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INFLUENCE OF ENVIRONMENT ON METHODS USED TO CONTROL BRIGALOW (ACACIA HARPOPHYLLA)

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SUMMARY

Three methods—spraying, ploughing and burning—were repeated at approximately monthly intervals on different plots to control 3 to 4-year-old brigalow suckers.

Regardless of the methods used, kills were generally better in the January-February period that at other times of the year. Trends of variability for treatments at different times of the year were similar in both the ploughing and the burning treatments but rather different in the spraying treatments.

With ploughing treatments and burning treatments kills improved from a minimum in spring to a maximum in midsummer and early autumn, followed by a gradual decrease in effectiveness through the late autumn until late spring. This pattern is closely related to the pattern of shoot growth and in both the ploughing and burning treatments it could be suggested that results are correlated with the reduction and build-up of root reserves associated with the growth rhythm of the plant. Little or no correlation could be established between soil moisture status at the time of treatment and the results achieved with either ploughing or burning.

With spray treatments, using 2, 4, 5-T in diesel distillate, there was marked correlation between effectiveness and soil moisture status at the time of spraying and little or no correlation with shoot growth. Above-average kills were recorded following spraying during a winter period when soil moisture was relatively high but shoots were dormant.

I. INTRODUCTION

One of the major factors limiting production on cleared brigalow (*Acacia harpophylla*) country is the ability of the plant to produce suckers from the roots. Modern methods of clearing have accentuated the regrowth problem and in some large areas of cleared brigalow forest pastoral productivity has declined due to severe competition from regrowth suckers.

Methods used to control brigalow regrowth are basically of three types—ploughing, spraying and burning (Johnson 1964, 1968). Regardless of the particular method used, results are extremely variable and there is strong field evidence that they are influenced by environmental conditions at and prior to treatment (Johnson 1964). Best results have usually been obtained when soils were moist, and treatment in the summer-autumn period usually has been more effective than winter-spring treatments.

Johnson (1964) showed that the vigour of leaf (phyllode) and shoot growth during the growing period from late spring to autumn is greatly influenced by soil moisture. As it is easier to estimate visible growth than it is to estimate soil moisture, particularly at depth, any correlation between effectiveness of treatment and amount of recent growth would provide a very useful and practical basis for prediction. However, a few isolated cases of good control have been recorded following spraying with 2, 4, 5-T when the soil was moist but the plants were dormant. This would indicate, at least with spraying, that the influence of soil moisture might be independent of foliar growth.

The purpose of this study was to define more precisely the correlation between growth and environmental factors on the one hand and the effectiveness of various control measures on the other.

II. MATERIALS AND METHODS

(a) General

The trial was carried out on the Brigalow Research Station, 32 km northwest of Theodore. The average annual rainfall is between 680 and 700 mm, two-thirds of which falls during November to March.

The trial area was originally covered by an immature brigalow–wilga (*Geijera parviflora*) forest with trees 9–12 m tall and Ellangowan poison bush (*Myoporum deserti*) common in the understorey. The soil is a dark greyish brown uniform cracking clay (Northcote Ug 5.24) with weak melonhole development and the site has a westerly aspect.

The forest was pulled in September 1963 by a heavy chain dragged between two high-powered bulldozers. The trash was burnt on December 6, 1963, and a mixed pasture of Rhodes grass (*Chloris gayana*), Biloela buffel grass (*Cenchrus ciliaris*) and green panic (*Panicum maximum* var. *trichoglume*) was established on the ash seedbed. The burn was not complete and native grasses, chiefly brigalow grass (*Paspalidium caespitosum*), formed colonies in the sown pasture.

In September 1966 three adjacent areas, each of approximately 24·7 ha, were pegged out for spraying, ploughing and burning treatments. At a point located centrally to the above three areas an untreated area was reserved for the regular measurement of shoot growth and soil moisture. This area was called the "Central Control" and was additional to untreated control plots in each of the treated blocks.

At the commencement of these experiments the brigalow suckers were approximately 3 years old.

(b) Central Control

In the central control five suckers were tagged in each of four randomly allocated sites. As Johnson (1964) found that increase in shoot length and leaf length were approximately parallel, we decided to measure the former because this could be done more rapidly. A shoot was considered to be growing when it had reached a length of 2·5 mm. All growing shoots were measured weekly. If the terminal bud died, then that particular shoot was no longer measured, and in calculating total growth its length in subsequent weeks was regarded as being static. After the death of the terminal bud some of the shoots suffered tip dieback or abscission. However, for the purpose of this experiment no account was taken of these phenomena.

