THE EFFECT OF *ELEUSINE INDICA*, HERBICIDES AND ACTIVATED CHARCOAL ON THE SEEDLING GROWTH OF *LEUCAENA LEUCOCEPHALA* CV. PERU

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ABSTRACT

Leucaena leucocephala, *a potentially useful pasture legume, is difficult to establish in southern Queensland due to its susceptibility to weed competition. Glasshouse experiments using* Leucaena leucocephala *cv. Peru were conducted to measure the effects of weed competition and of some promising herbicides. The presence of the annual weed grass* Eleusine indica *(crowsfoot) reduced the yield of leucaena seedlings* 92 *days after sowing to* 25, 17, 18 *and* 16 *per cent of the weed free control yield when* 4, 8, 16 *or* 32 *grass seeds were sown with the four leucaena seeds in each pot.*

Dacthal (DCPA) applied at pre-emergent rates equivalent to 0-12.6 *kg/ha a.i. reduced leucaena yield, plant height and root length. At the highest rate, yield was only* 2 *per cent of the control yield. Severe tap root damage was noted above* 4.2 *kg/ha a.i.. Treflan (trifluralin) at rates of* 0 *to* 0.56 *kg/ha a.i. as a pre-emergent spray controlled crowsfoot at all rates but resulted in a linear reduction in leucaena yield with increasing herbicide rate* ($r = -0.984^{**}$). *No obvious damage to the plants was apparent.*

Activated charcoal at 25 *and* 50 *kg/ha applied above the sown seed reduced the toxic effect of pre-emergent sprays of* 2,4-*D and Dacthal. In the absence of charcoal, leucaena yield was reduced by the herbicides to about* 40% *of the control (no herbicide, no charcoal) yield. Increasing charcoal rates alleviated the adverse effects of the herbicides and increased leucaena height and plant weight; root damage caused by Dacthal was prevented by using charcoal. At the highest charcoal rate the seedling heights with herbicide were similar to the controls but the weights were only about* 66% *of the control weights. In the absence of herbicide, charcoal reduced the root weights of leucaena but the reason for this was not ascertained.*

The results suggest that the use of herbicides and activated charcoal is a potential method for field establishment of leucaena which needs to be evaluated under field conditions.

INTRODUCTION

Leucaena leucocephala (leucaena) is a leguminous shrub with potential for increasing animal production in the tropics and sub-tropics (Hutton and Gray 1959, Gray 1968, Hill 1971). The seedling growth in the field is slow and the seedlings are often suppressed by weed species. This slow establishment and the absence of a reliable recommendation for control of weeds (Cooksley 1974) has discouraged farmers and graziers from accepting leucaena as a sown pasture species in Queensland. Shaw (1965) showed that removing competing weed species resulted in a dramatic increase in leucaena yield and indicated possibilities for improving the first season's growth by the use of herbicides. In the studies reported here an attempt was made to quantify the depressing effect of the weed grass *Eleusine indica* (crowsfoot) —the most common annual weed of leucaena pastures sown in summer at Samford, S.E. Queensland—and also the effect of two pre-emergent herbicides known to control annual grass weeds, namely Dacthal (D.C.P.A.), dimethyl 2, 3, 5, 6 tetrachloroterephthalate 75% w/w and Treflan (Trifluralin), ∝, ∝, ∝—trifluoro -2,

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6-dinitro-N, N-dipropyl-p-toluidine 40% w/v. A further experiment investigated the use of activated charcoal to reduce the adverse effects of Dacthal and 2,4-D on seedling growth.

MATERIALS AND METHODS

The studies were made in heated glasshouses at the CSIRO Pasture Research Station, Samford, and at the Cunningham Laboratory, Brisbane, in S.E. Queensland. Seed of *Leucaena leucocephala* cv. Peru was immersed in water at 80°C for 3 minutes to overcome hardseededness (Gray 1962) then dried prior to use. No nitrogen fertilizer was added. *Rhizobium* strain NGR 8 in peat culture was applied to the pots after sowing and watered in. Pots were watered once or twice daily. Details of the potting mixtures used and the sowing and harvesting dates for each experiment are given in Table 1.

TABLE 1

Details of soils, pots, sowing and harvesting dates for the four experiments.

