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FORAGE PRODUCTIVITY OF THREE FODDER SHRUBS IN MALAYSIA

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Keywords: Leucaena, Cassava, *Gliricidia sepium,* Napier, Forage productivity, *In vitro* dry matter digestibilities, Mineral composition.

RINGKASAN

Tiga tanaman foder iaitu *Gliricidia sepium, Leucaena leucocephala* dan *Manihot esculenta* bersama spesies kawalan, napier, dinilai bagi mengkaji pengeluaran forej dengan pembajaan dan tanpa pembajaan nitrogen, serta dengan tiga jarak masa pemotongan iaitu 4, 8 dan 12 minggu. Napier memberikan hasil bahan kering paling tinggi (15.6 t/ha/tahun) diikuti oleh *M. esculenta* (6.2 t/ha/tahun), *L. leucocephala* (5.5 t/ha/tahun) dan *G. sepium* (2.1 t/ha/tahun). Pada amnya, hasil bahan kering bertambah dengan meningkatnya jarak masa pemotongan serta pemberian baja nitrogen. Penghadaman bahan kering *in vitro* foder-foder jenis dicot adalah rendah tetapi kandungan nitrogen dan zat galian lebih tinggi daripada napier. *Leucaena leucocephala* mempunyai daya pulih yang paling tinggi dan napier pula paling rendah. Asid hidrosianik di dalam daun *M. esculenta* adalah tinggi tetapi menurun dengan bertambahnya jarak masa pemotongan.

INTRODUCTION

In Malaysia, smallholders form the bulk of ruminant rearers whose animals are normally kept in a semi-intensive system of feeding on poor quality crop residues, agricultural by-products and indigenous forages from roadsides and plantation holdings. Although the indigenous forages could be improved through cultivation of improved tropical grasses and legumes, such an undertaking has never been adopted largely because of the small farm size.

To overcome the constraint, fodder trees and shrubs which are the natural endowment of the humid tropical habitats, have been recommended as potential high-protein forages (SKERMAN, 1977; GOHL, 1981; DEVENDRA, 1984). *Leucaena leucocephala* (Lam.) de Wit is one such fodder shrub which has become increasingly popular as a village forage and green manure in the tropics (JONES, 1979; ANON., 1984). More recently, *Gliricidia sepium* (Jacq.) Walp. and *Manihot esculenta* Crantz were promoted as potential fodder shrubs for ruminant production (DEVENDRA, 1977; CHADHOKAR and KANTHARAJU, 1980).

This paper reports the effects of defoliation frequencies and nitrogen fertilization on dry matter (DM) productivity and growth performance of three fodder species compared with napier grass, *Pennisetum purpureum* Schrumach.

MATERIALS AND METHODS

The experiment was conducted in February 1979 at MARDI Research Station, Serdang, on well-drained Bungor series soil that had been previously under rubber cultivation until 1971.

The soil pH at the site was 4.2 and the chemical properties were well reported by LEAMY and PANTON (1966). The climate was wet, humid tropical with no distinct seasonal variation except for a short dry period between June and August (ANON., 1966).

The treatments were:

Fodder species	Defoliation interval	Nitrogen fertilization
Gliricidia *(G. sepium)*	4-week	No nitrogen (control)
Leucaena (*L. leucocephala* cv. Peru)	8-week	150 kg N/ha/yr (as urea)
Cassava (*M. esculenta* var. Black Twig)	12-week	
Napier *(P. purpureum)*		

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The experimental design was a split-split plot with three replications. The main plots were defoliation intervals, sub-plots were nitrogen fertilization and sub-sub-plots were fodder species.

Cassava and napier were all planted flat vegetatively from 15-cm stem cuttings while 50-cm stem cuttings of gliricidia were planted erect. Leucaena was sown from seeds, inoculated with *Rhizobium* CB81. The planting distance was 0.5 m x 0.5 m in a plot size of 5 m x 5 m, with one-metre border width between plots.

All plots received a basal fertilizer of 30 kg P/ha as triple superphosphate and 50 kg K/ha as muriate of potash after planting. The maintenance fertilizers were 40 kg P/ha/yr and 100 kg K/ha/yr split every three months. In addition, all leucaena plots received an initial dressing of 500 kg/ha of dolomite before sowing.