In some cases, when rain fell following the death of the terminal bud, axillary buds produced new shoots and these were measured. By the end of the growing season this had occurred numerous times and made accurate measurement difficult.

Three randomly selected sites were used to assess soil moisture changes. One hole 150 cm deep was dug with a 10 cm Jarret soil auger at each site every 14 days. Gravimetric soil moisture determinations for various depths—0–5 cm, 5–15 cm, 15–30 cm, 30–45 cm, 45–60 cm, 60–90 cm, 90–120 cm and 120–150 cm—were made by oven-drying at 105°C for 36 hr.

Measurement of soil moisture and shoot elongation was commenced on August 30, 1966.

Rainfall was recorded using a Mort pluviometer and a standard rain gauge, both of which were situated on the trial area. All additional data on the weather were recorded at the official meteorological site at the Brigalow Research Station, approximately 1·61 km from the trial area.

(c) Ploughing

The area used was stickraked in May 1966 and 96 plots, each 40 m x 13·4 m, were pegged out in rows. Some of these original plots were rejected because windrows of timber had been burnt on them. Others were rejected because they contained large melonholes which made ploughing at a uniform depth impossible. Eventually 78 plots were selected and two contiguous permanent quadrats each 20 m x 1·5 m were established along one diagonal of each plot.

Brigalow suckers were counted on all plots prior to the commencement of the trial. Because suckering is from horizontal roots it is impossible to distinguish the extent of any individual plant. As a convention, each stem of brigalow was counted as an individual when it was separated from its nearest neighbour by a gap of 7·5 cm or more. Groups of stems in which the individuals were less than 7·5 cm apart were counted as one.

After counting, plots were ranked in order of increasing density and grouped into 6 density classes each containing 13 plots. A completely randomized block design was used, the 6 density classes constituting the blocks.

A heavy duty offset disc plough, with 544 kg of additional weight, was used because this implement could be easily set to maintain an average plough depth of between 7·5 and 10 cm. In the initial treatments carried out on September 29, 1966, without the additional weight, difficulty was experienced in maintaining the required depth. For all subsequent treatments until the final ploughing on September 7, 1967, the additional weight was used.

Final counts of suckers were made approximately 12 months after treatment, by which time sucker densities were relatively stable.

(d) Spraying

Seventy-eight plots each 20 m x 20 m were pegged out. Two permanent quadrats each 20 m x 1·5 m were established in each quadrat. One quadrat was centrally placed along each diagonal. This meant that the central portion of each quadrat overlapped. It also meant that there was a buffer strip of approximately 3 m around the area used for assessing the effectiveness of spraying.

Counts of suckers were made on all plots prior to the commencement of spraying. As in the ploughing trial, 7·5 cm spacing was used to define one individual. Plots were ranked in order of increasing density and treatments were randomized within six blocks in a similar manner to that used in the ploughing section of the trial. Six different plots were sprayed at intervals of 4 weeks from September 29, 1966, until August 9, 1967, using an emulsifiable mixture of iso-butyl and butyl esters of 2, 4, 5-T ("Farmco 40") in diesel distillate.

The chemical was distributed with a knapsack misting machine using a technique designed to simulate aerial spraying or tractor-mounted misting. The mist was directed downward from above the suckers and the chemical was distributed as evenly as possible over the plots along premarked swathes each 3·3 m wide while walking at a speed of approximately 3·2 km/hr. No attempt was made to direct the spray into individual clumps of suckers. One rate only was used, approximately 0·5 kg in 45 litres distillate per hectare.

At the times of each spraying, data on soil moisture and growth data were collected from the central control and details of temperature, humidity and wind velocity were taken from the records at the Brigalow Research Station meteorological enclosure.

Final counts of suckers were made in February 1969. At this time 18 months had elapsed following the final treatment and sucker densities had become relatively stable. In contrast to the ploughing treatments, suckers die slowly after spraying and regrowth generally does not appear until about 6 months after treatment. Therefore a longer delay between the date of treatment and final counting is required for spraying treatments.

(e) Burning

For the burning trial, three blocks of existing suckers were selected. Each block was divided into eight plots separated by ploughed firebreaks. Plot size varied slightly between blocks but was approximately 40 m x 40 m, the aim being to include at least 66 suckers in each plot.

Within each plot, four sampling quadrats were selected at random, wherever possible one in each quarter of the plot. Quadrat size was varied to include between 10 and 40 suckers; in a few cases, where the randomly selected site contained fewer than 10 suckers, alternative sampling sites were chosen.