Experiment No.	Pots	Potting mixture	Date Sown	Date Harvested
1	Clay, 21 cm diameter, Volume 4·5 l.	Friable alluvial soil, pH 5·5 plus 0·25 kg potassium sulphate, 1 kg Mo superphosphate and 1 kg lime/m³.	16/7/69	16/10/69
2	,,	,,	16/7/69	16/10/69
3	Clay, 17 cm diameter, Volume 2·4 l.	,,	13/8/69	23/10/69
4	Plastic, 15 cm diameter, 1250 g dry potting mixture	2 volumes alluvial soil: one volume of dried cattle manure plus 0·25 kg potassium carbonate, 1 kg Mo superphosphate and 1 kg lime/m³.	24/3/71	25/5/71

Experiment 1

Five rates of crowsfoot were established by sowing 0, 4, 8, 16 or 32 viable seeds/pot at a depth of 1 cm. Each pot contained five seeds of leucaena (subsequently thinned to 4 plants) so that the ratio of crowsfoot:leucaena varied from 0:1 to 8:1 to represent low to heavy weed infestation. There were five replications with treatments arranged on the bench as a randomized block design.

At harvest the leucaena and crowsfoot were cut to soil level and the plant numbers, height and dry weight recorded.

Experiment 2

In this experiment the effect of rate of Dacthal on seedling growth of leucaena was studied. Dacthal in water suspension was applied to the pots to give the equivalent of 0, 4.2, 8.4 and 12.6 kg/ha a.i. in 500 l water/ha. The zero Dacthal treatment was the zero crowsfoot treatment of Experiment 1, since the treatments of this experiment and of Experiment 1 were randomized within each of 5 replicate blocks and treated in an identical manner. Harvesting procedure followed that of Experiment 1, except that the tap roots of the leucaena were also washed out and their lengths measured.

Experiment 3

In this experiment the effect of Treflan incorporated in the top 3 cm of soil at 0, 0.14, 0.28 and 0.56 kg/ha a.i. in 500 l water, in the presence of crowsfoot was measured. In addition, a control leucaena treatment with no herbicide and no crowsfoot was included. Plants were thinned to four of leucaena and four of crowsfoot per pot. The five treatments were replicated four times. At harvest, tops of both species were cut to soil level, dried and weighed.

Experiment 4

The treatments applied to five replicates after planting were factorial combinations of the following:

Herbicides—Nil
2,4-D sodium salt at 8 kg a.i. ha^{-1}
Dacthal at 13 kg a.i. ha^{-1}

Activated charcoal†—Nil
25 kg ha^{-1}
50 kg ha^{-1}

The activated charcoal was applied as a water suspension above the 7 leucaena seeds immediately before the application of the herbicides. Dacthal was applied as a suspension in water and the sodium salt of 2,4-D as a solution. The herbicides were applied in a spray using the equivalent of 500 l ha^{-1}. Control pots were sprayed with an equal volume of water.

Emergence was recorded for 12 days after sowing and the seedlings were then thinned to four per pot. Plant heights were measured on 16 and 29 April, and on May 17. At harvest, plants were cut to ground level, dried and weighed. Root systems were washed and recovered, dried and weighed.

RESULTS

Experiment 1

Crowsfoot grew much faster than leucaena throughout the experiment. There was no indication that leucaena suffered any nodulation problem or nutrient deficiency since plants in the control pots were dark green and appeared healthy.

In the presence of crowsfoot, leucaena seedlings remained a yellow-green colour for about 6 weeks after emergence. At harvest the leucaena in the crowsfoot treatment was shaded by a dense canopy of the grass which had just commenced to produce inflorescences. Yield of leucaena was greatly reduced by the presence of crowsfoot even at the ratio of 1:1. Further increase in weed density reduced the yield of associated leucaena only slightly (Table 2).

Overall the reduction in leucaena yield was more closely related to crowsfoot yield ($r = -0.996$) than to crowsfoot density ($r = -0.588$).

Total pot yields were approximately four times greater in the presence of crowsfoot than for the leucaena-only treatment and yields of the mixtures increased with increased sowing rate (Table 1). The height of the crowsfoot decreased with increasing crowsfoot density ($P < 0.01$ Table 1) but there was no marked depression in leucaena height as the crowsfoot density increased from 4 to 32 plants per pot. In the absence of crowsfoot, however, leucaena plants were about 35% taller (Table 2).

Experiment 2

Dacthal reduced leucaena yield, height of shoots and length of tap root (Table 3). The effects of rates above 4.2 kg/ha a.i. were associated with plant deaths and severe root damage. At the highest Dacthal rate most tap roots only grew to a length of about 0.5 cm. To survive, the plants proliferated secondary roots near the crown but they did not attain the dimensions of the original tap root.

