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A STUDY OF PREPLANTING HERBICIDES, NITROGEN, BURNING AND POST-EMERGENCE CULTIVATION ON THE ESTABLISHMENT OF LEUCAENA LEUCOCEPHALA CV. PERU

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SUMMARY

In a glasshouse trial chlorthal, trifluralin and benfluralin at 8.4, 1.12 and 1.68 kg active constituent/ha respectively, suppressed weed emergence without any detrimental effect on leucaena emergence. Doubling the herbicide rate reduced leucaena emergence. 2,4-D amine at 3.16 kg active constituent/ha did not give satisfactory weed suppression and at double this rate suppressed the leucaena emergence.

In the field, the lower rates of chlorthal, trifluralin and benfluralin did not affect weed or leucaena growth on a heavy self mulching loam. Although rhizobium NGR-8 failed to nodulate leucaena, growth was not improved by application of nitrogen (N) up to 45 kg/ha. Burning windrows of logs on the seedbed and post-emergence cultivation each improved leucaena growth. Chlorthal and trifluralin incorporated into a well-prepared seedbed at 8.0 and 1.0 kg/ha active ingredient respectively controlled grass weeds but not broad-leaf weeds and did not improve leucaena growth. Even when effectively nodulated by rhizobium CB-81 leucaena was unable to compete with weeds in this fertile soil and post-emergence cultivation gave a 93 fold increase in yield by the end of the growing season.

I. INTRODUCTION

The browse legume leucaena (*Leucaena leucocephala*) is naturalized in wide areas of the tropics and sub-tropics, such as Hawaii (Kinch and Ripperton 1962). In favourable environments, it spreads readily wherever it is introduced. Hutton and Gray (1959) state that the species requires an annual rainfall greater than 760 mm with summer dominance and a mean minimum temperature for July above 10°C for successful use in Australia.

In areas marginally suitable for leucaena, especially on fertile soils, weed competition can retard or completely prevent establishment. Dijkman (1950) reports that leucaena cannot tolerate deep shade and in Indonesia hand weeding every 2 to 4 weeks for the first 3 to 6 months is practised. In New Guinea, Hill (1970) considers that clean weeding and 30 kg N/ha are necessary for good establishment.

Experience in Queensland (Shaw 1965) showed that pre-emergence herbicides increased the yield of leucaena tops from 45 to 2 540 kg/ha and hand weeding increased the yield to 3 400 kg/ha. Jones (1970) showed that chlorthal, trifluralin and 2,4-D applied as pre-planting herbicides depressed early leucaena growth but not to the extent caused by uncontrolled weeds.

This paper gives the results of four experiments designed to investigate the effects of soil sterilization, pre-planting herbicides, nitrogenous fertilizer and post-emergence cultivation on the early growth of leucaena in pots and small field plots.

II. EXPERIMENTAL

The experiments, using leucaena cv. Peru, were carried out on a heavy, self-mulching soil (Ug 5·12) (Northcote 1971) derived from basalt at 'Brian Pastures' Pasture Research Station—latitude 25°47′S and longitude 151°52′E—during 1970–1972. Mean annual rainfall for the period 1954–1973 was 744 mm.

Experiment 1

This was a pot trial employing tapered plastic pots with a depth and top diameter of 18 cm and containing approximately 2·6 kg of topsoil which had passed through a 0·95 cm sieve.

Nine treatments were replicated five times in a randomized block design. The treatments were benfluralin, trifluralin, chlorthal and 2,4-D amine at 1·68, 1·12, 8·4 and 3·16 kg/ha active constituent (a.c.) respectively, and at double these rates, together with a control (nil herbicide).

Trifluralin and benfluralin were applied to the appropriate pots by removing the top 8 cm of soil and mixing before replacement. Thirty-nine days later, chlorthal was similarly incorporated into the top 5 cm of soil of its treatment pots. At this stage, 50 leucaena seeds previously treated with water at 80°C for 4 min were planted at a depth of 2·5 cm in all pots. The seeds were not inoculated. The 2,4-D was then spread uniformly over the appropriate pots and all pots were watered until excess moisture drained free. Subsequently the pots were surface-watered daily to field capacity and rotated twice weekly on the glasshouse bench for 21 days when the trial was concluded.