Plots were burnt at different times in accordance with a randomized block design. At the commencement of the trial it was planned to burn plots at monthly intervals to coincide with the spraying and ploughing treatments. As the trial progressed it became obvious that opportunity had to be taken of suitable conditions as they arose and in most instances it was not possible to keep to the original burning schedule. The first burn was undertaken in October 1966 and the final burn in January 1968. Prior to burning, standing suckers were delineated using a wire loop fixed to the ground and counts were recorded, unit being an individual stem or a multiple group in which the individual stems were not more than 7·5 cm apart.

Within 2 weeks of burning, an assessment of the severity of the burn was made in each plot. At the same time, the effect of the fire on individual suckers was rated according to the following table:

No visible effect	— 0
Partly browned	— 1
All attached leaves brown	— 2
No leaves remaining attached	— 3
Stems burnt to within 5 cm of ground	— 4.

The severity of the burn on the whole plot was expressed as a percentage varying from 100, where all suckers had been burnt to within 5 cm of ground level, to zero, where all suckers were unaffected.

A final assessment of results was made approximately 12 months after the time of burning, when sucker density was considered to be stable.

In this post-burning sampling, all recognizable stems were counted as individuals, including those spaced closer than 7·5 cm from the nearest neighbour.

(f) Timing and Grazing

Sampling for soil moisture and measurement of growth occupied a full day and in most cases the scheduled treatments were imposed on the following day. Spraying was undertaken early in the mornings while wind conditions were relatively calm, and ploughing treatments were carried out later in the day. Burning treatments were imposed when conditions were suitable. In January 1967, heavy rain fell after sampling and before spraying and additional soil moisture sampling had to be undertaken following spraying.

Cattle were excluded from the areas that were ploughed and burnt but were allowed access to the sprayed blocks to prevent shielding of suckers by grass.

III. RESULTS AND DISCUSSION

(a) Central Control

Soil moistures.—The gravimetric soil moisture values obtained and rainfall recorded between sampling dates are given in Table 1. The dates of the various spraying, ploughing and burning treatments are also given in Table 1. Soil moisture percentages represent total moisture at the various depths and not available moisture. An attempt was made to measure the wilting point of the soil at 15 atm tension using pressure-plate equipment. "Wilting points" measured by this technique varied between 18·3% and 24·8%.

From Table 2 it can be seen that growth was still occurring when soils were at or below this "wilting point" and it is obvious that figures for wilting point arrived at by the method used did not give a true indication of the moisture available to brigalow in the field. For this reason total soil moistures were used.

The soil profile is very uniform and though "wilting point" measurements varied slightly throughout the profile we considered that variations in waterholding capacity at different levels could be ignored. Variations in total soil moisture between different sampling dates could be expected to reflect changes in available soil moisture and not variations in soil type.

Soil moistures recorded at the different times of treatment showed that the soils gradually dried out from September to November 1966 and then soil moisture rose to a peak in January 1967. In January 1967 the spraying treatment was imposed within 14 hr of receiving 74 mm of rain and moisture was still moving downward through the profile. This made sampling very difficult and accounts for the very high moisture values recorded in the top 30 cm of soil.

In the period following January 1967, when rainfall was well below average, soil moisture declined further, but it rose again in July and August 1967 following good winter rain.

