The effect of cutting interval on the growth of *Leucaena leucocephala* and three associated grasses in Thailand

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Abstract

Leucaena (*Leucaena leucocephala*) was grown with 3 grasses: ruzi (*Brachiaria ruziziensis*), and dwarf napier and Taiwan A25 (both *Pennisetum purpureum*) under rainfed conditions in Thailand. The pastures were cut at 20, 30 and 40-day intervals for 840 days. Dwarf napier produced more total and leaf dry matter than Taiwan A25 and ruzi ($P < 0.05$). Yield of all grass species increased with increasing cutting intervals. Leucaena yield was generally unaffected by cutting interval. However, at 40-day cutting intervals, leucaena dry matter yield was lower in the dwarf napier plots than in the ruzi and Taiwan A25 plots, which produced similar legume yields ($P > 0.05$). Growing leucaena with dwarf napier gave the lowest total legume dry matter yield ($P > 0.05$). Less frequent cutting increased total dry matter yields in all combinations through increases in grass yield. Maximum dry matter yield (41.5 t/ha) was produced by leucaena-dwarf napier.

Dwarf napier produced herbage of higher quality than the other grass species in terms of crude protein concentration in both stems and leaves and had a higher leaf : stem ratio. Leucaena produced higher crude protein levels than grasses. The crude protein concentration in stems and leaves of all species decreased with increasing cutting intervals. Phosphorus concentrations in leucaena and associate grasses were similar and declined little with age. Leucaena was lower in potassium but higher in calcium concentration than the associated grasses.

The results of this study are discussed in relation to the management of leucaena in mixed pastures for dairy production in Thailand.

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Introduction

Since leucaena (*Leucaena leucocephala*) is a shrub legume with a deep rooting system, it retains green leaf throughout the dry season. It can produce protein-rich forage to supplement the basal diet of tropical grasses (Maasdorp and Dzowela 1998; Abdulrazak and Ondiek 1998) and has been grown for many years in many tropical countries such as Thailand (Tudsri *et al.* 1999a), Australia (Jones *et al.* 1998) and Africa (Nyaata *et al.* 1998). Leucaena can be highly productive when grown as a pure stand.

In pure stands, total production of leucaena increased with less frequent cutting (Guevarra *et al*. 1978; Ferraris 1979), where cutting 4 times per year at a density of 80 000 trees/ha produced the highest dry matter yield. Infrequently cut trees had bigger stumps and suffered least mortality (Cobbina 1998). Growing leucaena in mixed pastures has been found to be mutually advantageous in terms of total dry matter production. For example, Nyaata *et al*. (1998) reported that there was a significant increase in annual dry matter yield over that from a pure stand of napier grass (*Pennisetum purepureum*) when leucaena was intercropped with the grass. Intercropping leucaena with napier grass also contributes to an increase in soil fertility and has the potential to prolong the productive life of napier grass. Tudsri *et al.* (1999a) also reported that the presence of leucaena in pastures significantly increased the level of crude protein and hence the potential value of the feed to livestock.

Tudsri *et al*. (1999a) suggested that grasses be sown in alternate rows with leucaena at a spacing of 100 cm between rows, whereas Nyaata *et al*. (1998) suggested the best combination would be 1 or 2 rows of leucaena to 1 row of napier. However, the productivity of leucaena in mixed pastures may vary depending on the associate grass species, and the compatibility of the leucaena and grasses may be influenced by defoliation practices.

This experiment, therefore, examined the effects of different cutting intervals on the growth of both leucaena and grass when leucaena was grown with 3 different grasses: ruzi (*Brachiaria ruziziensis*), and dwarf napier and Taiwan A25-both cultivars *of Pennisetum purpureum*. Taiwan A25 is a new grass cultivar which will be released for commercial use in the near future in Thailand while dwarf napier and ruzi are commonly used by dairy farmers in Thailand.