Two rounds of hand-weeding were carried out at four weeks after planting and six weeks after the last weeding. An overall cut was imposed on all plots in October 1979 before commencement of defoliation treatments. Owing to the poor regrowth of leucaena and gliricidia, their defoliation treatments were deferred for six months.

All fodder species were hand-harvested to a 50-cm cutting height except napier which received a 15-cm cutting height. The harvested materials from each plot were weighed fresh, sub-sampled and oven-dried overnight in an air-forced draught dehydrator at 80° Celsius. The dried samples were weighed for DM yield estimation. When the different defoliation intervals coincided on a common harvest date, the sub-samples were separated into leaf and stem portions for leaf:stem ratio (DM) determination.

All dried samples with the common harvest dates were ground to pass through 1 mm screen for nitrogen and mineral composition analyses. Nitrogen was determined by the Kjeldahl digestion technique while phosphorus, potassium, calcium, magnesium, manganese, iron, copper, zinc and boron by the standard auto-analyser technique (A.O.A.C., 1970), and *in vitro* DM digestibility (IVDMD) by the method of McLeod and Minson (1978). The hydrocyanic acid (HCN) released from cassava leaves was determined by Guignards test (Indira and Sinha, 1969). Plant survival percentage, measured as persistence of the species, was taken at the end of the experiment.

All data obtained were subjected to an analysis of variance for a split-split-plot design.

RESULTS

Rainfall

The monthly rainfall at the experimental site for the duration of the defoliation treatments (January 1980 – November 1982) is depicted in *Figure 1a*. Mean annual rainfall for the experimental period was 2 260 mm with June 1981 and January 1982 being the two driest months. The rainfall pattern could be described as normal and was favourable for plant growth.

Establishment

All plots were well established within one month after planting except gliricidia which required about 30% overall replacement. Growth of cassava and napier was vigorous and the plants had to be cut twice prior to the overall defoliation. The slow establishment of leucaena and gliricidia resulted in deferred defoliation for six months.

The major dicot weed in the plots was *Boreria latifolia* Schumach which declined over time. Lallang, carpet grass, buffalo grass and creeping panic grass were the common monocot weeds which persisted throughout the experiment. There were no major plant diseases and pest problems