TABLE 1

GRAVIMETRIC SOIL MOISTURE PERCENTAGES AND RAINFALL IN CENTRAL CONTROL AND SUCKER CONTROL TREATMENTS

DATE	SOIL DEPTH (cm)									RAINFALL (points) †	TREATMENT No.		
	0–5	5–15	15–30	30–45	45–60	60–90	90–120	120–150	5–150		Spray	Plough	Burn
30.viii.66	n.a.	n.a.	21·97	22·34	20·27	19·25	19·44	19·16	n.a.	167*	..	..	..
13.ix.66	n.a.	n.a.	19·75	19·09	18·32	18·62	18·90	19·45	n.a.	96	..	..	..
30.ix.66	20·26	18·23	19·26	18·70	18·80	19·20	19·70	20·36	19·39	18	1	1	..
11.x.66	11·79	17·30	19·14	18·55	18·25	19·86	19·70	19·50	19·20	268	..	..	1
25.x.66	10·06	15·57	17·37	18·24	19·47	20·04	20·06	20·08	19·22	60	2	2	..
9.xi.66	24·40	24·84	21·19	18·59	18·18	17·97	18·74	19·55	19·35	200	..	..	..
22.xi.66	9·88	14·89	16·24	16·88	18·41	18·50	19·27	18·95	18·09	0	3	3	..
6.xii.66	12·25	13·52	14·43	14·75	16·03	16·83	17·66	19·54	16·79	31	..	..	2
20.xii.66	13·19	17·01	16·30	17·28	18·26	18·88	19·01	19·54	18·42	282	4	4	..
4.i.67	18·42	15·45	15·81	16·48	17·06	18·08	18·64	18·61	17·62	104	..	..	..
17.i.67	8·03	11·41	13·63	15·09	16·20	17·14	15·83	18·03	15·99	68	..	..	3
20.i.67	48·97	36·82	33·15	31·26	25·84	22·86	16·41	18·03	23·32	384	5	..	..
31.i.67	10·84	16·70	19·41	21·33	20·45	19·42	18·81	18·69	19·26	4	..	..	..
14.ii.67	8·55	14·47	16·69	18·08	18·89	18·98	18·71	18·69	18·21	113	6	5	..
28.ii.67	7·13	12·35	14·93	15·21	15·85	17·14	18·21	19·16	16·89	8	..	..	..
14.iii.67	13·37	17·45	16·43	16·96	17·91	17·88	19·02	20·25	18·33	96	7	6	..
28.iii.67	8·94	12·39	13·30	14·74	15·65	15·89	17·13	17·39	15·80	42	..	..	4
11.iv.67	9·80	11·55	13·76	14·80	15·76	16·22	16·93	17·10	15·77	10	8	7	..
24.iv.67	9·08	11·38	13·55	14·74	16·06	16·52	16·73	16·84	15·74	11	..	..	..
9.v.67	19·94	16·50	13·40	13·18	14·39	15·79	15·47	17·20	15·40	66	9	8	..
23.v.67	9·73	13·12	12·83	13·90	14·51	14·96	16·39	17·55	15·29	0	..	..	5
6.vi.67	9·42	11·24	11·27	13·48	15·08	15·03	15·48	16·60	14·64	0	..	..	..
13.vi.67	24·13	19·04	14·18	13·80	14·62	14·95	15·56	16·60	15·48	86	10	9	..
27.vi.67	26·71	24·10	22·29	19·45	18·30	17·36	18·25	18·51	19·07	164	..	..	..
11.vii.67	12·26	17·40	19·71	18·83	17·31	17·13	16·53	17·54	17·57	0	11	10	..
21.vii.67	9·61	14·37	16·16	16·67	15·61	16·57	17·18	17·24	16·56	16	..	..	6
8.viii.67	10·16	14·20	15·99	17·68	18·46	18·11	18·28	18·47	17·72	0	12	11	7
22.viii.67	20·00	19·87	15·65	14·89	15·48	16·32	17·60	18·20	16·91	134	..	..	..
5.ix.67	11·83	15·95	19·15	18·07	16·38	16·50	17·24	17·93	17·40	0	..	12	..
17.x.67	25·14	21·33	14·36	13·78	14·77	15·51	15·55	15·77	15·69	140	..	..	8
29.i.68	10·41	15·00	16·64	16·45	15·83	17·57	17·68	18·46	17·20	0	..	..	9

Soil moisture percentages are averages of three samples.
Rainfall is that recorded since the previous sampling date, except for the first record (see *).
n.a. Not available.
* Rainfall recorded in previous fortnight. † 100 points=25·4 mm

Growth.—Measurable growth was first recorded on September 6, 1966, and growth ceased on March 14, 1967. Results are shown in Table 2 together with the dates of the ploughing, spraying and burning treatments which were applied during the growing period. The growth rate fluctuated considerably from week to week with peaks occurring in October 1966 and in the December 1966 to February 1967 period. The most rapid growth was recorded in late January 1967. The sudden cessation of measurable growth at the end of January 1967 was due to a build-up of leaf-eating insects after heavy rain. These insects caused extreme damage to the young shoots although the plants were growing vigorously at the time. From January 24, 1967, to February 14, 1967, insect damage exceeded the production of new shoots. Damage was caused mainly by the larval stage of *Agrischaeta crinita* Pasc.