Experiment 3

In the absence of herbicide, crowsfoot reduced the yield of the associated leucaena to 6% of that in the leucaena-only treatment (Table 4). Treflan gave complete control of crowsfoot even at the lowest rate. However, it also adversely affected leucaena, reducing its yield linearly ($r = -0.984$) with increasing applications. Severe injury to the leucaena tops or roots was not evident, but one plant (6% of the total) died at the highest rate.

† Activated Charcoal Powder—B.D.H. No. 33033.

TABLE 2

Effect of the weed grass Eleusine indica (*Crowsfoot*) *at various densities on the seedling growth of associated* Leucaena leucocephala *cv. Peru* (*Leucaena*).

Treatment	Yield of Leucaena	Yield of Crowsfoot	Total Yield	Height of Leucaena	Height of Crowsfoot
Ratio of Crowsfoot to Leucaena	g/pot*	g/pot	g/pot	(cm)	(cm)
1. 0:1	3·58 (0·658)	0	3·58 (0·658)	13·7	—
2. 1:1	0·91 (0·273)	12·42 (1·126)	13·34 (1·154)	10·3	35·6
3. 2:1	0·62 (0·208)	13·78 (1·166)	14·40 (1·185)	9·6	34·5
4. 4:1	0·65 (0·217)	13·92 (1·173)	14·56 (1·192)	9·9	30·8
5. 8:1	0·57 (0·197)	15·38 (1·212)	15·95 (1·227)	9·8	29·7
LSD 5%	(0·077)	(0·062)	(0·064)	2·49	2·43
1%	(0·107)	(0·085)	(0·088)	3·43	3·34

*There were 4 Leucaena plants per pot.
( ) Transformed data, log (χ + 1)

TABLE 3

Effect of the herbicide Dacthal on yield, survival and shoot and root length of Leucaena laucocephala *cv. Peru.*

Dacthal Rate kg/ha a.i.	Leucaena Yield g/pot*	Plant Survival %	Mean height of surviving plants cm	Mean Tap Root length and associated standard errors cm
0	3·58 (0·658)†	100	13·7	27·2 ± 3·7
4·2	2·31 (0·515)	100	8·8	18·2 ± 7·0
8·4	0·36 (0·132)	40	4·0	1·2 ± 0·2
12·6	0·15 (0·057)	20	3·6	0·8 ± 0·3
LSD 5%	(0·090)	25	3·0	
1%	(0·126)	35	4·2	

*Initially 4 plants/pot.
†Transformed data, log (χ + 1).

TABLE 4

Effect of Treflan herbicide and the weed grass Eleusine indica *on yield of* Leucaena leucocephala *cv. Peru.*

Treflan rate kg/ha a.i.	Leucaena yield (g/pot)	Eleusine yield (g/pot)
0	2·39 (0·529)*	0
0+ Eleusine	0·15 (0·061)	6·34
0·14+ Eleusine	2·20 (0·498)	0
0·28+ Eleusine	1·82 (0·449)	0
0·56+ Eleusine	1·51 (0·400)	0
LSD 5%	(0·081)	
1%	(0·118)	

*Transformed data, log (χ + 1).

Experiment 4

Emergence

The 2,4-D treatment markedly delayed emergence of seedlings, and both herbicides reduced establishment compared with the control treatments ($P < 0.05$) when measured 12 days after sowing (Fig. 1). Charcoal had no significant effect on emergence and the interaction of charcoal rate and herbicide treatment was not significant ($P > 0.05$).