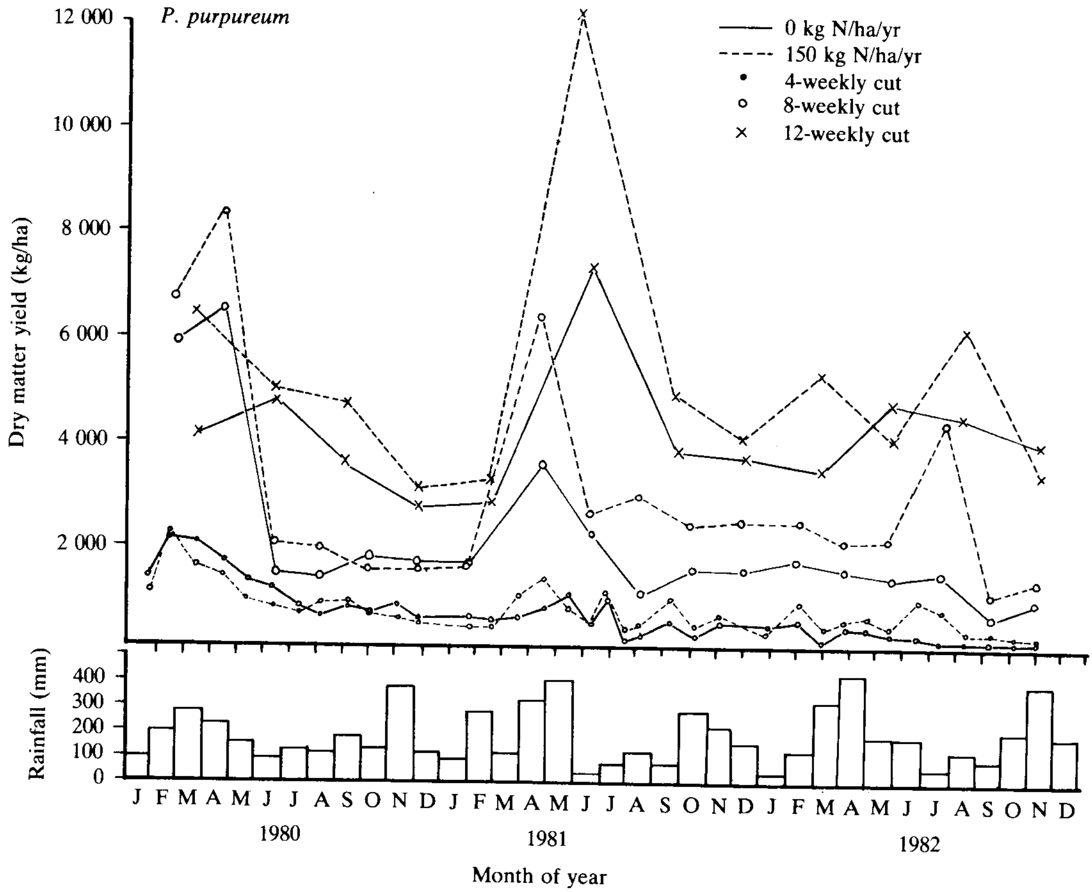

Figure 1a. Monthly rainfall and dry matter production of ***Pennisetum purpureum*** *as a function of time and defoliation intervals with and without nitrogen fertilization at Serdang.*

except in gliricidia where the young shoots were heavily infested with *Brachyplatys* species. Consequently, growth was retarded.

Effect of Defoliation Interval on DM Yield

The DM yields of the four fodder species generally declined over time under the three defoliation intervals and nitrogen fertilization treatments with marked depression in the 4-weekly cut *(Figures 1a–1d)*.

Harvests with high DM production in all the defoliation intervals appeared to coincide with periods of high rainfall, especially at the start of the experiment. However, DM yields of the four fodder species under the defoliation treatments were not well correlated.

The mean annual DM yield for the 4-weekly cut was significantly lower ($P<0.05$) than the 8 and 12-weekly cuts which were not significantly different *(Table 1)*. Mean annual DM yields were, however, significantly different ($P<0.05$) among the fodder species and their interactions between species and defoliation intervals.

Napier was by far the highest DM yielder with about 16 t/ha/yr followed by cassava and leucaena with an average of 6 t/ha/year. Poor regrowth of gliricidia resulted in low DM production (2 t/ha/yr).

Prolonged cutting interval increased the mean total DM yield in all the fodder species except for leucaena and gliricidia at 12-week cutting interval which were lower than the 8-weekly cut *(Table 1)*.

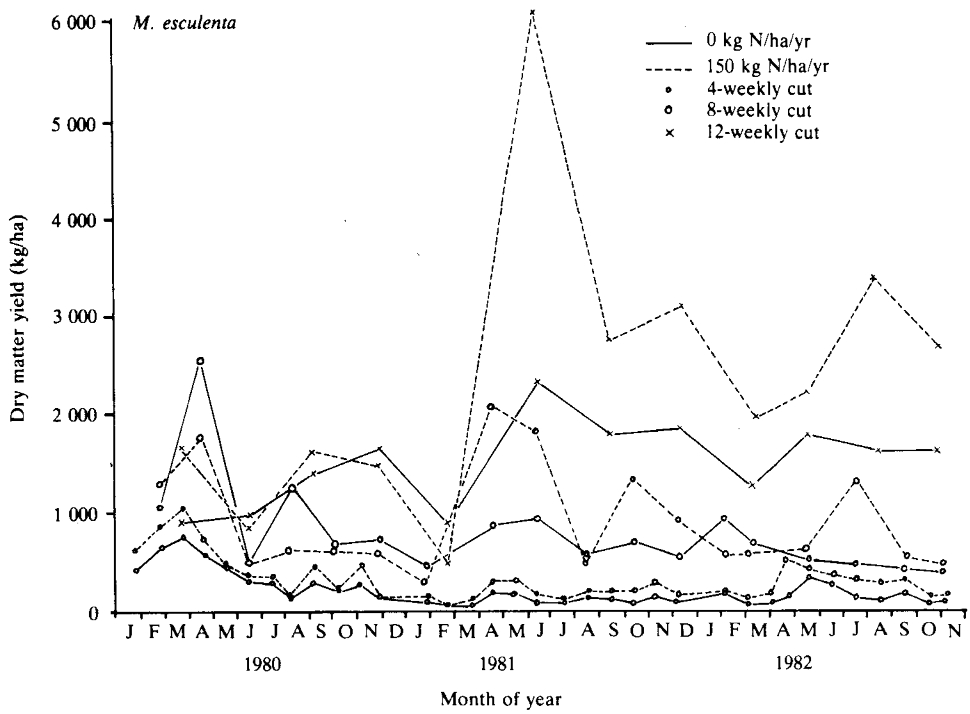

*Figure 1b. Dry matter production of **Manihot esculenta** as a function of time and defoliation intervals with and without nitrogen fertilization at Serdang..*