TABLE 2

TOTAL SHOOT NUMBER, TOTAL SHOOT LENGTH AND NUMBER GROWING OF TWENTY SUCKERS IN CENTRAL CONTROL AND SUCKER CONTROL TREATMENTS

Date	Rainfall (points)	Shoot No.		Shoot Length		No. of Growing Plants	Treatment No.		
		Total	Increase	Total (m)	Increase (m)		Spray	Plough	Burn
6.ix.66	88	76	76	0·196	0·196	10	..	..	..
13.ix.66	8	378	302	1·651	1·455	11	..	..	..
20.ix.66	0	459	81	3·790	2·139	12	..	..	..
27.ix.66	18	881	422	7·767	3·978	15	1	1	..
4.x.66	268	1,012	131	13·142	5·375	17	..	..	..
11.x.66	0	1,318	306	17·633	4·491	18	..	..	1
18.x.66	51	1,721	403	38·316	20·683	19	..	..	..
25.x.66	9	1,894	173	54·894	16·578	19	2	2	..
1.xi.66	0	2,068	174	63·716	8·312	15	..	..	..
9.xi.66	200	2,090	22	64·079	0·363	5	..	..	..
15.xi.66	0	2,136	46	64·531	0·452	13	..	..	..
22.xi.66	0	2,428	292	66·619	2·088	19	3	3	..
29.xi.66	31	3,123	695	73·914	7·295	20	..	..	..
6.xii.66	0	3,218	95	80·020	6·106	19	..	..	2
13.xii.66	146	3,318	100	83·279	3·259	12	..	..	..
20.xii.66	136	3,866	548	95·263	11·984	20	4	4	..
27.xii.66	2	4,008	142	106·144	10·881	20	..	..	..
3.i.67	102	4,087	79	110·703	4·559	14	..	..	..
10.i.67	68	4,103	16	113·337	2·634	7	..	..	..
17.i.67	0	4,351	248	118·011	4·674	11	5	..	3
24.i.67	384	6,345	1,985	151·158	33·147	19	..	..	..
31.i.67	4	6,345	0	151·158	0·0	0	..	..	..
7.ii.67	113	6,345	0	151·158	0·0	0	..	..	..
14.ii.67	0	6,345	0	151·158	0·0	0	6	5	..
21.ii.67	0	6,786	441	153·904	2·746	9	..	..	..
28.ii.67	8	7,322	536	167·140	13·236	10	..	..	..
8.iii.67	20	7,503	181	174·549	7·409	11	..	..	..
14.iii.67	76	7,532	29	177·046	2·497	7	7	6	..
21.iii.67	42	7,532	0	177·046	0·0	0	..	..	..

Rainfall is that recorded since the previous sampling date.

No further growth was recorded until 31.x.67.

Suckers were sprayed with chlordane, and following the insect control measures a further flush of growth was recorded in late February and early March 1967. No shoot growth was recorded after March 14 until October 31, 1967, when seasonal growth commenced again.

(b) Ploughing

Results expressed as a percentage reduction in density are given in Table 3. A positive reduction in density (numbers per unit area) was recorded at only six of the 12 times of treatment. The general pattern of control was for kills to increase up until the February 1967 ploughing and then to decrease until the following September. The December 1966 ploughing was followed by a marked increase in regrowth and results from this particular ploughing are at variance with the general pattern. Both of the September ploughings (1966 and 1967) were followed by the greatest increases in sucker populations.

TABLE 3

PLOUGHING TRIAL: NUMBER OF SUCKERS PER ACRE AND PERCENTAGE REDUCTION

Date of Treatment*	Treatment No.	Initial Density†	Final Density‡			Change in Density§ (%)	Kill of Original Suckers (%)
			Original	New	Total		
29.ix.66 ..	1	8,118	3,960	6,721	10,681	−33·1	51·3
27.x.66 ..	2	8,239	1,772	4,847	6,919	10·7	77·4
24.xi.66 ..	3	7,645	1,793	4,664	6,457	18·8	78·0
22.xii.66 ..	4	7,227	1,947	6,204	8,151	−13·2	75·0
17.ii.67 ..	5	5,236	957	2,915	3,872	21·4	81·8
17.iii.67 ..	6	8,877	2,101	5,467	7,568	15·7	77·1
13.iv.67 ..	7	6,776	1,034	5,181	6,215	7·9	83·8
14.v.67 ..	8	8,041	1,408	6,754	8,162	−9·0	79·4
14.vi.67 ..	9	10,263	2,442	8,393	10,835	−4·6	78·1
12.vii.67 ..	10	7,590	1,903	7,359	9,262	−25·7	74·7
9.viii.67 ..	11	7,249	1,144	6,413	7,557	−2·2	84·1
7.ix.67 ..	12	7,997	2,706	7,392	10,098	−29·7	63·2
Control ..	13	7,337	7,337	..	7,337	0·0	0·0
Necessary differences for significance	..	..	..	..	5%	25·3	11·2
					1%	33·7	14·8

* Because of rain the treatment due in January 1967 could not be applied and was replaced by an extra treatment in September 1967.