Results were assessed by counting and removing emerged leucaena seedlings daily. On completion of the experiment, weeds were identified and the oven-dried weight of their above ground parts was recorded.

Experiment 2

A 3 x 3 x 2 factorial design with two replicates was used in a field experiment to investigate the effects of seedbed preparation, pre-planting herbicides and post-emergence cultivations on leucaena establishment. The plots were 9·13 m x 9·13 m, of which the centre 7·6 m x 7·3 m was the datum area containing four rows of leucaena.

The treatments were—

Seedbed preparation		Herbicides		Post-emergence cultivation
(a) Burning windrows of logs (10 Dec 1970)		Nil		Nil
(b) Chisel ploughing (18 Nov 1970 and 17 Dec 1970)	x	Trifluralin (1·12 kg/ha a.c.)	x	Cultivated (8 Mar 1971)
(c) (a) + (b)		Chlorthal (8·4 kg/ha a.c.)		

Trifluralin was applied to the dry soil in the equivalent of 500 litres of water/ha in the late afternoon of 22 December 1970 and disced in to 7 cm depth. Chlorthal was applied on 6 January 1971 in the same manner, but incorporated with spike harrows.

Leucaena seeds were immersed in water at 80°C for 2 min and soaked in aerated water for 2 days before sun-drying and storage. Following 30 mm of rain in 2 days, the seeds were inoculated with rhizobium NGR-8, and nine seeds per 1 m were sown at a depth of 2·5 cm with a Rasspe hand planter on 20 January 1971. Subsequently the seedlings were thinned to one plant per 30 cm. Follow-up rain began on 23 January 1971 and continued for 16 days.

Post-emergence cultivation plots were tilled on 25 February 1971, subsequently rotary hoed, and hand cultivated on 8 March 1971. Plant counts were made on 23 to 24 February 1971, and herbage yields were measured by harvesting all leucaena growth within the datum areas on 6 May 1971, oven-drying and weighing.

Experiment 3

The effects of pre-emergence herbicides, nitrogen fertilizer and post-emergence cultivations on leucaena establishment were investigated in a field experiment identical to experiment 2 in design, plot size, installation dates and techniques.

Treatments were—

Herbicides		Nitrogen		Post-emergence cultivation
Nil		Nil		Nil
Benfluralin (1·68 kg/ha a.c.) (23 Dec 1970)	x	22 kg/ha N	x	Cultivated (8 Mar 1971)
Chlorthal (8·4 kg/ha a.c.) (7 Jan 1971)		45 kg/ha N		

The nitrogen treatments were applied as ammonium sulphate watered onto a band 30 cm wide along the proposed planting row on 8 January 1971. Leucaena plant counts were made on 23 February and yield was measured on 10 to 11 May 1971.

Experiment 4

A 4 x 3 split plot factorial design with three replicates was used to investigate the effects of weed control techniques (main plots) and fertilizer nitrogen (split plots) on leucaena establishment.

Treatments were—

Weed Control		Nitrogen
Trifluralin (1·0 kg/ha a.c.)		Nil
Chlorthal (8·0 kg/ha a.c.)	x	25 kg/ha N
Cultivation		50 kg/ha N
Nil		

Plots were 10 m x 8 m with a central datum area 6 m x 4 m containing four rows of leucaena 1 m apart.

A seedbed with a soil aggregate size of 1 cm or less was prepared during August–September 1971. On 27 September 1971 ammonium sulphate was broadcast and disced into the nitrogen treatments and the herbicides were applied late in the afternoon in the equivalent of 500 litres of water/ha. Trifluralin was incorporated to a depth of 8 to 10 cm by four discings at 7 km/hour immediately after application while chlorthal was incorporated by harrowing the following morning.

