PRODUCTIVITY OF LEUCAENA LEUCOCEPHALA IN THE WET TROPICS OF NORTH QUEENSLAND

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ABSTRACT

Results are reported of two experiments examining the productivity of leucaena (Leucaena leucocephala) *in the wet tropics of North Queensland. In the first experiment leucaena cvv. Cunningham and Peru were grown for* 2 *years in rows spaced at* 0.3 *or* 0.9 *m and harvested at* 2 *or* 4 *month intervals or to a set regrowth level. Cutting height averaged* 10 *cm. Cultivar differences were not significant. Highest yields of leaf and stem and lowest nitrogen contents were obtained with* 4 *monthly cuts. The narrow spacing increased yields in the second year. Yields over all treatments averaged* 20 *t total DM* ha^{-1} yr^{-1} *and* 10 *t leaf DM* ha^{-1} yr^{-1} *with nitrogen content of* 2.4% *and* 3.9% *respectively.*

In the second experiment hedges of leucaena cv. Peru *were spaced* 2.44 *m apart and were harvested at monthly intervals for* 2 *years. Hedges had been formed with* 2 *or* 4 *rows of plants initially pruned to* 10 *or* 30 *cm. Yields and nitrogen content were unaffected by number of rows per hedge or by pruning height. Annual dry matter yield averaged* 7 *t* ha^{-1} *with an average nitrogen content of* 3.75%. *Variation between individual harvests was significantly associated with degree days received in both experiments, the association being positive for yield and negative for nitrogen content.*

INTRODUCTION

There is growing interest in the potential of leucaena (*Leucaena leucocephala*) as a forage for grazing or mechanical harvesting, and as a fuel, pulp, or timber crop for the tropics both in Australia (e.g. CSIRO Division of Tropical Crops and Pastures 1977) and overseas. This interest was recently manifested in a report by the International Consultation on Ipil-Ipil (Philippine Council for Agricultural Resources Research and U.S. National Academy of Sciences 1977). Leucaena has been studied at several sites in coastal Queensland (Cooksley 1974, Hutton and Beattie 1976) and in the monsoon environment of north west Australia (Blunt and Jones 1977) but as yet no reports of the productivity of leucaena in the wet tropics of north Queensland have been published. The following paper describes two experiments designed to assess productivity of leucaena under cultural systems suited to mechanical harvesting, the object being the production of mechanically harvested protein-rich animal feed. However, the results provide a guide to leucaena's productivity as a browse crop in north Queensland's wet belt.

MATERIALS AND METHODS

Experiment 1

The experiment was sited at South Johnstone Research Station (17°36′ S, 146°00′ E) on a deep mixed alluvial soil with basaltic influence, of Northcote's (1965) principal profile form Um 6.34. Surface pH varied from 5.8 to 6.3. Details of soil and climate are given by Teitzel and Bruce (1971). Mean climatic data for the experimental period are given in Figure 1.