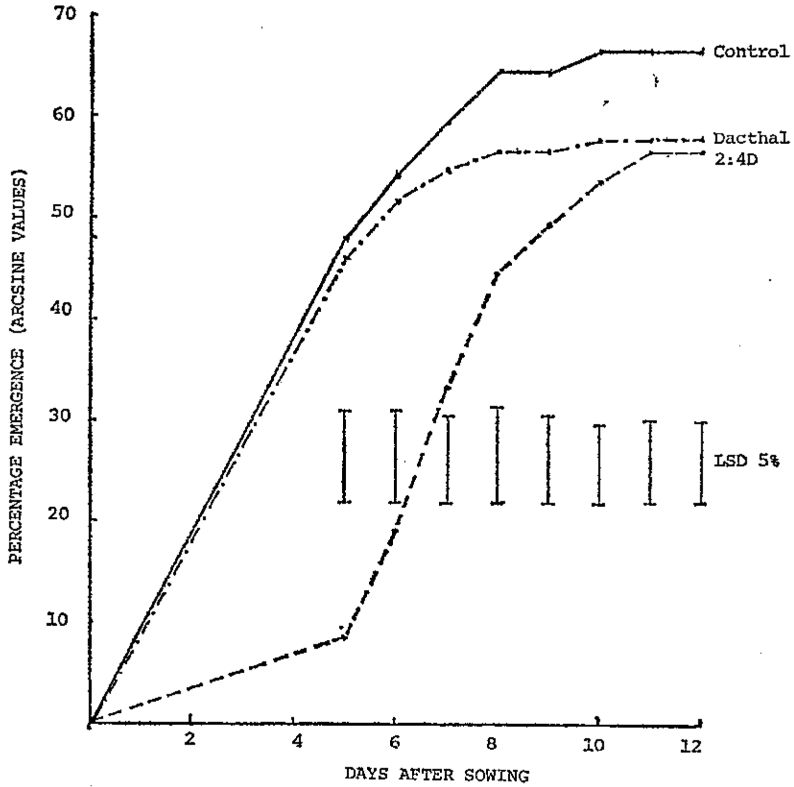

FIGURE 1

The effect of the herbicides 2,4-D and Dacthal on the seedling emergence of leucaena.

Height of seedlings

In the absence of charcoal the herbicides reduced the height of leucaena when measurements were made on day 21, 34 and 56 after sowing (Fig. 2). A significant herbicide × charcoal interaction occurred at each occasion. In the absence of herbicide, charcoal reduced leucaena height (at day 21 and 34) or had no significant effect on leucaena height (day 56), whereas in the presence of herbicide charcoal alleviated the adverse effect of herbicides on plant height (Fig. 2). There was little difference between the two herbicides with respect to their effect on plant height, although in the absence of charcoal the effect of Dacthal was more severe than that of 2,4-D.

Shoot weights

Both herbicides depressed shoot yields ($P < 0.001$) but charcoal reduced this yield depression ($P < 0.05$) (Table 5). The herbicide × charcoal interaction was not significant—however, in the absence of herbicide charcoal had little effect on shoot weights.

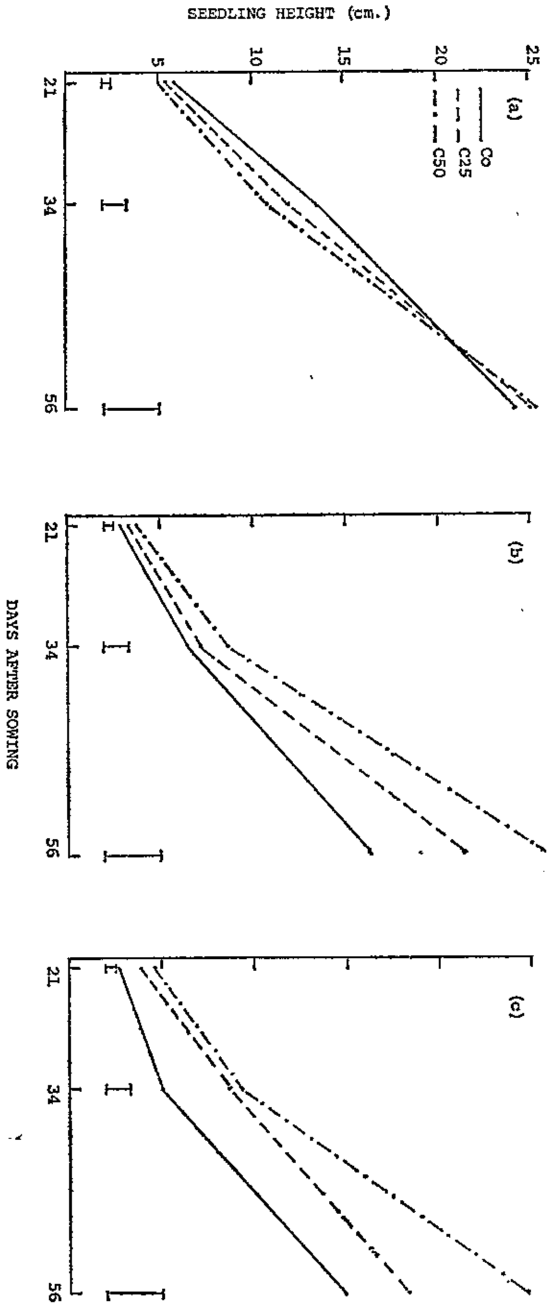

FIGURE 2

The effect of activated charcoal in alleviating the effects of pre-emergence herbicides on the seedling growth of leucaena.