Following 39 mm of rain on 16 October 1971, hot-water treated (80°C for 2 min.) leucaena seed was inoculated with rhizobium CB-81 and nine seeds per 1 m were sown at a depth of 2·5 cm with a Rasspe hand planter on 18 October 1971. The main germination followed 34 mm of rain which fell on 26 to 30 November 1971.

Cultivation plots were both rotary hoed and hand cultivated on 2 November 1971 and 21 December 1971, and hand cultivated on 28 January 1972.

The above-ground volumes of four randomly tagged plants in each plot were periodically calculated from plant height and diameters along and across the row from day 36.

During early May 1972, the four tagged plants and six others in each plot were harvested by removing leaves, flowers, seed pods and stems having a diameter of 6·4 mm or less. Additionally, broad and narrow-leaf weeds were harvested from six 1·0 m x 0·5 m quadrats placed randomly in each plot. Leucaena and weeds were oven-dried and weighed.

III. RESULTS

Experiment 1

The effect of herbicides on leucaena and weed emergence is shown in Table 1.

TABLE 1

EFFECT OF HERBICIDES ON EMERGENCE OF LEUCAENA, FINAL WEED POPULATIONS AND OVEN-DRIED WEED YIELD IN POTS (EXPERIMENT 1)

Herbicide		Leucaena emergence (%)	Narrow-leaf weeds population (plants/pot)	Black pig weed population (plants/pot)	Yield of all weeds (g/pot)
Type	Rate (kg/ha a.c.)				
2,4-D amine	3·16	44 (0·73)*	7 (2·67)†	29 (5·41)†	1·3
2,4-D amine	6·32	7 (0·28)	3 (1·78)	17 (4·11)	0·9
Benfluralin	1·68	62 (0·90)	3 (1·89)	62 (7·87)	0·5
Benfluralin	3·36	52 (0·81)	1 (1·15)	46 (6·81)	0·2
Trifluralin	1·12	52 (0·80)	2 (1·66)	48 (6·90)	0·3
Trifluralin	2·24	8 (0·29)	1 (1·22)	38 (6·13)	0·2
Chlorthal	8·4	83 (1·15)	0·2 (0·81)	10 (3·20)	0·1
Chlorthal	16·8	73 (1·02)	0·2 (0·81)	7 (2·59)	0·03
Nil	. .	48 (0·76)	15 (3·9)	74 (8·58)	2·4
Mean	. .	48 (0·75)	3 (1·76)	33 (5·73)	0·7
LSD 5%	. .	(0·17)	(0·63)	(1·38)	0·5
LSD 1%	. .	(0·22)	(0·85)	(1·85)	0·6

* Inverse sine transformation used for analysis of variance.
† Square root (X + ½) transformation used for analysis of variance.

At the low application rates all herbicides significantly reduced narrow leaf weeds, chiefly *Urochloa panicoides* with some *Panicum maximum* var. *trichoglume* cv. Petrie, but only chlorthal and 2,4-D reduced black pigweed (*Trianthema portulacastrum*). The high application rates of 2,4-D amine and trifluralin suppressed leucaena emergence while chlorthal improved leucaena emergence at both rates compared with the control ($P<0{\cdot}01$).

Experiment 2

Neither land preparation nor herbicide treatment affected the number of leucaena seedlings but there was a visible reduction in weed growth in the plots that had received trifluralin and chlorthal. (Data not presented).

The effects of seedbed preparation and post-emergence cultivation on the yield of leucaena are shown in table 2.

TABLE 2

THE EFFECTS OF SEEDBED PREPARATION AND POST-EMERGENCE CULTIVATION ON THE YIELD OF LEUCAENA (kg/ha) (EXPERIMENT 2)

Post emergence cultivation	Seed bed preparation				
	Chisel ploughing	Burning	Burning and chisel ploughing	Mean	L.S.D. 5%
Nil	4·7	32·9	12·4	16·6	12·6
Cultivation	12·8	129·8	112·5	85·1	
Mean	8·7	81·4	62·5		
LSD 5%	..	15·4			

Seedbed preparation x post emergence cultivation LSD 5% = 21·8.

