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Effects of planting depth and sowing methods on emergence of leucaena (*Leucaena leucocephala* cv. Peru) seed in a light medium clay

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Summary

In a series of field plantings carried out over 4 years at 'Brian Pastures' Pasture Research Station, Gayndah, 5 to 6 cm was determined to be the optimum sowing depth for leucaena (*Leucaena leucocephala*) into moist, well cultivated seed beds. When follow up rain fell, shallow sown seed also emerged in this black basalt derived soil and the optimum sowing depth was reduced to 3 cm. However, weeds also emerged after this follow up rain that suppressed leucaena growth. Leucaena sown before the end of December was better able to cope with frost in the following winter and had higher yields than leucaena sown in February.

1. INTRODUCTION

Leucaena has potential to provide a high quality protein supplement for cattle grazing native forest blue grass (*Bothriochloa bladhii*)-spear grass (*Heteropogon contortus*) pastures in south-east Queensland. However, establishment difficulties have been encountered in heavy basalt soils of the Central Burnett. Scattini and Addison (personal communication) had difficulties in getting leucaena to emerge on 'Brian Pastures'. Also, Shaw (1965) and Cooksley (1974a) found that weed competition significantly retarded leucaena dry matter production in the first season to approximately 1% of weeded control.

The objective of the experiments reported in this paper was to examine possible methods of improving the emergence potential of leucaena seedlings. Effects of sowing depth, time of sowing, soil moisture status at sowing, seed pelleting and seed bed compaction on emergence of leucaena (*Leucaena leucocephala* cv. Peru) were studied. These were supplementary to earlier experiments (Cooksley 1974b).

2. MATERIALS AND METHODS

General

Between 1970 and 1974, seven trials were conducted on 'Brian Pastures' Pasture Research Station, Gayndah: latitude 25° 39′ S; longitude 151° 47′ E; altitude 130.6 m; mean annual rainfall 734 mm on Ug 5.12 soil (Northcote 1971) derived from basalt.

Seed was treated in hot water (80°C) for 4 min in Trial 1, 2 min in Trials 2 to 5, and 6 min in Trials 6 and 7. With the exception of Trial 1, seed was then soaked in water at room temperature for 2 days and dried to its original weight before sowing. Seed was pressed into soil by hand and then covered for Trials 1 to 3. Remaining trials were sown using a cone planter (Fletcher 1970) and seed was covered by cultivating tines. Spray irrigation was used to wet soil to a depth greater than 15 cm.

Leucaena seed was inoculated in Trial 1 only. This was the only trial where leucaena was grown for more than 6 weeks thus allowing the rhizobium to play a substantial role in nutrient supply to leucaena.

Initial emergence counts were made before later falls of rain or irrigation promoted further seedling emergence. Emergence counts were also made at the conclusion of each trial.

Analysis of variance was used to test effects of treatments; treatment means were compared using protected l.s.d. method at 5% level of significance. The relationship of percentage emergence to sowing depth was examined by fitting a quadratic polynomial regression equation of the form $y = a + bx + cx^2$, where y = percentage emergence and x = sowing depth (cm); optimum sowing depth was estimated as $-b/2c$.

Trial 1

Using results from a glasshouse pot trial, seed was sown by hand at depths of 1, 3 and 4 cm in the field. Trial design was three replicates of a 3 × 3 factorial in a randomized block (RB) layout. The seed was sown into moist soil on 25 September 1970, 1 December 1970 and 12 February 1971. This trial was spray irrigated if the median fortnightly rainfall was not received. The trial area was kept weed free.

Plots were harvested on 7 May 1971 (datum area 7.6 × 1.85 m). Pods, leaves and stems up to a diameter of 6 mm were harvested, dried and weighed. Some plants were excavated to examine root growth and extent of nodulation. Other plants were examined for frost damage on 17 August 1971.

Trial 2

This trial examined the viability of leucaena seed that was sown and left in dry soil for 3 weeks and compared to similar seed sown into a moist seed bed. Sowing depths were 1, 2, 3 and 5 cm and half the seed was lime pelleted. Design was a 2 × 2 × 4 factorial with three replicates in a RB layout.

The soil moisture status treatment was achieved by sowing half of the seed by hand on 9 to 10 November 1971 into dry soil. The lime pellet was 10% by weight of the seed. The soil was wet by irrigation on 1 December 1971 and the remaining seed sown on 2 to 3 December 1971. Rain fell on 15 December 1971 (39 mm) and 25 to 28 December 1971 (40 mm). Frequent leucaena counts were made until the trial was terminated on 12 January 1972.