† All plots were counted prior to commencement of trial.

‡ Final counts were made approximately 12 months after treatment.

§ Mean of plot means.

Table 3 also shows that there was little variation among treatments in the number of original suckers which survived the ploughing treatment. Only the September 1966 ploughing without weights had significantly fewer original suckers chopped off after ploughing than any of the other treatments. The September 1967 ploughing was also less effective in ploughing out the original suckers. The main differences among treatments were variations in the density of fresh regrowth which followed ploughing.

The statistical analysis did not show a significant block effect, indicating that the results were not affected to any great extent by the density of the initial population.

The greatest reduction in density followed ploughing in February 1967. This ploughing was undertaken under relatively good soil moisture conditions though the surface soil was fairly dry. Soil moisture, however, was greater at some other times of ploughing and there appears to be little obvious correlation between soil moisture and effectiveness (see Figure 1).

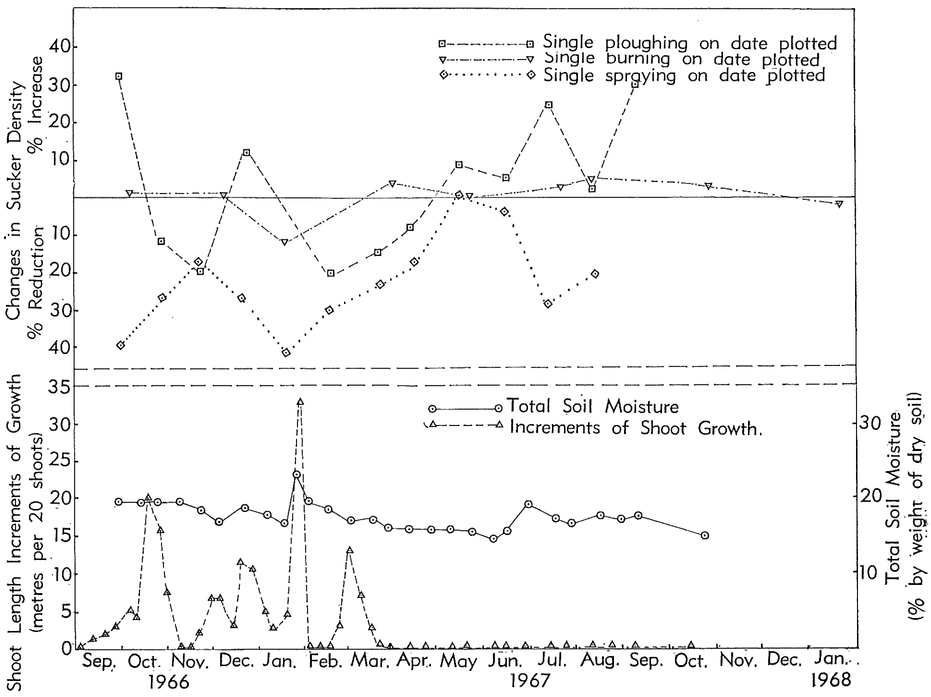

Fig. 1.—Changes in sucker density during the year after treatment.

It is interesting to note that the February 1967 ploughing followed the period of greatest foliage growth. It was unfortunate that this growth coincided with the infestation of leaf-eating larvae and consequently could not be measured. While the insect damage was severe enough to upset the recording of growth increments, the amount of plant material removed was insignificant compared to the total plant biomass and we do not consider insect damage to be a significant factor contributing to the improved kills recorded in February 1967. Examination of the growth measurement obtained at other times shows little obvious correlation between the actual amount of shoot growth and the kill obtained by any particular ploughing treatment. However, results show that ploughing at a time when shoots were growing (irrespective of the amount of growth) gave better kills than ploughing at a time when the suckers were dormant (see Figure 1).

The trend for kills to increase until February 1967, at which time the summer flush of growth was terminating, and then decrease again until September 1967, suggests that the effectiveness of ploughing may be correlated with the amount of reserve food material stored in the plant at time of treatment. In theory there is a reduction in reserve food material following the commencement of growth in September and a gradual increase following the cessation of growth in the autumn. Ploughing in the late winter to early spring period resulted in the most prolific regrowth. This was at the end of a long period of dormancy when food reserves within the plant were likely to be high.