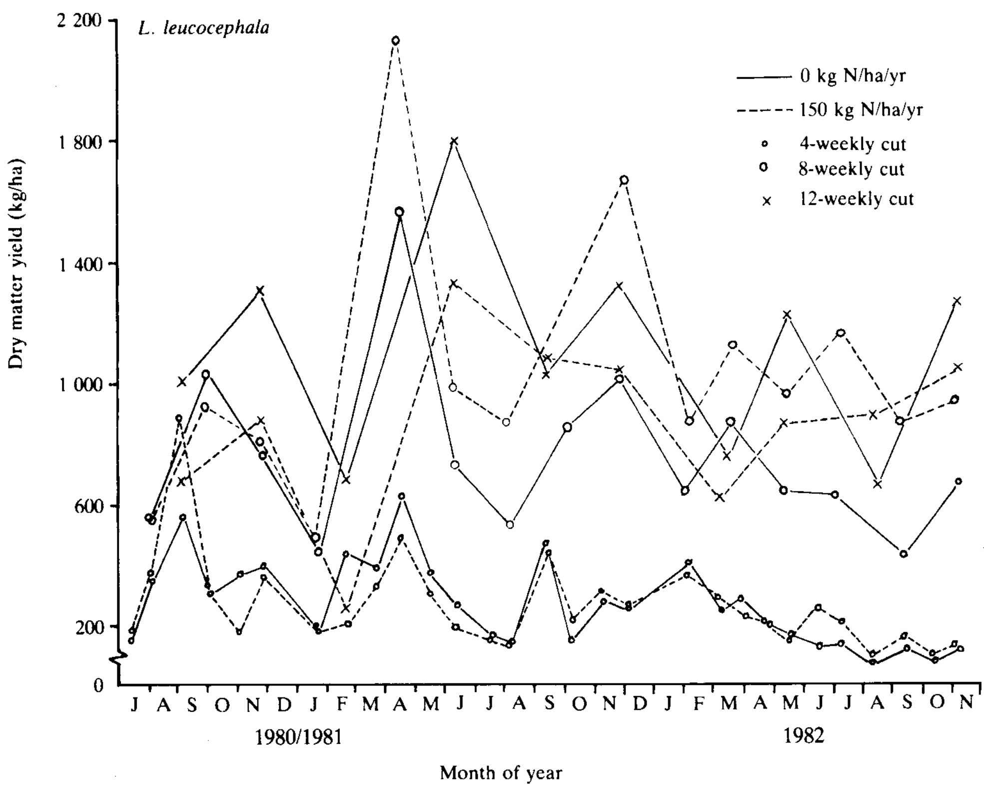

*Figure 1c. Dry matter production of **Leucaena leucocephala** cv. Peru as a function of time and defoliation intervals with and without nitrogen fertilization at Serdang.*