Rates were C_0—nil, C_{25}—25 kg/ha, C_{50}—50 kg/ha.

Herbicides were (a)—nil, (b) 2,4-D and (c) Dacthal.

Vertical bars are the LSD values at 5%.

TABLE 5

The effect of (a) herbicide and (b) activated charcoal on the shoot weights of Leucaena seedlings 61 days after sowing.

	(a)	
Herbicide treatment	Yield g/pot (mean over 3 charcoal rates)	
0	4·39	(0·730)*
2, 4-D	2·81	(0·563)
Dacthal	2·85	(0·557)
LSD 5%		(0·088)
1%		(0·019)

	(b)	
Charcoal rate kg/ha	Yield g/pot (mean over herbicide treatments)	
0	2·88	(0·550)*
25	3·36	(0·625)
50	3·80	(0·676)
LSD 5%		(0·088)
1%		(0·119)

*Transformed means (log χ + 1)

Root weights

Herbicides reduced root weights ($P < 0.001$) and the herbicide × charcoal interaction was also significant ($P < 0.05$). In the absence of herbicide, increasing charcoal rate depressed root weights whereas in the presence of each herbicide increasing charcoal rate resulted in increased root weights (Table 6).

TABLE 6

The effect of herbicide and charcoal combinations on the root weights of Leucaena seedlings 61 days after sowing (g/pot)

Herbicide	Charcoal Rate kg/ha						Mean	
	0		25		50			
0	2·07	(0·487)*	1·63	(0·418)	1·45	(0·385)	1·72	(0·430)
2, 4-D	0·73	(0·214)	0·83	(0·254)	1·13	(0·319)	0·90	(0·263)
Dacthal	0·58	(0·193)	1·09	(0·311)	1·10	(0·320)	0·92	(0·275)

LSD Herbicide means 5% (0·066) 1% (0·089).
LSD Pairs of Herbicide × Charcoal means 5% (0·114) 1% (0·154).
* Transformed means (log χ + 1).

Total plant weight

In the absence of charcoal, the herbicides reduced total plant weight to 46% and 37% of the control for the 2,4-D and Dacthal treatments respectively (Table 7).

TABLE 7

The effect of herbicides and of activated charcoal on the total (shoot and root) weights of Leucaena seedlings 61 days after sowing.

Herbicide	Charcoal rate kg/ha						Mean	
	0		25		50			
0	6·56	(0·878)*	5·68	(0·823)	6·08	(0·847)	6·11	(0·850)
2, 4-D	3·01	(0·548)	3·80	(0·674)	4·31	(0·721)	3·70	(0·647)
Dacthal	2·46	(0·512)	4·16	(0·680)	4·69	(0·752)	3·77	(0·648)
Mean	4·01	(0·646)	4·54	(0·726)	5·03	(0·774)		

LSD Herbicide and charcoal means 5% (0·099) 1% (0·133).
LSD Pairs of Herbicide × Charcoal means 5% (0·171) 1% (0·230).
* Transformed means (log χ + 1).

Charcoal reduced total yield in the absence of herbicide but alleviated the yield depression associated with herbicide treatment. Overall the linear correlation of yield on charcoal rate was $r = +0.999^{***}$ indicating a pronounced alleviation from the toxic effects of the herbicides by the use of charcoal.

DISCUSSION

The slow seedling growth of leucaena relative to crowsfoot has been clearly demonstrated in Experiments 1 and 3. As a result, the associated grass is rapidly able to shade the leucaena seedlings. The large difference in seedling growth occurred despite the very large difference in seed size between leucaena (52.3 ± 0.78 mg) and crowsfoot (0.40 ± 0.003 mg); a situation which has been noted between other tropical legumes and tropical grasses, and which is associated with higher net assimilation rates resulting from high photosynthetic rates found in tropical grasses (Ludlow and Wilson 1972). The height measurements indicate that leucaena has limited capacity to grow taller to avoid light competition and hence is at a serious disadvantage in the presence of weed growth. The drastic reduction in leucaena growth, even with a weed density of one grass seedling to one leucaena seedling, is indicative of strong competition; of which competition for light would form but a part. The much smaller effect of increasing grass density from a ratio of 1:1 to a ratio of 8:1 is probably due to the fact that at a ratio of 1:1 grass yield was already 80% of that at the 8:1 ratio, and suppression of leucaena was shown to be more closely related to grass yield than to grass density.