Several workers (Wood *et al.* 1959; Cook 1966; Wright and Stinson 1970) have suggested that mechanical control of woody plants is most effective if applied when root reserves are at their lowest point and our results fit this pattern. The situation is, however, confounded by balances in hormonal levels, which are also influenced by the growth rhythm of the plant. While the number of suckers initiated may be a function of hormonal levels, the survival and growth of these suckers is dependent on adequate carbohydrate reserves (Schier and Johnston 1971).

The poor results following the September 1966 ploughing can probably be partly attributed to the fact that the plough was not weighted. This ploughing time also coincided with the first flush of growth, when food reserves were probably very high following the dormant period. A poor result was also recorded in September 1967. Again food reserves would probably have been high. In this particular year growth did not commence until the end of October. At this stage no explanation can be offered for the very poor result in December 1966.

The results did not appear to be strongly related to surface soil moisture at the time of treatment, even though moist surface soil enables the plough to penetrate the soil more easily and to sever the horizontal roots. The moisture in the surface 15 cm of soil at ploughing in February 1967 was about average for the trial. In fact, there appeared to be little difference within the mechanical effect itself at the various times of ploughing. This is supported by the data in Table 3, which show that except for both September ploughings there was little difference in the percentage of the original suckers which remained after ploughing.

Best results were obtained towards the end of the growing season; ploughing at other times usually resulted in increased suckering. In general, the results indicate that ploughing in late spring to early autumn is more effective than similar treatment in late autumn to early spring. They indicate that the effectiveness of ploughing is related to growth rhythm and in particular appears to be correlated with the abundance of food reserves in the root system.

(c) Spraying

Results expressed as percentage reduction in density (numbers per unit area) are given in Table 4.

TABLE 4

SPRAYING TRIAL: NUMBER OF SUCKERS PER ACRE AND PERCENTAGE REDUCTION

Date of Treatment	Treatment No.	Initial Density* (suckers/ac)	Final Density† (suckers/ac)	% Reduction‡ in Density	% Reduction in Density Adjusted for Slope§
29.ix.66 ..	1	6,644	3,828	39·7	38·2
27.x.66 ..	2	7,029	5,434	26·7	27·9
24.xi.66 ..	3	6,688	5,423	17·3	20·3
22.xii.66 ..	4	6,402	4,521	28·8	30·9
20.i.67 ..	5	6,897	4,048	41·9	40·7
16.ii.67 ..	6	6,952	4,708	30·3	34·2
17.iii.67 ..	7	6,842	5,159	24·7	21·7
14.iv.67 ..	8	6,446	5,357	17·6	18·4
14.v.67 ..	9	6,710	6,710	−0·4	1·7
14.vi.67 ..	10	6,996	6,743	3·2	3·1
12.vii.67 ..	11	6,468	4,334	29·1	23·3
9.viii.67 ..	12	6,611	5,544	21·2	23·9
Control ..	13	7,260	7,227	−0·1	−4·5
Necessary differences for significance	..	..	.. 5%	21·2	19·4
			1%	28·3	25·9

* All plots were counted prior to the commencement of the trial.
† Final counts were made 18 months after the last treatment.
‡ Mean of plot means.
§ The trial area was on a slope and there was a highly significant increase in kills on the lower slope.

The statistical analysis did not show a significant block effect, indicating that the results were not affected to any great extent by the density of the initial population.

In all months, initial kills following spraying were better than those following ploughing. The best results were obtained following spraying in September 1966 and January 1967. Soil moistures at these times of spraying were higher than at any other time. Poorest kills were obtained in May and June 1967 when the soils were at their driest. The marked increase in kill from June to July 1967 is reflected in the marked increase in soil moisture which followed the very effective rain received in the second half of June.

In an attempt to decide which soil depths provide the most reliable information for predictive purposes, the data were analysed using a stepwise multiple regression programme. Soil moisture measurements from each of the soil depth intervals were used as the independent variables. The variables representing the surface 15 cm and the lowest 30 cm were the first eliminated, indicating that the best prediction is obtained from soil moistures in the interval between 15 cm and 120 cm.

There appears to be no direct relationship between visible shoot growth and the effectiveness of spraying (see Figure 1). At the time of the January 1967 spraying only 50% of the tagged suckers in the Central Control were growing. However, the rain which fell a few hours before spraying did result, within a week, in the most active period of growth during the season. Most plants were making some growth when spraying was undertaken in September 1966 but growth was more prominent in October 1966 when kills were poorer. The marked increase in kill between June and July 1967 was during a period when no visible foliage growth was being produced.