Materials and methods

The experiment was conducted on a sandy clay loam soil at the Kasetsart University farm (Suwanvajokkasikit Research Station), Pakchong, approximately 150 km north-east of Bangkok (101° 19 E', 14° 38' N; elevation 388 m asl). Soil of the experimental area is classified as a moderate, reddish-brown lateritic (Oxic Paleustalf) with pH 6.95. The chemical composition of the top 0–15 cm of soil was 115 ppm available P (Bray II), 205 ppm K and 2.23% organic matter. A split-plot design with 3 replications was used. The main plots consisted of 3 tropical grasses (ruzi, dwarf napier and Taiwan A25) planted between rows of leucaena, and the sub-plots were the cutting intervals (20, 30 and 40 days). Subplot size was 4 m × 5 m with 2 rows of grass as borders.

The area was ploughed and cultivated to produce a good seedbed before planting/sowing on November 10, 1993. Seed of leucaena cv. Ivory Coast, dwarf napier and Taiwan A25 was planted in small plots and seedlings were transplanted into the experimental area when the plants were 4–5 weeks old. Leucaena was transplanted into rows 2 m apart (50 cm apart within rows) and the two grasses were transplanted in rows 50 cm apart between the leucaena rows, creating 3 rows of grass between the leucaena rows. The spacing between napier plants within rows was 50 cm. Ruzi grass was sown by seed (60% germination) at 12 kg/ha in rows 50 cm apart. An initial fertiliser dressing of N:P:K (15:15:15) at 300 kg/ha was applied at sowing, with further annual applications at the same rate in May 1995 and May 1996. The area was cut to 10 cm for grasses and 25 cm for leucaena on May 4, 1994. This date was taken as week 0, with the cutting treatments commencing from that date and continuing for 840 days. Seven cycles of 120 days duration were incorporated in the whole 840-d period. During each cycle, plants were cut 6, 4 and 3 times for 20, 30 and 40-d cutting intervals, respectively.

Dry matter yields of grasses were measured by cutting 2 quadrats (1.5 m × 1.5 m) at 10 cm above ground level in each subplot. Ten plants of leucaena were also cut at 25 cm above ground level to measure leucaena dry matter yield. A 500 g subsample was separated into leaf and stem components. For leucaena plants, leaves (leaflet plus rachis) were stripped off the stems and total leaf and green stem estimated from the subsample. Each component was dried at 80°C for 72 h and dry weight recorded. The dry leaf and stem subsamples were analysed for N to calculate crude protein (%N × 6.25), P, K and Ca concentrations. After each sampling cut, the remaining pasture was cut to 10 and 25 cm for grass and leucaena, respectively, and cut material was removed from the plots.

For statistical analysis, a simple split-plot design was used and differences were tested for significance at $P<0.05$.

Results

Rainfall and temperature change

In the first year (1994), rainfall was evenly distributed in the wet season (May–October) (Table 1). Little rainfall was recorded during the dry, cooler period (November 1994–February 1995). Rain recommenced in March 1995 and continued for 2 months after which dry conditions were again experienced during June–July 1995. However, good rainfall was recorded during August–October 1995 followed by a dry cool period from November 1995–January 1996. Rainfall was slightly above normal from April–November 1996. Temperatures were much less variable than rainfall (Table 1).

Table 1. Rainfall and temperature at Suwanvajokkasikit Research Station, Pakchong, Nakornratchasima during the study and the long-term rainfall mean (1972–1996).