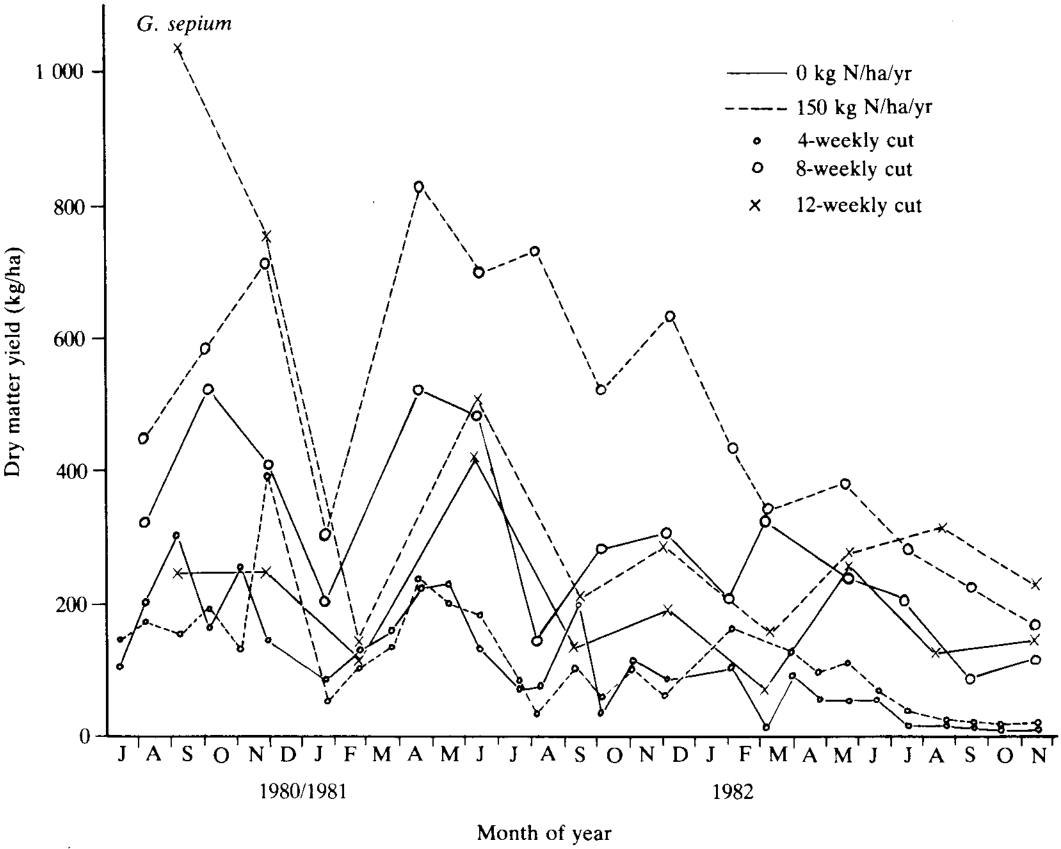

*Figure 1d. Dry matter production of **Gliricidia sepium** as a function of time and defoliation intervals with and without nitrogen fertilization at Serdang.*

Effect of Nitrogen on DM Yield

The nitrogen fertilizer at 150 kg N/ha/yr significantly increased (P<0.05) the mean annual DM yield *(Table 1)*. A 25% increase was obtained over that of the control across all defoliation intervals and species. Gliricidia produced the highest (59.7%) annual DM yield in response to nitrogen fertilization. Cassava and napier responded positively with an increase of 34% and 24% in DM production respectively while leucaena had an 8% increase. The interactions between species and nitrogen were also significant (P<0.05).

Leaf:stem Ratio

No significant differences were detected in the nitrogen fertilizer treatment on the leaf:stem ratio in all the four fodder species although the ratios of the dicot fodders tended to be lower in the nitrogen applied treatment. Nevertheless, leaf:stem ratio declined significantly (P<0.05) with increase in defoliation intervals *(Table 1)*.

Again, gliricidia produced the highest leaf:stem ratio followed by leucaena and cassava. Napier, being a fast grower, was lowest in leaf:stem ratio in all the defoliation regimes.

***In Vitro* DM Digestibility (IVDMD)**

The effects of nitrogen fertilization on IVDMD was not significant but IVDMD declined significantly (P<0.05) from 51.3% in the 4-weekly cut to 42.3% in the 12-weekly cut *(Table 2)*.

Table 1. Effects of defoliation intervals and nitrogen fertilization on mean annual dry matter production and leaf:stem (DM) ratio of 4 fodder species

Treatment	Dry matter yield (kg/ha/yr)				
	Napier	Cassava	Leucaena	Gliricidia	Mean
Defoliation interval					
4-wk	10 449 (3.1)	3 426 (7.2)	4 211 (9.2)	1 690 (11.3)	4 944b
8-wk	17 744 (1.3)	6 258 (3.6)	7 213 (2.5)	3 203 (4.8)	8 604a
12-wk	18 506 (0.7)	8 999 (1.0)	4 964 (1.5)	1 315 (4.0)	8 446a
Nitrogen fertilization (kg N/ha/yr)					
0 (control)	13 929 (1.49)	5 322 (4.55)	5 239 (5.06)	1 594 (8.41)	6 521c
150	17 204 (1.68)	7 133 (2.77)	5 685 (4.80)	2 546 (6.07)	8 142d
Mean	15 567a(1.59)	6 228b(3.66)	5 462b(4.93)	2 070c(7.24)	7 332

Species x nitrogen interactions were significant at P<0.05.
Means with the same subscript within and between columns for each treatment are not significant at P<0.05.
Values in ( ) indicate leaf:stem ratios.

