiveness of the spraying must be reduced.

A suggested ideal would be to undertake the initial spraying under wet soil conditions during early summer and to respray following the first good fall of rain more than 10 months after the initial spraying. Pastures are usually most heavily grazed in the spring and it would be advantageous to time the second spraying with the increase in soil moisture during the early summer and before the main flush in pasture growth.

Double spraying in the opposite direction on the same day would appear to have commercial possibilities although the results were obtained from observations plots only. However, this technique would double the application cost and it would probably be more economical to use a second spraying at a latter date preferably after a pasture burn.

No evidence was obtained from this trial that sown pastures can be established if seed is sown onto the sprayed area. Because of the difficulty in establishing sown species, particularly on cracking clay soils, without some seed-bed preparation, it is advisable to use spraying before the sown pastures have greatly deteriorated.

Double spraying offers an additional method for the control of brigalow suckers. Its ultimate use will depend on the particular property situation.

IV. ACKNOWLEDGMENTS

The authors are indebted to the owners of 'Thomby' and 'Oranje' for providing the trial areas and to the Australian Meat Board for financial assistance. They are also grateful to Miss E. Goward, Biometry Branch, for the statistical analyses, to Mr. R. Thompson, for his accurate aerial spraying, and to Mr. W. Bisset, Agriculture Branch, for his comments on the manuscript.

REFERENCES

COALDRAKE, J. E. (1965)—Uptake and translocation of 2,4,5–T (2,4,5–Trichlorophenoxy acetic acid)–1–C_{14} in brigalow seedlings. Australian Weeds Conference 1965, 1(2):6-8.

JOHNSON, R. W. (1962)—'Clearing the Scrub' *Qd. agric. J.* 88:736-50.

JOHNSON, R. W. (1964)—'Ecology and Control of Brigalow in Queensland.' (Qd. Dept. of Primary Industries, Brisbane).

JOHNSON, R. W. and BACK, P. V. (1973)—Influence of environment on methods used to control brigalow (*Acacia harpophylla*) *Qd. J. agric. Anim. Sci.* 30:199-211.

McDONALD, T. J. (1967)—Proceedings of School for Brigalow Development, Biloela. Queensland Department of Primary Industries.

McDONALD, T. J. (1970)—Experiments in chemical control of brigalow (*Acacia harpophylla*) suckers in sheep country. *Qd. J. agric. Anim. Sci.* 27:1-15.

PEDLEY, L. (1963)—Control of brigalow suckers. Australian Weeds Research Newsletter Number 4:17-19.

(Received for publication 29 June 1976)

Dr Johnson is Director, Botany Branch, Queensland Department of Primary Industries, and is stationed at Indooroopilly, Brisbane. Mr Back was an Experimentalist in the Department's Agriculture Branch stationed at Rockhampton.