Month	Long-term rainfall	1994			1995			1996		
		Rainfall	Temperature		Rainfall	Temperature		Rainfall	Temperature	
			Max	Min		Max	Min		Max	Min
	(mm)	(mm)	(°C)		(mm)	(°C)		(mm)	(°C)	
Jan	11	8	30.3	15.9	2	30.2	14.9	0	29.6	15.3
Feb	19	15	32.0	20.5	15	31.2	15.4	55	29.2	18.8
Mar	63	68	32.0	19.4	68	33.6	19.3	38	33.5	18.2
Apr	87	80	33.3	21.1	149	34.3	21.8	127	32.9	21.1
May	151	180	31.6	21.2	259	31.7	21.5	175	31.1	21.2
Jun	99	171	30.0	21.9	19	31.8	22.0	103	30.8	21.1
Jul	107	100	29.0	22.3	65	31.7	22.1	167	29.8	21.0
Aug	144	202	29.0	20.2	167	30.0	21.8	137	29.7	21.5
Sep	222	152	28.8	20.8	375	29.6	21.0	394	29.3	20.8
Oct	165	50	28.7	18.6	186	29.0	19.9	154	28.8	19.9
Nov	36	10	29.2	18.7	9	27.8	17.6	199	27.8	18.8
Dec	6	0	29.7	17.6	0	26.8	15.3	0	26.1	14.6
Total/Mean	1110	1032	30.3	19.9	1314	30.6	19.4	1546	29.9	19.4

Grass production

The data for the 840 days were divided into seven 120-day cycles with six 20-d cuts, four 30-d cuts and three 40-d cuts in each cycle. Dwarf napier produced significantly ($P < 0.05$) more total dry matter (Table 2), and leaf dry matter (Table 3) than Taiwan A25 or ruzi. Taiwan A25 was significantly ($P < 0.05$) more productive over the whole period than ruzi grass (Table 2), the advantage being in leaf production (Table 3).

All grass species exhibited a marked response to cutting frequency and average dry matter yield over the 3 cultivars significantly increased from 27.2 t/ha at the 20-day cutting to 35.5 t/ha at the 40-day cutting interval over the total 840-day experimental period (Table 2). Interactions for total dry matter yield between cultivar and cutting were generally non-significant. However, there was a significant ($P<0.05$) cultivar × cutting interval interaction for leaf yield. An increase in cutting interval increased leaf yield in dwarf napier, but had no effect in ruzi and Taiwan A25. Increasing the cutting interval from 20 days to 40 days increased stem dry matter yield in all cultivars.

The lowest total dry matter yields were recorded between October and January (Cycles 2 and 5) which represents the normal dry, cool period in Thailand (Table 2).

Leucaena production

Under cutting intervals of 20 and 30 days, leucaena yields were similar when grown with all 3 grasses (Table 3). However, at the 40-day cutting interval, leucaena in the ruzi and Taiwan A25 plots outyielded leucaena in the dwarf napier plots (Table 3). Leucaena in all grass plots was most productive from February–September with much less growth during the cool, dry period (October–January) in each year (Table 2).

Total production (Grass + leucaena)

Total dry matter yield followed the order of dwarf napier > Taiwan A25> ruzi ($P < 0.05$) (Table 2). The difference was due to the grass component. Total dry matter yield increased progressively with increase in cutting interval ranging from 32.3 t/ha at 20-day cutting to 40.4 t/ha at 40-day cutting ($P < 0.05$) (Table 2). There was generally no significant interaction between cultivar and cutting interval in all cycles.

Chemical composition

The crude protein concentration in both leaf and stem decreased as the cutting interval increased in all species (Table 4). The crude protein concentration in leucaena was greater than that in

Table 2. Effect of grass species/cultivar and cutting interval on dry matter yield of grass and leucaena and grass plus leuceana in each cycle (120 days) and total yields over 840 days between 1994–1996.