Table 2. Effects of defoliation intervals on the *in vitro* dry matter digestibilities of 4 fodder species

Treatment	*In vitro* dry matter digestibilities (%)			
	4-wk	8-wk	12-wk	Mean
Fodder species				
Napier	55.8	50.4	44.0	50.1a
Cassava	49.7	48.9	47.9	48.8ab
Leucaena	49.0	40.1	32.8	40.6c
Gliricidia	50.6	48.1	44.6	47.8b
Mean	51.3a	46.9b	42.3c	46.8
Nitrogen fertilization (kg N/ha/yr)				
0 (control)	52.9	48.5	44.4	48.6d
150	49.6	45.2	40.2	45.0e

Means with the same subscript within or between columns for each treatment are not significant at P<0.05.

Napier was highest in IVDMD which ranged from 55.8% to 44.0% for the 4 to 12-weekly cut. The IVDMDs of cassava and gliricidia declined by about 2% and 6% respectively with the same defoliation treatment. Leucaena was the lowest in IVDMD in all the defoliation intervals.

Nitrogen and Mineral Composition

The effects of nitrogen fertilization and defoliation intervals on the nitrogen and mineral concentrations were generally not significant (P<0.05) except for nitrogen, potassium and zinc *(Table 3)*. However, there were significant differences (P<0.05) in the nitrogen and mineral profile among the four fodder species with the exception of copper and iron.

Leucaena forage had the highest nitrogen and magnesium contents. Napier was lowest (1.5%) in nitrogen while gliricidia was lowest in magnesium (0.15%). Cassava forage was richer in phosphorus, potassium, calcium, manganese, copper and zinc. Generally, the mineral contents of napier were lower than in the other fodder species. The calcium to phosphorus (Ca : P) ratio was greater than two in the dicot

Table 3. Effects of species, defoliation intervals and nitrogen fertilization on the nitrogen and mineral concentrations of fodder top growth

Treatment	Nitrogen and mineral concentration as DM										
	%					Ca:P	ppm				
	N	P	K	Ca	Mg		Mn	Fe	Cu	Zn	B
Fodder species											
Napier	1.53c	0.26b	1.47b	0.24c	0.17c	0.92	74.2b	164.5a	2.56a	32.8b	5.0b
Cassava	3.21b	0.31a	2.09a	0.85a	0.22b	2.74	113.6a	131.6a	9.88a	69.1a	19.1a
Leucaena	3.75a	0.23bc	1.14b	0.57b	0.28a	2.48	45.3c	114.0a	1.45a	32.8b	19.2a
Gliricidia	3.19b	0.20c	1.98a	0.53b	0.15c	2.65	41.3c	109.1a	4.29a	34.7b	19.6a
Defoliation interval											
4-wk	3.45a	0.27a	2.20a	0.58a	0.23a	2.15	80.3a	147.7a	3.66a	42.4a	14.0a
8-wk	2.91b	0.24a	1.47b	0.54a	0.20a	2.25	64.6a	137.5a	11.17a	34.8b	19.3a
12-wk	2.41c	0.23a	1.35b	0.53a	0.19a	2.30	61.0a	104.3a	3.00a	43.4a	13.8a
Nitrogen fertilization (kg N/ha/yr)											
0 (control)	2.93a	0.24a	1.91a	0.51a	0.19a	2.13	72.4a	122.7a	7.3 a	40.1a	14.2a
150	2.91a	0.25a	1.43b	0.59a	0.23a	2.36	64.9a	136.8a	4.2 a	40.5a	17.2a

Values with the same subscript within each column for each treatment are not significant at $P<0.05$.

fodder species except napier which had a value of slightly below one. The Ca : P ratio increased slightly with increased defoliation intervals.

Plant Survival

The influence of nitrogen fertilization on the plant survival count at the end of the experiment was not significant in all the species but increased cutting interval significantly enhanced ($P<0.05$) the plant survival percentage in all the species except gliricidia *(Table 4)*.

Leucaena was the most persistent fodder. Cassava ranked second with over 70% survival in the 8 and 12-weekly cuts but only 29.2% in the 4-weekly cut. Napier was the least persistent of the four fodder species.

Hydrocyanic Acid

The hydrocyanic acid content in cassava leaves was not only high but also varied widely. Over 1.1 g of HCN/kg of fresh cassava leaves was detected in the 4-weekly cut but it declined with increased cutting intervals *(Table 5)*.