Trial 3

Trial 3 was an extension of Trial 2 including sowing depths of 4, 6, 7, 8 and 9 cm. The trial was an 8 × 2 factorial with three replicates in a RB layout. Seed was hand sown on 6 March 1973 into dry soil, and on 9 March 1973 into moist soil that was irrigated on 7 March 1973. During the trial period, no rain fell so plots were irrigated on 20 March 1973. Datum plots (1.0 × 1.0 m) were harvested and plants counted on 4 and 6 April 1973.

Trials 4 and 5

In these two trials leucaena seed was sown into moist soil at depths of 3, 4, 5, 6 and 7 cm using a cone planter (Fletcher 1970) and half of the plots rolled with a rubber tyre roller. In Trial 4, rain fell on 10 October 1973 (11 mm). No rain fell during Trial 5.

Design of each trial was 5 × 2 factorial with five replicates in RB layouts. They were sown on 2 to 3 October 1973 and 15 November 1973. Datum areas harvested from plots were

2.0 × 1.24 m. Plots were harvested on 24 October 1973 (Trial 4) and 6 December 1973 (Trial 5).

Trials 6 and 7

Trials 6 and 7 examined effects of sowing leucaena down to depths of 10 cm and 12 cm, respectively. In Trial 6, seed was sown at depths of 0, 2, 4, 6, 8 and 10 cm into dry soil and irrigated on 4 October 1974. Rain fell on 6 October 1974 (34 mm). In Trial 7, seed was sown at depths of 0, 2, 4, 6, 8, 10 and 12 cm into dry soil on 4 November 1974 and irrigated the next day. Rain fell on 14 November 1974 (27 mm) and 18 November 1974 (44 mm).

A RB layout was used with six replicates in these trials. Datum areas in Trial 6 were 2.0 × 1.24 m and were harvested on 29 October 1974. In Trial 7, datum areas were 2.0 × 1.07 m and were harvested on 27 November 1974.

3. RESULTS

In Tables 1 and 2, results from treatments were transformed to a percentage of the treatment in each trial with a maximum number of plants.

Effect of sowing depth

Before follow up rain or irrigation germinated further seed

An optimum sowing depth of 5.0 cm was calculated from the fitted equation $y^* = -20.2 + 26.5x\ (\pm\ 4.0) - 2.63x^2\ (\pm\ 0.41)$ ($100\ R^2 = 88.8\%$, $P < 0.05$) for seed sown into dry soil by hand and irrigated. Optimum sowing depth for seeds sown into moist soil was 6.3 cm (calculated from the fitted equation $y^* = -13.6 + 10.4x\ (\pm\ 3.1) - 0.83x^2\ (\pm\ 0.33)$ ($100\ R^2 = 57.2\%$, $P > 0.05$) but numbers of plants to emerge were less than from the dry soil and irrigated treatments. The points were pooled from Trials 2 and 3 for the equations.

The optimum sowing depth for seed sown with the cone planter before follow up rain was 6.8 cm as estimated from the fitted equation $y^* = 3.53 + 5.73x\ (\pm\ 1.2) - 0.42x^2\ (\pm\ 0.095)$ ($100\ R^2 = 61.5\%$, $P < 0.05$). These points were pooled from Trials 4, 5 and 7 for the equations.

Table 1. Initial emergence and emergence from planting depths excluding Trials 1 and 6

Trial	Soil moisture status at planting	Maximum emergence (%) before later rain or irrigation	Number of growing days*	Emergence as a percentage of the maximum emergence											
				Planting depth (cm)											
				0	1	2	3	4	5	6	7	8	9	10	12
2	Dry†	48.8	14		0*a*	17*b*	64*c*		100*d*						
	Moist	35.2	14		0*a*	3*ab*	14*b*		100*c*						
	Mean	41.9			0*a*	10*b*	41*c*		100*b*						
3	Dry†	51.3	14			76*f*	94*f*	100*f*	91*f*	66*def*	50*cde*	44*cde*	29*abc*		
	Moist	18.7	14			0*a*	0*a*	18*ab*	64*abc*	100*bcd*	57*abc*	57*abc*	46*abc*		
	Mean	29.3				65	83	93	100	90	61	57	40		
4	Moist	26.7	14				61	92	92	100	97				
5	Moist	14.1	14				83	87	87	100	81				
7	Dry	36.3	16	7*a*		32*ab*		92*c*		68*c*		100*d*		39*b*	36*b*

*Measured from the time seed contacts moist soil.
†Emergence from dry sowings significantly greater ($P < 0.05$) than those from moist sowings.
Means in the same row differ significantly ($P < 0.05$) from each other if they have no following letter in common.
Inverse sine transformations were used in the data analysis. Back transformed means have been converted to a percentage of the maximum emergence.