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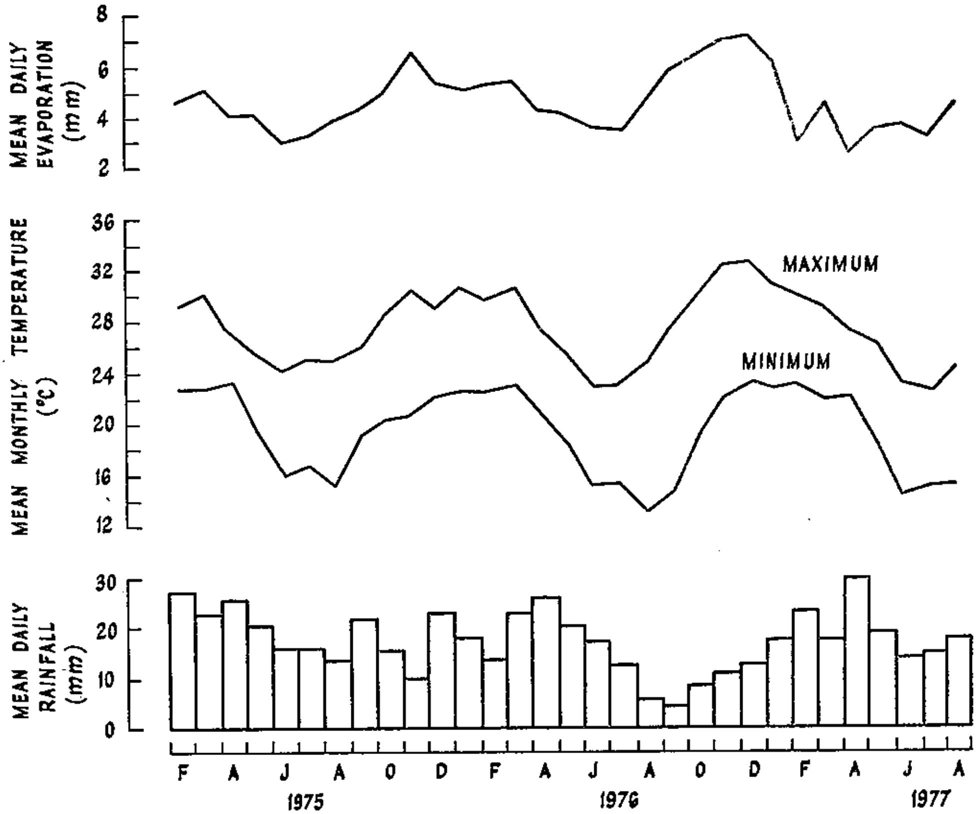

FIGURE 1
Monthly climatic data (Experiment 1).

The experimental design was a factorial within a randomized complete block of two replicates. Treatments were:

Cultivar (2)	×	*Harvest Interval* (3)	×	*Spacing* (2)
Peru		2 months		30 cm
Cunningham		4 months		90 cm
		Set regrowth level (1.0–1.5 m)		

Because of heterogeneity of variances between the years comparisons of means between years was carried out by the method of Snedecor and Cochran (1967) for unequal variances.

Fertilizer was broadcast annually at a rate of 500 kg agricultural lime ha^{-1}, 25 kg P ha^{-1} as superphosphate and 50 kg K ha^{-1} as KCl. Plot dimensions were 9 m × 2.7 m. Seed was hot water treated at 80°C for 2 min. A mixture of *Rhizobium* strains NGR8 and CB81 was applied as a wet slurry to seeds before planting. Seed was drill sown at the respective interrow spacings to 1 cm depth, 2 seeds every 5 cm. Planting was completed on January 15, 1975. A clearing cut was given on May 8, 1975 and the 2 year experiment commenced from this date. Cutting height was initially at 5 cm but this increased with time to 15 cm due to the development of a dense woody base. Harvests were taken from the centre 5 m × 0.9 m. Total fresh weight was recorded and a weighed subsample was partitioned into leaf (i.e. leaf plus tender stem) and woody stems and then dried and weighed. Nitrogen analysis was carried out on leaf and stem by the Kjeldahl method.

Experiment 2

The purpose of this experiment was to examine the productivity of leucaena under mechanized tea culture methods, frequent harvesting intervals hopefully providing a high quality product. The experiment was sited at the Nerada Tea Estates, 15 km west of South Johnstone, on a basaltic soil of Northcote's (1965) principle profile form Gn 3.11. Details of soils and climate may be found in Teitzel and Bruce (1971) and Isbell *et al.* (1976).

Treatments were arranged in a factorial design within a randomized complete block replicated twice. Treatments were:

Rows/hedge	×	*Pruning height*
2		10 cm
4		30 cm

Plots consisted of 3 hedges, 13 m long. One meter wide black polythene strips were laid out to give a 2.44 m spacing between hedges. Seeds of cv. Peru were sown into holes in the polythene at 23 cm intra and interrow spacing. Sowing was completed on October 22, 1974. The pruning treatments were started 109 days after sowing. A clearing cut to establish horizontal tops on the hedges (a "cutting table") at 1.2 m was given at 164 days after sowing. Harvests were taken from the centre 10 m of the top of the central hedge at approximately monthly intervals. Sides of hedges were not harvested. Fertilizer rates and seed treatment were similar to Experiment 1.