Table 5. The effects of defoliation intervals on hydrocyanic acid content in foliage of cassava

Defoliation interval	HCN content (mg/kg of fresh foliage)
4-wk	1 100
8-wk	788
12-wk	464

DISCUSSION

Of the two treatments, namely defoliation intervals and nitrogen fertilization on forage production and mineral composition among the fodder species, nitrogen fertilization had the least effect with the exception of napier which showed its superiority as a fodder plant in DM yield to nitrogen fertilization in all the defoliation intervals. Its DM yield was at least 60% more than those of the other fodder species. Being a C_4 plant, napier was generally more productive in dry matter than the other C_3 plants (LUDLOW and WILSON, 1972). Despite its high DM productivity, napier was poor in persistence (<50% plant survival) in all the defoliation intervals, lower in leaf:stem ratio, nitrogen content and mineral concentrations.

Cassava ranked second in terms of forage yield in all the defoliation intervals. Its yield was as good as that of leucaena in the 4 and 8-weekly cuts and even out-yielded leucaena at the 12-weekly cut regime. A total of 3.4–9.0 tonnes of DM was obtained *(Table 1)*. A fresh foliage yield of 6.7 t/ha/yr was also reported for Black

Table 4. Effects of defoliation intervals and nitrogen fertilization on plant survival count of 4 fodder species at the end of the experiment

Treatment	Plant survival count (%)			
	4-wk	8-wk	12-wk	Mean
Fodder species				
Napier	44.9	41.7	50.5	45.7d
Cassava	29.2	76.8	78.6	61.5c
Leucaena	83.3	81.5	90.3	85.0a
Gliricidia	81.1	66.7	70.8	72.9b
Mean	59.6b	66.7b	72.6a	66.3
Nitrogen fertilization (kg N/ha/yr)				
0 (control)	60.2	67.8	71.7	66.6e
150	59.0	65.6	73.4	66.0e

Means with the same subscript within or between columns for each treatment are not significant at $P<0.05$.

Twig (cassava) under a 6-weekly defoliation in Serdang (AHMAD, 1973). The 8-weekly cut appeared to be the optimum harvest interval as 4-weekly cut was detrimental to its persistence and 12-weekly cut resulted in lower leaf:stem ratio with no significant differences in total DM production compared with that of the 8-weekly cut. As a non-legume, cassava was responsive (34% increase) to nitrogen fertilization *(Table 1)*.

Ease of establishment and rapid growth of cassava are the two agronomic attributes that could confer advantages over leucaena as a fodder. In addition, the mineral concentrations of cassava were higher than those of leucaena *(Table 3)*. Leucaena is always slow in establishment and requires heavy liming in tropical acidic soils for high DM productivity (WONG, IZHAM and DEVENDRA, 1980).

However, the major constraint in using cassava forage is the presence of high HCN which is a deterrent to its use. Feeding forage with 180–240 mg/kg of fresh cassava foliage to local goats produced chronic toxicity and even death (DEVENDRA, 1977). It thus appears that direct use of cassava foliage by livestock will be restricted and some forms of processing may be necessary to reduce the HCN content. Sun-dried cassava foliage had been used by small-holders without detrimental effects and incorporation of 25% fresh cassava foliage into a grass diet also improved liveweight gains in cattle (MOORE, 1976). Possibly, screening for varieties with low foliage HCN may help to overcome the HCN toxicity.

The leucaena forage yields obtained in all the defoliation regimes were rather low. Such low productivities in dry matter were attributed to the low dolomite application at establishment. A minimum liming rate of 2 t/ha was recommended for effective establishment and high forage yield (THAM, WONG and AJIT, 1977; WONG and DEVENDRA, 1983). The lower DM yield at 12-weekly cut compared with that of the 8-weekly cut could be attributed to the initial poor growth and interspecific competitions arising from the tall, fast growing species like cassava and napier in the neighbouring plots. Also, leucaena showed no benefits from the nitrogen fertilization at the 12-weekly cut.

Nonetheless, leucaena persisted well with over 90% survival in all the defoliation intervals as had been observed in Australia (JONES and HARRISON, 1980). The 8-weekly cut appeared to be the optimum harvest interval since longer cutting intervals also resulted in lower DM productivity in leucaena (MENDOZA, ALTAMARINO and JAVIER, 1976). Its IVDMD was somewhat low as reported elsewhere (IZHAM, CHEN and ABDULLAH, 1983) but GRANT, PEREZ, VAN SOEST and MCDONALD (1973) and JONES (1979) indicated high IVDMD.