Burning resulted in better leucaena growth, both in the presence and absence of post-emergence cultivation. However, when burning was associated with chisel ploughing, its effect was significantly reduced ($P < 0{\cdot}05$). Post-emergence cultivation increased leucaena growth ($P < 0{\cdot}01$) especially when associated with burning.

Effective nodulation was not achieved.

Experiment 3

Neither herbicides nor applied nitrogen had any significant effect on numbers of established leucaena plants 35 days after planting, nor on oven dry weight of leucaena ($P < 0{\cdot}05$) at harvest.

Nitrogen application plus rain which fell on 33 of the 47 days between planting and post-emergence cultivation resulted in vigorous weed growth.

Post-emergence cultivation significantly ($P < 0{\cdot}01$) increased leucaena yield from 5·4 kg/ha to 21·5 kg/ha.

Effective nodulation was not achieved.

Experiment 4

The relationship between plant volume and age and the influence of treatment on this relationship are shown in Figure 1.

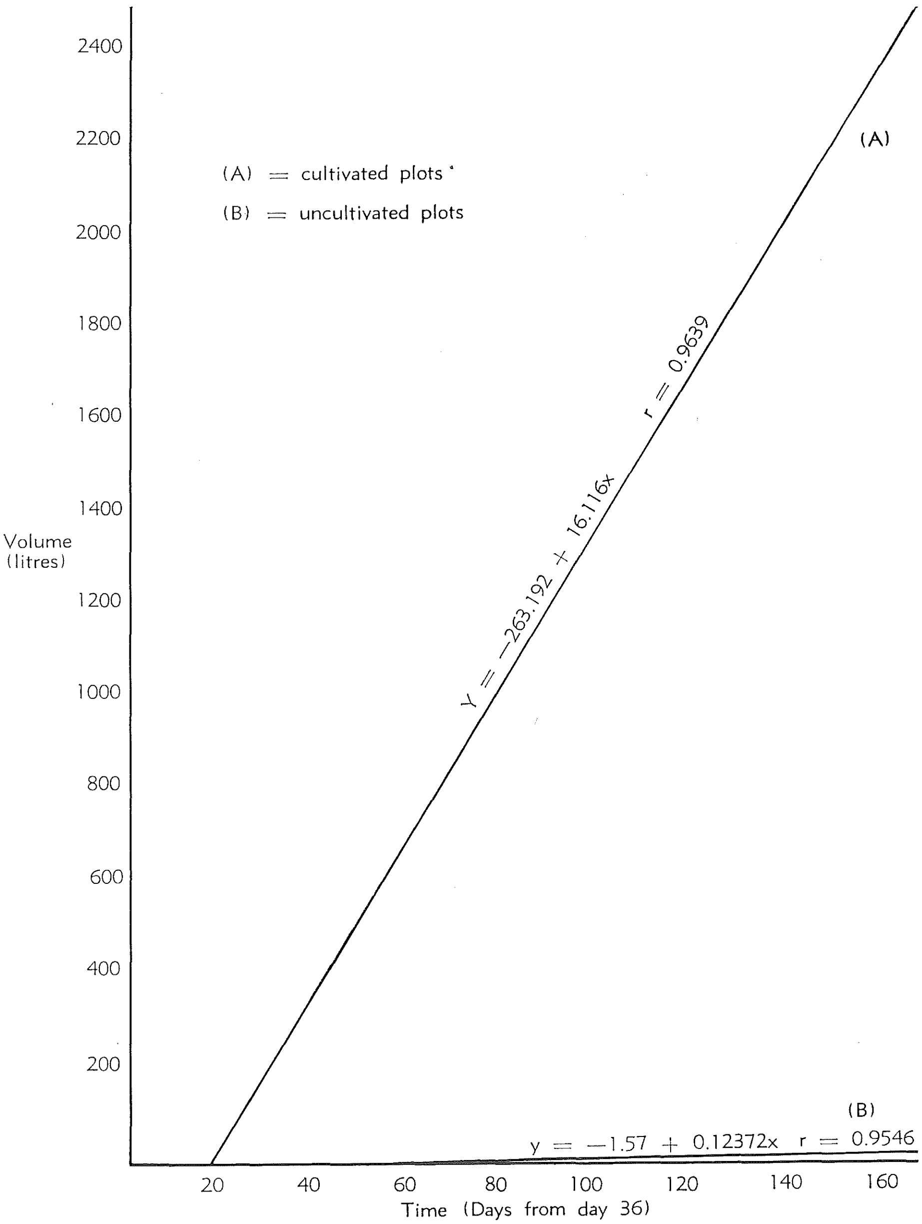

Figure 1. Relationship between treatments, plant age and plant volume from day 36 (EXPERIMENT 4).

Leucaena volume in unweeded control plots increased at the rate of 0·12 litre/day and this was not affected by herbicide or nitrogen treatments. Cultivation increased the rate ($P < 0{\cdot}01$) to 16 litres/day irrespective of nitrogen application (Figure 1).

Unweeded control plots produced 52 kg leucaena dry matter/ha and yield was not affected by herbicides. Application of 50 kg N/ha increased yield of leucaena dry matter to 99 kg/ha while cultivation increased it to 4 934 kg/ha. (Data not presented).

Both herbicides reduced the yield of grassy weeds ($P < 0 \cdot 01$) from 898 to 290 kg/ha but did not affect the yield of broad-leaf weeds. (Data not presented).

IV. DISCUSSION

In the pot trial (experiment 1), trifluralin, benfluralin and chlorthal each gave satisfactory weed control at the low application rates. At double these rates, both trifluralin and 2,4-D had an adverse effect on leucaena emergence. Doubling the rate of chlorthal did not alter its effects on weeds or leucaena. 2,4-D at the low rate did not give a satisfactory level of weed control.

In subsequent field experiments, trifluralin, benfluralin and chlorthal applied at the low rates had little effect on weed control or establishment and production of leucaena.