RESULTS

Experiment 1

Establishment of leucaena required frequent hand weeding for the first three months. Once established the plants grew vigorously and were not troubled by pests or diseases. Heavy flooding after a harvest in the 1976–77 wet season did not appear to affect leucaena regrowth.

Cultivars did not differ significantly in dry matter yields in either year (Table 1). In the first year Cunningham produced a higher nitrogen yield than Peru and had higher nitrogen content in total and leaf dry matter but these cultivar differences were not carried through into the second year. In both years yield attributes tended to be higher and nitrogen contents lower with the 4 month than the 2 month cut. Narrow (30 cm) row spacings increased total and leaf dry matter nitrogen content in the first year. In the second year the 30 cm row spacing produced higher dry matter yields but did not influence nitrogen content. No significant interactions were recorded in either year. Yields and nitrogen concentrations were usually lower in the second year.

The association of climatic factors with yield and nitrogen content over the two year period for all treatments is shown in Table 2. The length of the regrowth period, degree days and evaporation (as an estimate of radiant energy) were positively correlated with yield and negatively correlated with nitrogen content. Total rainfall was correlated positively with yield and negatively with nitrogen content in some instances.

Experiment 2

The polythene film controlled weeds and allowed rapid establishment and growth, plant height averaging 150 cm 109 days after planting. Pest and disease control was not necessary.

Hedge shaping treatments (number of rows, pruning height) had no significant effect on any of the attributes measured nor were differences between years significant. Mean yields were:

Total DM yield (kg ha^{-1})	N content of dry matter (%)	Total nitrogen yield (kg ha^{-1})
6845	3.72	260

TABLE 1

Main effects of treatments on annual dry matter and nitrogen yields and on nitrogen content. (*Experiment* 1)

Treatment	Total dry matter yield t ha⁻¹	Leaf dry matter yield t ha⁻¹	Stem dry matter yield t ha⁻¹	Total nitrogen yield kg N ha⁻¹	Leaf nitrogen yield kg N ha⁻¹	Stem nitrogen yield kg N ha⁻¹	TDM nitrogen content %	Leaf nitrogen content %	Stem nitrogen content %
					YEAR 1				
Variety									
cv. Peru	21.0	9.3	11.7	500†	383†	118†	2.5	4.1†	1.0†
cv. Cunningham	22.2	10.1	12.0	561†	428	133†	2.6	4.2†	1.1†
S.E. ±	0.93 n.s.	0.52 n.s.	0.54 n.s.	24.8*	21.5 n.s.	8.2 n.s.	0.03**	0.05*	0.04 n.s.
Harvest Interval									
2-month	17.0	9.2	7.8	472†	393†	79†	2.8	4.3†	1.0†
4-month	28.9	10.3†	18.6	613	414	200†	2.1†	4.0†	1.1†
Set level	18.8	9.6	9.2†	507†	409†	98†	2.7	4.3†	1.1†
S.E. ±	1.14**	0.64 n.s.	0.66**	30.4**	26.4 n.s.	10.0**	0.04**	0.07**	0.05 n.s.
Row spacing									
30 cm.	21.6	9.6†	12.0	541	410	131†	2.6†	4.3†	1.1†
90 cm.	21.6†	9.9†	11.7†	520†	401†	120†	2.5	4.1†	1.0†
S.E. ±	0.93 n.s.	0.52 n.s.	0.54 n.s.	24.8 n.s.	21.5 n.s.	8.2 n.s.	0.03**	0.05**	0.04 n.s.
					YEAR 2				
Variety									
cv. Peru	18.8	9.0	9.7	413†	332†	81†	2.3	3.7†	0.9†
cv. Cunningham	21.4	10.5	10.9	471†	381	89†	2.4	3.8†	0.9†
S.E. ±	2.45 n.s.	1.03 n.s.	1.48 n.s.	47.4 n.s.	39.2 n.s.	8.6 n.s.	0.11 n.s.	0.15 n.s.	0.04 n.s.
Harvest Interval									
2-month	13.7	8.0	5.7	363†	311†	52†	2.6	3.8†	0.9†
4-month	32.0	12.9†	19.1	581	435	146†	1.9†	3.4†	0.8†
Set level	14.5	8.4	6.1†	381†	323†	58†	2.7	3.9†	1.0†
S.E. ±	3.0**	1.26**	1.81**	58.1**	48.0*	10.6**	0.14**	0.19 n.s.	0.05*
Row spacing									
30 cm.	23.1	11.1†	12.1	497	397	100†	2.3†	3.7†	0.9†
90 cm.	17.0†	8.5†	8.6†	386†	315†	71†	2.5	3.8†	0.9†
S.E. ±	2.45*	1.03*	1.48*	47.4*	39.2 n.s.	8.6**	0.11 n.s.	0.15 n.s.	0.04 n.s.