The performance of gliricidia was by far the worst among the four fodder species. Establishment of gliricidia on Bungor series soil was poor and regrowth was not encouraging compared with those of cassava and leucaena. During the wet seasons, the young shoots were heavily attacked by *Brachyplatys* species. Gliricidia responded significantly to the nitrogen fertilization because of its poor regrowth.

The poor performance of gliricidia at Serdang was a big contrast to the good establishment and growth on a similar soil in Jasin, Malacca (WILLS, 1980). In Sri Lanka, a DM yield of 9 t/ha had been reported (CHADHOKAR, 1982). Despite its low yield and slow regrowth, its IVDMD, and nitrogen and mineral concentrations were comparable if not higher than those of cassava and leucaena. Owing to its availability as shade plants in cocoa plantations, its forage potential, therefore, will be in the integration of ruminants in such an environment.

The dicot fodder species could not outyield napier in DM production. However, their high nitrogen content and mineral constituents coupled with high persistence could surpass napier as good quality forage supplements for long-term ruminant livestock production in the smallholdings. Although their IVDMDs were generally lower than that of napier, the IVDMDs were not different from those of many other tropical legumes (REID, POST, OLSEN and MUGERWA, 1973). Besides, their nitrogen utilization and retention were enhanced in goats and sheep, and consequently more efficient use of nutrients was demonstrated by DEVENDRA (1983). The status of the mineral elements as well as the Ca : P ratio examined suggests adequacy except for copper, phosphorus and magnesium which may be supplemented to meet the higher nutritional requirements of the large dairy ruminants.

It thus seems that much use can be made of the various fodder species and their inclusion in the diets of the ruminants under semi-extensive system as practised in villages can promote better use of available forage resources for efficient ruminant production.

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ABSTRACT

Three fodder shrubs comprising *Gliricidia sepium, Leucaena leucocephala* and *Manihot esculenta* together with the control species, napier, were evaluated for forage productivity with and without nitrogen fertilization and under 4, 8 and 12-week cutting intervals. Napier was the best yielder in dry matter (15.6 t/ha/yr) followed by *M. esculenta* (6.2 t/ha/yr), *L. leucocephala* (5.5 t/ha/yr) and *G. sepium* (2.1 t/ha/yr). Dry matter yields generally increased with increased cutting intervals and nitrogen fertilization. *In vitro* dry matter digestibilities of the dicot fodders were low but their nitrogen and mineral contents were higher than those of napier. *Leucaena leucocephala* was the most persistent fodder with napier the least. Hydrocyanic acid in the foliage of *M. esculenta* was high but declined with increased cutting intervals.

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Nonetheless, leucaena persisted well with over 90% survival in all the defoliation intervals as had been observed in Australia (JONES and HARRISON, 1980). The 8-weekly cut appeared to be the optimum harvest interval since longer cutting intervals also resulted in lower DM productivity in leucaena (MENDOZA, ALTAMARINO and JAVIER, 1976). Its IVDMD was somewhat low as reported elsewhere (IZHAM, CHEN and ABDULLAH, 1983) but GRANT, PEREZ, VAN SOEST and MCDONALD (1973) and JONES (1979) indicated high IVDMD.

The performance of gliricidia was by far the worst among the four fodder species. Establishment of gliricidia on Bungor series soil was poor and regrowth was not encouraging compared with those of cassava and leucaena. During the wet seasons, the young shoots were heavily attacked by *Brachyplatys* species. Gliricidia responded significantly to the nitrogen fertilization because of its poor regrowth.

The poor performance of gliricidia at Serdang was a big contrast to the good establishment and growth on a similar soil in Jasin, Malacca (WILLS, 1980). In Sri Lanka, a DM yield of 9 t/ha had been reported (CHADHOKAR, 1982). Despite its low yield and slow regrowth, its IVDMD, and nitrogen and mineral concentrations were comparable if not higher than those of cassava and leucaena. Owing to its availability as shade plants in cocoa plantations, its forage potential, therefore, will be in the integration of ruminants in such an environment.

The dicot fodder species could not outyield napier in DM production. However, their high nitrogen content and mineral constituents coupled with high

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