*y = percentage emergence, x = depth (cm).

Emergence varied between trials after 2 weeks. Seed sown into dry soil and then irrigated had a significantly ($P < 0.05$) higher emergence percentage than the seed sown into moist soil (Trials 2 and 3). Highest percentage emergence occurred at 5 cm (49%) and 4 cm (51%) in Trials 2 and 3, respectively. Seed was sown into moist soil in Trials 4 and 5 and highest percentage emergence occurred in 6 cm sowing depth treatment: 27 and 14%, respectively. Seed was sown into dry soil and irrigated in Trial 7 and significantly ($P < 0.05$) highest emergence (36%) occurred at 8 cm (Table 1).

After follow up rain or irrigation germinated further seed

Final optimum sowing depth of 3.8 cm was calculated from the fitted equation $y = 31.0 + 14.2x\ (\pm\ 3.5) - 1.88x^2\ (\pm\ 0.36)$ ($100\ R^2 = 74.4\%$, $P < 0.05$) for seed sown into dry soil by hand that received two or more wettings by rain or irrigation. Fewer plants emerged in treatments where seed was sown into moist soil and received later falls of rain or irrigation. Optimum sowing depth of 3.0 cm was calculated from the fitted equation $y = 56.2 + 10.3x\ (\pm\ 3.4) - 1.7x^2\ (\pm\ 0.35)$ ($100\ R^2 = 80.1\%$, $P < 0.05$) for these. Points were pooled from Trials 2 and 3 for equations.

Optimum sowing depth for seed sown with a cone planter after later falls of rain was 5.2 cm as calculated from the fitted equation $y = 21.58 + 4.74x\ (\pm\ 1.07) - 0.459x^2\ (\pm\ 0.09)$ ($100\ R^2 = 84.2\%$, $P < 0.05$). Points were pooled from Trials 4, 6 and 7 for this equation.

Final emergence numbers varied between trials. Seed sown into moist soil that received rain or irrigation had a higher emergence level than seed sown into dry soil (Trial 2 ($P < 0.05$) and Trial 3 ($P > 0.05$)). In Trials 2 and 3, most plants emerged from treatments where seed was sown 3 cm deep (77 and 76%, respectively). Final emergence was 35% (Trial 4) when seed was sown 7 cm deep into moist soil and further plants emerged after rain. Seed was sown into dry soil and irrigated in Trials 6 and 7. In Trial 6, emergence was greatest from a depth of 6 cm (35% emergence) with no significant difference from depths of 0 to 6 cm. Two days after initial irrigation, 34 mm of rain was recorded. In Trial 7, rain fell on two occasions (27 and 44 mm) which increased numbers of plants to emerge from shallow sown treatments to a maximum of 46% at 4 cm sowing depth (Table 2).

Table 2. Final emergence and emergence from sowing depth. Trials 1 to 7

Trial	Soil moisture status at planting	Maximum final emergence (%)	Number of growing days*	Emergence as a percentage of the maximum emergence											
				Planting depth (cm)											
				0	1	2	3	4	5	6	7	8	9	10	12
1	Moist	76.6	84–224		95		100	95							
2	Dry†	60.4	40		52	100	98		88						
	Moist	77.3	42		83	93	100		97						
	Mean	68.3			70*a*	97*b*	100*b*		94*b*						
3	Dry‡	69.3	28			76	100	91	73	57	41	37	24		
	Moist	76.0	28			75	100	86	73	83	33	28	20		
	Mean	72.7				75*c*	100*d*	89*d*	73*c*	71*c*	37*b*	32*ab*	22*a*		
4	Moist	35.0	21				61	85	90	96	100				
5	Moist	14.1	21				83	87	87	100	81				
6	Dry	35.0	25	89*b*		77*ab*		73*ab*		100*b*		52*a*		54*a*	
7	Dry	46.4	22	50*ab*		70*ab*		100*d*		74*bc*		94*cd*		39*a*	32*a*

*Measured from the time seed contacts moist soil.
†Emergence from moist sowings greater ($P < 0.05$) than dry sowings.
‡Emergence from moist sowings not greater ($P > 0.05$) than dry sowings.
Means in the same row differ significantly ($P < 0.05$) from each other if they have no following letter in common.
Inverse sine transformations were used in data analysis. Back transformed means have been converted to a percentage of the maximum emergence.