**Significant at $P<0.01$
*Significant at $P<0.05$

†Means are significantly different ($P<0.05$) between years
n.s. Not Significant.

TABLE 2

Linear correlations of leucaena yields and nitrogen content with growing period and climatic factors (Experiment 1)

Attributes	Growing period (days)	Degree days (°C)	Total rainfall (mm)	Total evaporation (mm)	Attributes, range of values
cv. Peru					
Total dry matter yield (t ha^{-1})	0.738**	0.878**	0.293*	0.780**	0.30–13.33
Leaf yield (t DM ha^{-1})	0.728**	0.807**	0.164	0.783**	0.30– 4.71
Stem yield (t DM ha^{-1})	0.712**	0.872**	0.336*	0.746**	0–10.06
N content, TDM (%)	−0.503**	−0.685**	−0.431**	−0.617**	1.50– 3.95
N content, Leaf (%)	−0.314*	−0.293*	−0.140	−0.270	3.05– 4.78
N content, Stem (%)	−0.134	−0.278*	−0.265	−0.292*	0.60– 2.05
cv. Cunningham					
Total dry matter yield (t ha^{-1})	0.696**	0.839**	0.193	0.815**	0.25–20.26
Leaf yield (t DM ha^{-1})	0.678**	0.783**	0.105	0.819**	0.25– 7.83
Stem yield (t DM ha^{-1})	0.686**	0.845**	0.235	0.791**	0–12.43
N content, TDM (%)	−0.489**	−0.671**	−0.380**	−0.621**	1.41– 4.21
N content, Leaf (%)	−0.433**	−0.454**	−0.198	−0.400**	2.74– 5.00
N content, Stem (%)	−0.042	−0.221	−0.167	−0.344**	0.56– 1.64
Age and climatic factors, range of values	27–132	570–3205	40–4030	130–799	

*Significant at P<0.05, **Significant at P<0.01.

Nitrogen content was lower than expected, although some harvests (Figure 2) did contain high nitrogen contents, nitrogen content being inversely associated with yield ($r = -0.680$, $P < 0.01$). Harvest yields tended to be greatest in the summer months. As climatic data were not available for the site, temperature data from the Joint Tropical Research Unit 12 km distant was used to calculate the relationship of yield (Y) and nitrogen content (N) with degree days (X). These relationships were:

$$Y = -943 + 2X \ (r = 0.735, P < 0.01)$$
$$N = 6.26 - 0.003X \ (r = 0.618, P < 0.01)$$

DISCUSSION

Although Cunningham produced higher mean yields than Peru in both years of testing, cultivar differences were not significant, contrary to the findings of Hutton and Beattie (1976) who found Cunningham superior to Peru. However, conditions of growth were wetter and harvest intervals shorter in the present study than for Hutton and Beattie's study. These conditions would tend to mask differences which would become apparent under longer harvest intervals.