Treatment	Cycle							Total 1–7
	1	2	3	4	5	6	7	
	(Jun–Sep)	(Oct–Jan)	(Feb–May)	(Jun–Sep)	(Oct–Jan)	(Feb–May)	(Jun–Sep)	
Grass (G)				(t/ha)				
Cultivars								
Ruzi	7.97	1.27 b[1]	3.51 b	3.77 b	0.68 c	3.77 c	4.23 b	25.02 c
Dwarf napier	9.39	1.65 a	5.96 a	7.04 a	0.98 b	5.62 a	6.20 a	36.84 a
Taiwan A25	7.62	1.41 b	5.14 a	6.44 a	1.24 a	4.69 b	4.96 a	31.50 b
Cutting interval (days)								
20	7.74	2.16 a	4.02 b	3.78 c	0.97 b	4.01 b	4.56 b	27.24 c
30	8.43	1.36 b	5.24 a	5.51 b	0.56 c	4.83 a	4.86 b	30.79 b
40	8.82	0.81 c	5.36 a	7.96 a	1.37 a	5.24 a	5.98 a	35.54 a
Leucaena (L)								
Cultivars								
Ruzi	0.44	0.28	0.64	1.18 a	0.29	1.16	1.19	5.18
Dwarf napier	0.53	0.35	0.60	0.84 b	0.28	1.03	1.06	4.69
Taiwan A25	0.58	0.33	0.65	1.07 a	0.28	1.08	1.16	5.11
Cutting interval (days)								
20	0.51 b	0.44 a	0.75 a	1.06	0.24 b	1.01	1.02 b	5.03
30	0.56 b	0.31 b	0.54 b	0.96	0.40 a	1.18	1.29 a	5.24
40	0.68 a	0.20 c	0.57 b	1.07	0.19 b	1.08	1.10 b	4.89
Total (G + L)								
Cultivars								
Ruzi	8.41	1.54 b	4.15 b	4.95 b	0.97 c	4.93 b	5.42 b	30.37 c
Dwarf napier	9.91	2.00 a	6.56 a	7.88 a	1.26 b	6.65 a	7.26 a	41.53 a
Taiwan A25	8.19	1.73 b	5.75 a	7.51 a	1.52 a	5.77 a	6.12 b	36.59 b
Cutting interval (days)								
20	8.24	2.59 a	4.77	4.84 c	1.21 b	5.03	5.57 b	32.25 c
30	8.98	1.67 b	5.78	6.47 b	0.96 c	6.01	6.15 b	36.02 b
40	9.50	1.02 c	5.93	9.03 a	1.56 a	6.32	7.08 a	40.44 a

[1]Within columns for each main effect, values followed by different letters are significantly different ($P < 0.05$).

Table 3. Effect of pasture species/cultivar and cutting interval on the leaf and stem components of the cumulative dry matter yield of grass and leucaena over 840 days.

Treatment	Cutting interval (days)					
	20		30		40	
Grass	Leaf	Stem	Leaf	Stem	Leaf	Stem
			(t/ha)			
Ruzi	16.5 c[1]	7.7 a	17.5 c	6.6 a	16.8 c	10.5 a
Dwarf napier	27.2 a	3.6 b	32.4 a	4.6 b	35.3 a	7.4 b
Taiwan A25	22.6 b	4.2 b	24.1 b	7.1 a	24.7 b	11.9 a
Leucaena						
Ruzi	4.4	0.9	3.7	1.1	4.3 a	1.7 a
Dwarf napier	4.2	0.9	4.0	1.0	2.7 b	1.1 c
Taiwan A25	3.9	0.8	4.3	1.1	3.6 a	1.4 b

[1]Within columns for each main effect, values followed by different letters are significantly different ($P < 0.05$).

the grasses but the difference decreased with regrowth age. The level in leucaena stems was less than half that in leucaena leaf at all cutting intervals (Table 4).

There were no significant cultivar × cutting interval interactions for phosphorus, potassium and calcium concentrations in the leaf and stem components and main effects only are presented (Table 4). Phosphorus concentrations in leucaena and the associated grasses were similar and declined only at the longest cutting interval. The effects of cultivars and cutting intervals on

Table 4. Effect of cutting frequency on mean concentration[1] of crude protein, phosphorus, potassium and calcium in grass and leucaena (DM basis).