The plastic nature of crowsfoot is reflected in the ability of plants at low density to compensate by producing more tillers. Mean tiller number per plant at densities of 32, 16, 8 and 4 plants per pot were: 2.5, 4.2, 6.2 and 11.7. From the practical point of view this may indicate that unless very substantial reductions in grass weed populations are effected by herbicide treatment then little benefit in terms of leucaena growth will accrue since the remaining grass plants will grow larger and compensate for the reduced population.

The reduction in weed resulting from the use of herbicide must be measured against the reduction in leucaena caused by the herbicide. In these experiments, and the results from field trials (unpublished data), the herbicides resulted in depressed growth of leucaena, especially at levels necessary to control weeds effectively in the field (8.5 kg a.i. Dacthal/ha and 1.0 kg/ha a.i. of Treflan) (Langford 1974). 2,4-D was the only herbicide to seriously influence seedling emergence—causing both a delay and an overall reduction. Generally the effects of the herbicides only became apparent from two to three weeks after emergence. With Dacthal the major effect was the death of the terminal portion of the tap root. Under conditions of drought stress such damage would result in greater reduction in yield than that measured in this well watered experiment.

The results for Dacthal are in contrast to those obtained in the field in Hawaii by Nicholls, Plucknett and Burrill (1973). They reported no adverse effect of pre-emergent Chlorthal (= Dacthal) at rates of 4.48 and 8.96 kg/ha a.i. on leucaena seedlings four weeks after sowing, but no yield data for the leucaena was obtained.

Activated charcoal clearly reduced the adverse effects of both 2,4-D and Dacthal applied as pre-emergent sprays. In particular the root damage evident at high rates of Dacthal was overcome. There is little doubt that the effects noted were due to the adsorption of part of the sprays by the activated charcoal as reported in other studies (Linscott and Hagin 1967, Cowan 1970).

The adverse effects of charcoal alone were unexpected. Plant height and particularly root weights were reduced with increasing charcoal rate in the absence of herbicides. The possibility arises that either the charcoal adsorbed nutrients which were required by the leucaena seedlings or that the charcoal contained toxic substances. An analysis of the charcoal indicated zero or only small amounts of heavy metals but it did contain 11 ppm of boron and 29 ppm of manganese. It is doubtful, however, that such concentrations would have adversely affected leucaena growth. The effect of the charcoal on top growth appeared to be transient but the effect was much more pronounced on the root system.

The effects of these and other herbicides, with and without activated charcoal, for control of weeds in the field are being studied and the results will be reported in a subsequent paper.

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REFERENCES

COOKSLEY, D. G. (1974)—Growing and grazing Leucaena. *Queensland Agricultural Journal* **100**: 258-261.

COWAN, R. (1970)—Factors in influencing the production of high quality forage crop seed. Proceedings of the XI International Grassland Congress, Surfers Paradise, Australia 305-308.

GRAY, S. G. (1962)—Hot water seed treatment for *Leucaena glauca* (L) Benth. *Australian Journal of Experimental Agriculture and Animal Husbandry* **2**: 179-80.

GRAY, S. G. (1968)—A review of research on *Leucaena leucocephala*. *Tropical Grasslands* **2**: 19-30.

HILL, G. D. (1971)—*Leucaena leucocephala* for pastures in the tropics. *Herbage Abstracts* **41.**

HUTTON, E. M., and GRAY, S. G. (1959)—Problems of adapting *Leucaena glauca* Benth. as a forage for the Australian tropics. *Empire Journal of Experimental Agriculture* **27**: 187-96.

LANGFORD, S. (1974)—Relative efficiency of a number of herbicides in peanuts in the Burnett area of Queensland. *Queensland Journal of Agricultural and Animal Sciences* **31**: 159-164.

LINSCOTT, D. I., and HAGIN, R. D. (1967)—Protecting alfalfa seedlings from a triazine with activated charcoal. *Weeds* **15**: 304-306.

LUDLOW, M. M., and WILSON, G. L. (1972)—Photosynthesis of tropical pasture plants IV. Basis and consequences of differences between grasses and legumes. *Australian Journal of Biological Sciences* **25**: 1133-45.

NICHOLLS, D. F., PLUCKNETT, D. L., and BURRILL, L. C. (1973)—Effect of herbicides on improved tropical pasture legumes and grasses. Proceedings of the Fourth Asian-Pacific Weed Science Society Conference, Rotorua, New Zealand pp. 55-65.

SHAW, N. H. (1965)—Weed control in *Leucaena leucocephala*. C.S.I.R.O., Division of Tropical Pastures Annual Report 1964-65 p. 42.

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