Total dry matter yields of leucaena recorded at South Johnstone are in reasonable agreement with findings by other workers in the wet tropics (e.g. Takahashi and Ripperton 1949, 16–21 t ha^{-1}, Partridge and Ranacou 1973, 15–27 t ha^{-1}). Highest dry matter yields of total and edible dry matter were associated with the longer regrowth periods of the four month harvest intervals. Takahashi and Ripperton (1949) also found that where cutting height was low this harvest frequency yielded most. The problem with extended harvest intervals in leucaena is the large amount of wood material recovered. It does, however, point to leucaena's usefulness as a source of wood for fuel or pulp under a coppicing regime (Philippine Council for Agricultural and Resources Research and U.S. National Academy of Sciences 1977) but where a cut and carry feed production system is required, more frequent harvesting

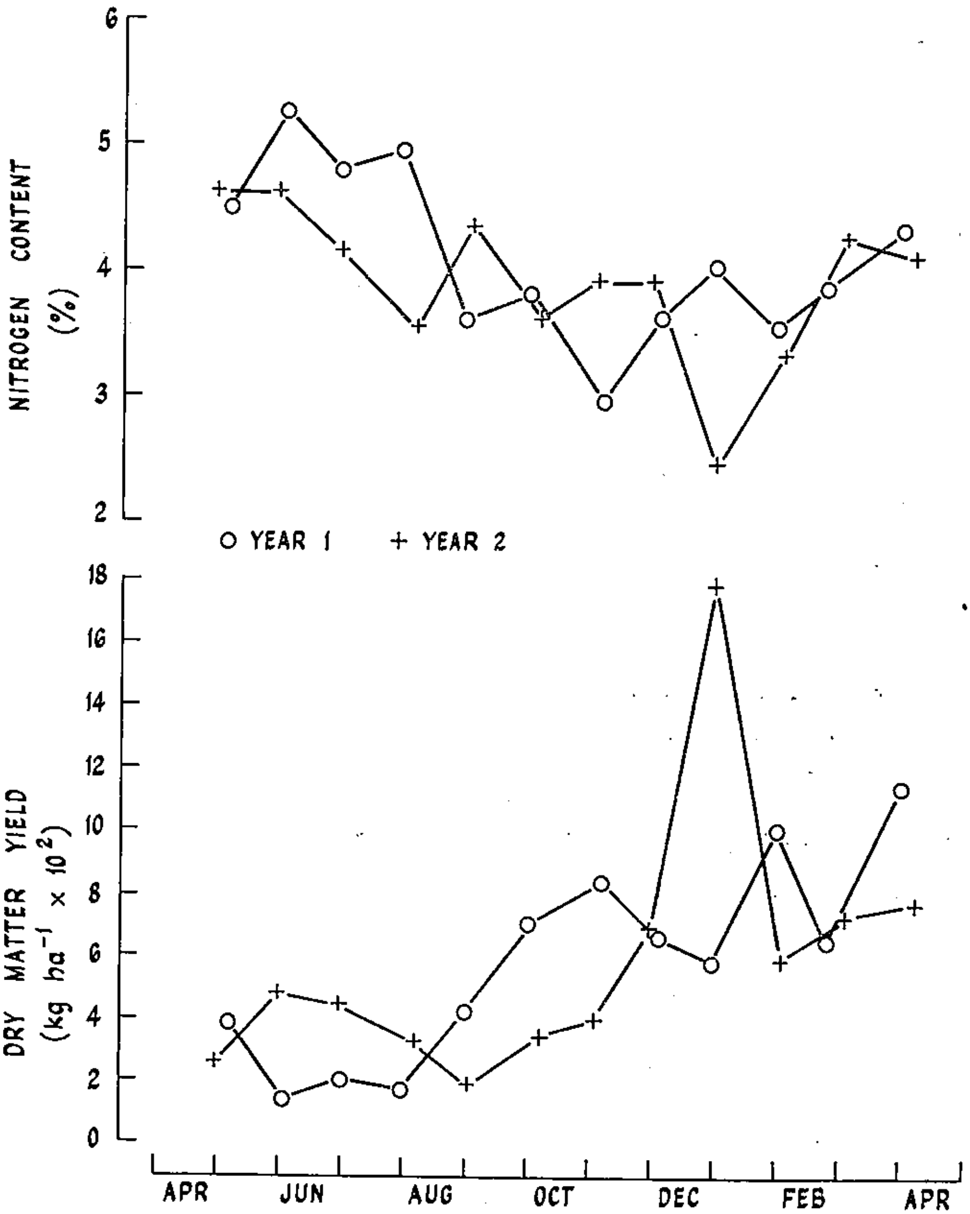

FIGURE 2

Individual mean monthly harvest yields and nitrogen content (Experiment 2).

would produce similar amounts of edible matter of higher quality (Table 1). Very short harvest intervals, as in Experiment 2, reduced yields without any apparent gain in quality, even though the well established woody framework in this case should have provided more buds for regrowth (Hutton and Beattie 1976). However, yields in Experiment 2 were limited by not harvesting the sides of hedges. Hill (1971) cites evidence that hedge sides can contribute substantially to yields.