At each time of application the whole spraying operation rarely took more than 1-1½ hr to complete. In that time the environmental conditions such as temperature, humidity and wind velocity did not vary greatly. It is therefore not surprising that there was no obvious correlation between these factors and the kill obtained on the plots sprayed on any one day.

The trial area sloped from east to west and kills on plots low down on the slope were consistently better than kills obtained on plots high up on the slope. Soil depth was found to increase down-slope and in Central Control tagged suckers from low down on the slope tended to begin growing before suckers higher up on the slope. These observations indicate that the better kills on the lower slopes may be the result of better soil moisture relationships. An analysis of covariance for position down-slope and percentage kill gave a highly significant error regression, and mean percentage kills adjusted for position are also included in Table 4.

(d) Burning

Results expressed as percentage reduction in density (numbers per unit area) are given in Table 5. Burning resulted in little change in density, a significant kill being recorded at only one time of treatment, January 1967. At all other times except January 1968 a slight increase in density followed burning.

Burning at a time when brigalow suckers were making active foliage growth caused significantly more deaths among the original populations than burning while brigalow was dormant, but in most cases sufficient new root suckers were produced to maintain the initial density. The relatively high kill in January 1967 resulted from a highly significant reduction in density in the initial population combined with relatively less new regrowth after burning.

TABLE 5

BURNING TRIAL: SEVERITY OF BURN INDEX, NUMBER OF SUCKERS PER ACRE AND PERCENTAGE REDUCTION

Date of Treatment	Treatment No.	Severity of Burn* (%)	Initial Count†	Final Count‡ Old	Final Count‡ New	Final Count‡ Total	Change in Density§ (%)	Top Kill of Original Suckers (%)
10.x.66 ..	1	..	260	245	18	263	−0·95	6·56
8.xii.66 ..	2	72	224	207	19	226	−0·92	10·42
17.i.67	3	72	257	202	24	226	11·99	22·57
30.iii.67 ..	4	66·5	305	284	27	311	−4·07	6·75
19.v.67	5	57	274	268	6	274	−0·26	1·97
17.vii.67 ..	6	55	322	318	12	330	−2·18	1·80
9viii.67 ..	7	62	281	280	18	298	−4·87	0·26
17.x.67 ..	8	67	295	289	14	303	−3·43	1·95
29.i.68	9	54	282	262	13	275	1·88	6·62
Control ..	10	..	239	239	..	239	0·00	..
Necessary differences for significance		..	..	..	..	5%	8·26	4·67
						1%	11·32	6·39

* This is based on an assessment of the suckers 2 weeks after burning. For details see "Materials and Methods".

† Plots were counted prior to burning.

‡ Plots were counted approximately 12 months after burn.

§ Mean of plot means.

The period of active growth of brigalow coincides with higher daily temperatures and this generally resulted in hotter fires. However, it would appear that growth and possibly root reserves may have a greater influence on the result than the actual heat of the fire. The severity of the burns recorded in both December 1966 and January 1967 was the same, yet the January fire killed more suckers. It seems likely that a better result was achieved in January because food reserves at that time were lower.

The burning times which approximated most closely to the peak of foliar growth and presumably the lowest level of food reserves were January 1967 and January 1968. The ratio of new regrowth to old suckers killed was much lower following both January burns. A low level of food reserves could be postulated as the reason why an appreciable percentage of the original suckers was unable to regrow after burning at these times. The kill obtained in January 1968 was significantly poorer than that obtained in January 1967. This may be due to the fact that in January 1968 cool conditions prevailed and the resultant burn was not severe (see Table 5).

There appears to be little correlation between soil moisture at the time of burning and the effectiveness of the fire. However, the amount of moisture in the soil after burning may be important. In the 3 days following the January 1967 burn 96 mm of rain fell. Rain began to fall within 1 hr of burning. Johnson (1964) suggested that a large amount of rain following burning may improve the effectiveness of burning and this trial would tend to reinforce this belief. It has been observed that brigalow suckers tend to die in clumps following treatment. This is probably due to the death of the common root system. The maintenance of moist soil conditions following damage to the root system resulting from burning could create favourable conditions for fungal attack and this could be an explanation of the possible correlation between improved kills and rain following burning.

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Editorial note: Circumstances required that this paper go to press without the conversion of suckers/ac to suckers/ha in Tables 3, 4 and 5).