	Cutting intervals (days)					
	20		30		40	
	Leaf	Stem	Leaf	Stem	Leaf	Stem
CP (%)						
Grass						
Ruzi	12.6 b[2]	9.6	9.6 b	8.4 b	10.3 b	6.0 b
Dwarf napier	15.5 a	9.4	12.9 a	10.5 a	12.1 a	8.5 a
Taiwan A25	15.4 a	9.1	13.6 a	8.4 b	10.5 b	6.8 b
Mean	14.5	9.4	12.0	9.1	11.0	7.1
Leucaena	30.1	12.6	25.7	9.4	20.9	8.7
Phosphorus (%)						
Grass	0.261	0.215	0.289	0.289	0.224	0.212
Leucaena	0.239	0.232	0.242	0.216	0.195	0.202
Potassium (%)						
Grass	2.91	3.17	3.28	3.20	2.31	2.23
Leucaena	1.69	1.80	1.77	1.64	1.73	1.47
Calcium (%)						
Grass	0.312	0.195	0.314	0.155	0.324	0.138
Leucaena	0.347	0.319	0.482	0.314	0.463	0.311

[1]With the exception of CP concentration in grasses all values quoted for grasses are overall mean values.
[2]Within columns for grass crude protein, values followed by different letters are significantly different (P<0.05).

potassium and calcium concentrations in leaf and stem showed no clear or consistent trends. However, the grasses showed much higher potassium levels than leucaena, while calcium levels in leucaena were higher than in the grasses.

Discussion

Results of this experiment showed that leucaena produced similar yields with all 3 grasses when cut every 20 and 30 days. However, when the cutting interval was extended to 40 days, leucaena production in the dwarf napier plots was noticeably depressed relative to that in Taiwan A25 and ruzi grass plots. Ruzi is stoloniferous with a low-growing habit while Taiwan A25 is relatively tall with low leaf production (Table 3). These growth habits, together with their lower production, may have resulted in these grasses providing less competition for leucaena than dwarf napier which is an erect, leafy grass. Lengthening of the cutting interval would have resulted in strong competition from this grass. Nevertheless, the total dry matter yield (grass+leucaena) was highest in the dwarf napier plots due to the contribution of the grass component (Table 3).

This experiment also showed that moderate (30 day) and frequent (20 day) cutting of leucaena grown with grasses reduced total dry matter yield (grass+ leucaena) by approximately 11% and 25%, respectively, compared with infrequent (40 day) cutting. The increase in total dry matter yield recorded under less frequent cutting was clearly due to an increase in the yield of the grass component because leucaena yield was generally unresponsive to cutting interval.

The exception to this general trend was Cycle 2 which occurred in the cool, dry season. This was a very dry period and total dry matter yield in both grass and legume was negatively correlated with cutting interval. This suggested that regrowth after cutting was restricted by the limited water reserves. Higher transpiration rates with longer cutting intervals may have adversely affected growth rates.

The patterns of response to cutting treatments of all grass species used in this study were similar to those reported for *Cynodon dactylon* (Juntakool 1967), *Pennisetum purpureum* cv. Common (Wilaipon 1967) and *Digitaria decumbens* (Tudsri *et al*. 1999b). The lower yield under frequent cutting may have been due to lower residual leaf area, and food reserves and hence slower recovery (Ward and Blaser 1961).

The general decline in crude protein concentration in the grasses and leucaena with increasing length of cutting interval is similar to results elsewhere in Thailand with ruzi (Kasantikul 1993), napier grass (Sukkagate 1994) and legumes (Tudsri 1986). However, there were marked differences in crude protein concentrations in the different grasses. With frequent and moderate cutting, the crude protein concentrations were similar for dwarf napier and Taiwan A25 but both were much higher than for ruzi grass. When cutting interval was increased to 40 days, the crude protein concentration in both leaf and stem of dwarf napier was 2 percentage points higher than for ruzi and Taiwan A25. Even at 40-day cutting intervals, crude protein levels in leaves exceeded the level considered critical by Milford and Minson (1966) for achieving maximum intake. However, levels in stem for ruzi and Taiwan A25 were below the critical level. Animals normally select leaf in preference to stem, but a shortage of protein in the rumen could occur under long cutting intervals for ruzi and Taiwan A25 if animals are forced to consume stem which constitutes 30–40% of the available grass dry matter.