Yields of leucaena were shown to be well associated with the thermal and radiant energy received. The poorer association with rainfall indicated that this factor was rarely limiting to growth on the deep soils in the South Johnstone environment. Because of these associations, yields in the cooler months were only half that of the wet summer months (Figures 2 and 3), but 900 kg edible dry matter ha^{-1} could be expected every 2 months under the production systems of Experiment 1 (Figure 3). The general inverse association of nitrogen content with climatic factors reflected the commonly found inverse relationship of yield with nitrogen content, suggesting a dilution effect at times of high productivity.

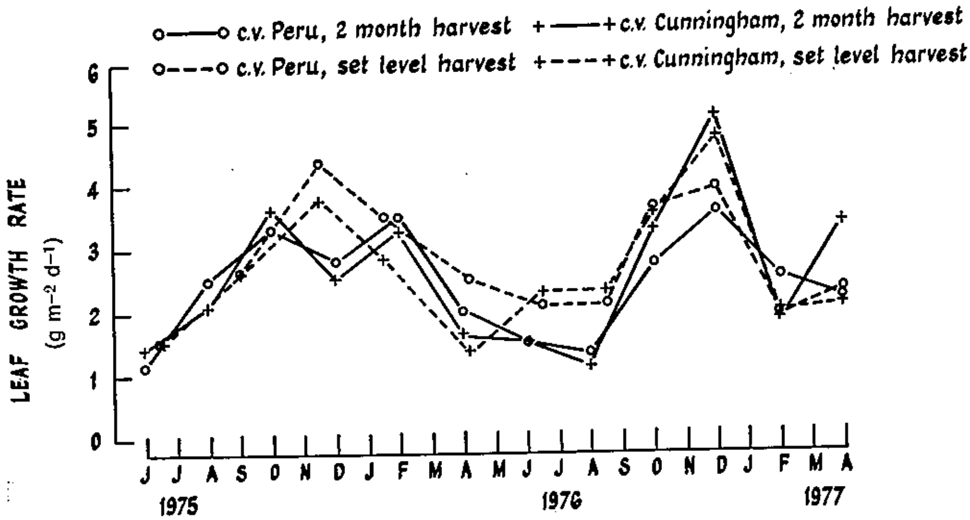

FIGURE 3

Edible dry matter growth rates of leucaena cultivars at 30 cm spacing harvested at intervals of 2 months or to a set regrowth level (Experiment 1).

These results suggest that leucaena is relatively productive in the wet tropics of Queensland and deserving of investigation to assess whether or not it has a place in the grazing situation or as a special purpose forage. Against its adoption is the presence of mimosine which requires special grazing management (Blunt and Jones 1977), though the anticipated release of low-mimosine lines would reduce this requirement (Philippine Council for Agriculture and Resources Research and U.S. National Academy of Sciences 1977). Leucaena-based pastures require new and unfamiliar establishment and management techniques. They would need to compete against the familiar grass/legume pastures which utilise herbaceous rather than shrub legumes and which can be highly productive (Harding and Cameron 1972). Yet animal production on leucaena/grass pastures can also be high (Blunt and Jones 1977, Philippine Council for Agriculture and Resources Research and U.S. National Academy of Sciences 1977). Once established leucaena can compete well, because of its height and persistence, with the weed growth which so often occurs with time in the humid tropics. It can supply high quality feed well into the dry season (Figure 3), possibly because of its deep root system (Philippine Council for Agriculture and Resources Research and U.S. National Academy of Sciences 1977).

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