Effect of sowing time

Of the three sowing times and three sowing depths in Trial 1, most rapid emergence was from seed sown 4 cm deep in December. September sowing treatments had the lowest ($P < 0.05$) total emergence but highest dry matter yield at harvest (Table 3). Sowing depth had no effect ($P > 0.05$) on final number of plants to emerge (Table 2). Only plants from the February sowing were killed by frost.

Seed sown into dry soil and left for 3 weeks had a 29% lower final emergence than seed sown into moist soil (Trial 2; Table 2).

Effect of pelleting

Pelleting had no effect ($P > 0.05$) on the time taken or total number of seeds to emerge (Trial 2).

Effect of rolling

Number of leucaena plants to emerge during or at the end of the trial was unaffected ($P > 0.05$) by rolling (Trials 4 and 5).

Yield of leucaena

Leucaena yield per plant declined with increasing sowing depth from 33 mg (4 cm) to 25 mg (7 cm) ($P < 0.05$) after 21 days (Trial 4). Seed sown into dry soil (Trial 3) had a mean time to emergence of 10.6 days and produced seedlings weighing 118 mg. This differed significantly ($P < 0.05$) from moist sowings (Trial 3) (16.9 days and 47 mg respectively).

There was a significant ($P < 0.05$) effect of time of sowing on leucaena yield (harvested May 1971). February sown leucaena yielded much less than leucaena sown at either of the other two times while September sown leucaena outyielded the December sown leucaena (Table 3).

Table 3. Number of days to emergence, total emergence, dry matter yield of available leucaena and number of plants killed by frost for three times of sowing (Trial 1)

	Sowing date			
	25 Sep 70	1 Dec 70	12 Feb 71	l.s.d. $P = 0.05$
Mean time to emergence (days)	32.4*c*	8.9*a*	12.0*b*	2.2
Total emergence at 7 May 71 (percentage of seed sown)	57.9*a*	83.3*b*	81.8*b*	7.1
Available dry matter* kg ha^{-1}, 7 May 71	3637	841	7	
Percentage of plants* killed to 27 Aug 71 by earlier frosting	0.0	0.0	11.5	

*Differences obviously significant, so statical analysis not undertaken.
Means in the same row differ significantly ($P < 0.05$) from each other if they have no following letter in common.

4. DISCUSSION

Results from an earlier glasshouse trial by the author and those reported by Jones (1970) suggest that 2.5 cm was optimum sowing depth for leucaena. Although there was considerable variation in final emergence in the series of field trials in this paper, results indicate that leucaena will tolerate a range of planting depths from 2 to 8 cm (Table 2). This permits a reasonable margin for operator error when using planting machinery.

Irrigation or rain following planting can promote germination of more seed, especially shallow sown seed. This was shown clearly in Trial 3 for seed sown into moist soil. Maximum emergence was 19% (at 6 cm) before irrigation and 76% (at 3 cm) after the irrigation.

However, rain following planting will germinate not only leucaena seed, but also weed seed. These weeds, if not controlled, will reduce leucaena growth (Cooksley 1974b). Weeds can be reduced by cultivation but they will still suppress leucaena's growth (Shaw 1965). Sowing into moist soil with no follow up rain results in fewer plants emerging but cultivating soil when sowing also helps control weeds.

Seed sown by hand in Trials 1 to 3 had a higher percent final emergence than seed sown with the cone planter. Rolling seed beds after planting, or lime pelleting seed, did not improve emergence.

However, seed sown and left in dry soil for 3 weeks before germination had a lower final emergence than seed sown into moist soil in Trial 2. In Trial 3, similar final emergences were recorded when seed was sown into moist soil or left for only 1 day in dry soil before being irrigated. Hence seed mortalities will occur if seed is sown to dry soil to await rain.

Planting later than January can result in loss of plants caused by frosting in the following winter. Similarly, highest leucaena yield per unit area was obtained from September sown plants even though a smaller population was achieved. Also, September sown leucaena plants recovered faster after winter than those from December or February sowings (Trial 1).

Follow up rain increased numbers of leucaena to emerge but also caused some mortalities. Root expansion was prevented if the soil set around the root. Also, with increasing sowing depth the cotyledons grew closer to the soil surface and were covered by lateral soil erosion.

From this work, it would appear that for the black self-mulching basaltic soils in the Burnett, placement of seed at 5 to 6 cm into a well prepared seed bed following suitable rain in spring–early summer should give an adequate leucaena population. If follow up rain occurs and weeds germinate, an appropriate weed control programme would need to be implemented.

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