In a field experiment in the following season in which the herbicides were more thoroughly incorporated into the soil, only the grassy weeds were significantly reduced and the broad-leaf weeds suppressed leucaena growth to the level of the unweeded control.

Burning windrows of logs on proposed planting rows was a successful treatment. This is attributed to sterilization of weed seeds present in the surface soil and the release of nutrients. At harvest, leucaena was still growing strongly even though the area was covered with weeds that had encroached from the plot margins. When the burnt plots were chisel ploughed before sowing, the effectiveness of burning was reduced, presumably because fertile weed seeds were brought to the surface from the deeper layers. Follow-up cultivation improved leucaena production and removed differences between burning treatments which were both superior to the hand-weeded (non-burnt) plots. Poor performance of the hand-weeded plots was due to prolonged rain after planting (506 mm in 32 days) so that weeding was not completed until the forty-seventh day after planting. As well, no subsequent rain fell before the harvest. As a result, the leucaena plants in the weeded plots were not significantly larger than those in the uncultivated plots. Leucaena plants on unburnt plots receiving no post emergence cultivation were small, wilted and starting to shed leaves at harvest.

Diatloff (1973) found few establishment problems on an infertile soil where nutrient deficiencies (except nitrogen) were corrected. The effectively nodulated leucaena dominated the weeds. In trials 2 and 3 of the project reported here rhizobium strain NGR-8 failed to nodulate leucaena and the latter was unable to compete with weeds. Applied nitrogen was of no benefit to leucaena, presumably because of uptake by the weeds. Even when effectivelv nodulated (by rhizobium strain CB-81) leucaena failed to compete with weeds on this fertile soil. Post-emergence cultivation increased leucaena yield 93-fold over the unweeded control and the cutivated plants were sufficiently well grown to allow grazing at the end of the growing season.

In practice, leucaena will probably be row-planted. Apart from the poor performance of pre-planting herbicides in these trials, the need to apply them to the whole paddock precludes their use. Where land is being cleared of timber the on-site burning of such timber gives an ideal seedbed without cultivation.

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