The high crude protein in leucaena relative to grass highlights the importance of maintaining adequate quantities of high protein legume, in this case leucaena, in the pasture and in the diet. Milking dairy cows are often presented with grass containing seriously low crude protein concentrations from very infrequent cutting on Thai dairy farms. Farmers commonly harvest the grass at 40–60^{+}day cutting intervals (Tudsri and Sawadipanich 1993). Growing leucaena with the grass will increase the overall crude protien concentration in the available forage and will minimise the decline with age. Dairy cows will still be able to eat mature forage (40 days or more) with high crude protein levels. Leucaena persisted strongly with grass in this experiment as compared with the severe death of *Stylosanthes hamata* plants grown with a similar grass as reported by Wongsuwan and Watkin (1990). Even perennial legumes declined rapidly in mixed pastures after 2–3 years (Hare *et al.*1999).

Any cutting management strategy for a pasture represents a compromise between maximum forage yield and acceptable forage quality. Our results suggest that an acceptable cutting interval for intercropping leucaena and ruzi or Taiwan A25 is around 40 days. When cut more frequently, both grass yield and total pasture yield are reduced with no increase in leucaena yield. If such mixtures were cut at intervals greater than 40 days, the grass yields especially stem components would probably increase but leucaena yields would decline resulting in a very low quality forage. This is in contrast to the finding of Cobbina (1998) that maximum production of leucaena was obtained from 12-week cutting intervals in a pure stand. He also observed that trees which were cut less frequently developed bigger stumps. Removal of these stumps would present problems for Thai dairy farmers when they decided to change to other crops. An aim of our work is to restrict stump growth by cutting the leucaena more frequently than suggested by Cobbina (1998). However, it is clear that the optimum cutting interval for leucaena-dwarf napier pasture is around 30 days. Cutting more frequently will depress grass and total dry matter production through a decline in both stem and leaf yield but increase quality (CP%). Cutting less frequently will increase grass production through leaf and especially stem dry matter yield but at the expense of the legume component and will reduce feed quality.

Phosphorus concentrations in both the grass and legume species were inadequate for lactating dairy cattle, which require 0.28–0.34% in the diet (NRC 1984), but sufficient for beef cattle, which require 0.20% in the diet. Feeding of phosphorus supplements to lactating dairy cows would rectify the problem. Of particular interest was the relatively low K concentration in leucaena relative to the grass species (Table 4). However, as the major component of the diet of livestock consuming such pasture would be grass of relatively high potassium concentration, it is unlikely that any nutritional problems would arise in animals consuming mixed forage. The decrease in K concentration when cutting was delayed agreed with the findings of Holm (1973) and Kasantikul (1993).

In contrast, the calcium concentration in leucaena was noticeably higher than in the grasses indicating its value in providing the required calcium for lactating dairy cattle which need 0.43–0.53% in the diet (NRC 1984). The levels of calcium in these forages are adequate for beef production. These results are supported by Holm (1973) who found that many cultivated grass species had calcium levels of 0.35–1.06%, which were much higher than those in native grasses (Yaowapaksopon 1991).

Management of leucaena in mixed swards can be difficult, especially when grown on acid sandy soils. The soils in this study represented the typical soil where dairy farms are situated. They were generally more fertile than the acid sandy soils in north-east Thailand. On these more productive soils, leucaena grown with grasses will increase pasture quality if the pastures are cut at 40-day cutting intervals when the quality of grasses declines rapidly. The work should also be carried out on acid sandy soils where beef cattle are raised.

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