Dry matter productivity and nutritive quality of leucaena hybrid lines for high protein feed production
(Hasil bahan kering dan mutu pemakanan titisan hibrid petai belalang untuk pengeluaran makanan ternakan berprotein tinggi)
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Key words: dry matter productivity, nutritive quality, leucaena hybrid lines

Abstract
Dry matter productivity and nutritive value of two leucaena hybrid lines namely 40-1-18 (Bharu) and 62-6-8 (Rendang) were studied at the Department of Veterinary Services farm, Kelantan from 1998 to 2001. The treatments comprised 8, 10 and 12 weekly cutting intervals.

Highest dry matter productivity was obtained at 12 weekly cutting interval with yields of 40 288 and 38 640 kg/ha per year obtained from 40-1-18 and 62-6-8, respectively. The cumulative dry matter productivity declined with shorter cutting intervals. Respective yields at 10 and 8 weekly intervals were 39 775 and 33 294 in 40-1-18, and 37 550 and 26 298 kg/ha per year in 62-6-8. The respective total leaf dry matter yields when harvested at every 12, 10 and 8 weekly intervals were 20 376, 18 460 and 17 970 kg/ha per year in 40-1-18, and 20 084, 17 470 and 16 038 kg/ha per year in 62-6-8. The mean crude protein content in 40-1-18 was 25.17% while 26.93% in 62-6-8. The mean crude protein yield calculated was 4 968 kg/ha per year in 40-1-18 and 4 635 kg/ha per year in 62-6-8. The ADF, ash, Ca, P and Mg were not much affected by the cutting frequencies in both lines.

Introduction
Leucaena (Leucaena leucocephala) has been recognized as an important feed for ruminants in the tropics because of its high crude protein, high palatability and ability to withstand repeated defoliation (NAS 1977). Many studies on leucaena establishment and productivity, and animal performance have been documented locally (Izham and Hassan 1983, 1984; Wong et al. 1983; Wong et al. 1987).

In the eighties, leucaena lines (ML 1 and ML 2) were recommended for use in Malaysia for livestock production due to their high protein content, nutritive quality and persistence to defoliation. However, these lines were susceptible to psyllid, jumping lice that damaged the growing shoots and plant when being attacked and were also not adapted to acid soils in the country. As such, new leucaena hybrid lines tolerant to acid soils and psyllid attack were bred for assessment.

In the study, several crosses between L. leucocephala and L. diversifolia have resulted in selection of a few good acid-soil and psyllid tolerant hybrid lines. These hybrid lines were superior to the earlier...
Dry matter productivity and nutritive quality of leucaena released lines, ML 1 and ML 2 in terms of growth performance and psyllid attack (Chen et al. 1996). These two lines, 40-1-18 and 62-6-8 were released as Bharu and Rendang, respectively (Anon. 1998).

With these new hybrid lines, there was a need to evaluate them for leaf meal production for use in animal feed. This could help to satisfy the need for high demand of high quality feed in the ruminant and equine industries. Therefore, a study was conducted to evaluate the hybrid lines for their dry matter productivity and quality potential for leaf meal production.

Materials and methods
The experiment was conducted at the Department of Veterinary Services farm in Tanah Merah, Kelantan from 1998 to 2001. The treatment consisted of two hybrid lines namely 40-1-18 (Bharu) and 62-6-8 (Rendang) cut at every 8, 10 and 12 weekly cutting intervals. The experiment was laid out in a randomised complete block design with three replications.

Prior to planting, dolomitic limestone at 1 t/ha was applied. This was followed by a basal fertilizer of triple superphosphate (TSP) at 30 kg P/ha and muriate of potash (MP) at 30 kg K/ha. Maintenance fertilizers at 50 kg P/ha per year (TSP) and 100 kg K/ha per year (MP) were split and applied after every harvest according to the cutting interval treatments. Weeding was done when necessary.

The two hybrid lines were first raised in the nursery for 2 months before planting in the field to obtain uniformity in seedlings size. These lines were planted at 50 cm x 50 cm in plots of 5 m x 10 m in three replications. The combination treatments were laid out in a randomised complete block design. The first overall cutback was done after 12 months of growth and cut thereafter according to the treatments. All the plants were cut at 50 cm above the ground level. The harvested portion was weighed and subsample was taken. The leaf and stem were separated, weighed and oven-dried at 65 °C for dry matter determination. The dried leaf portion was ground for proximate analysis. Total dry matter yield per hectare was derived based on the yield obtained from the plot while the crude protein yield was calculated by multiplying the crude protein content with the total leucaena leaf yield.

The data were analysed using analysis of variance (ANOVA) and further subjected to Duncan Multiple Range Test.

Results and discussion
Dry matter yield
The cumulative dry matter yield of leaf and stem increased as the cutting interval was increased from 8 to 12 weekly intervals. The increase was significant ($p < 0.05$) for both lines (Figure 1). Hybrid lines 40-1-18 produced higher dry matter yield than 62-6-8 at all cutting intervals. Total annual dry matter yield was highest at 12 weekly interval, but was not significant from those of the 10 and 8 weekly intervals. The total dry matter yields were 33, 39 and 40 t/ha for 40-1-18, and 26, 37 and 39 t/ha for 62-6-8 at 8, 10 and 12 weekly intervals, respectively.

The dry matter yield of leaf differed significantly ($p < 0.05$) in all three cutting intervals (Table 1). Hybrid line 40-1-18 achieved yields of 2 995, 3 692 and 5 094 kg/ha at 8, 10 and 12 weekly cutting...
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Similarly, 62-6-8 also showed a similar trend with 2 673, 3 494 and 5 021 kg/ha at the respective cutting intervals. It was estimated that an average leaf percentage of dry matter yield was about 50 and 53 in line 40-1-18 and 62-6-8, respectively.

The increase in total dry matter yield with the increase in cutting interval was in agreement with the results of Guevarra et al. (1978) and Ferraris (1979) which stated that cumulative yield increases with prolonged cutting intervals. This could be attributed to the development of more growing points and built up of food reserves that contributed to the growth of the plants before the main stem or coppice stem was cut. While at shorter cutting intervals, the recovery would be slower resulting in a lower rate of dry matter production (Cobbina 1998; Anon. 2002).

At longer cutting interval it is expected that there will be a decrease in leaf to stem ratio resulting from an increase in stem portion as the plant ages. However, in this study, the leaf dry matter yield continued to increase from 8, 10 to 12 weekly cutting intervals. Catchpool et al. (1985) found that cutting frequency ranging from 7–18 weeks has little effect on leaf dry matter yield. The optimum time for defoliation would be between 8–12 weeks (Wong and Devendra 1982).

### Crude protein in leucaena leaf meal

The crude protein content of both lines showed a significant decrease ($p <0.05$) with increased cutting intervals (Table 2). The highest crude protein content (29.6%) was obtained at the 8 weekly cutting interval in line 62-6-8. Similarly, line 40-1-18 gave the highest value of 28.77, but this was significantly ($p <0.05$) lower than that of line 62-6-8 cut at 8 weekly cutting interval.

The value generally decreased significantly ($p <0.05$) at 10 and 12 weekly cutting intervals in both lines. The crude protein content was 26.28% and 24.90% in 62-6-8, and 25.11% and 25.17% in 40-1-18 at their respective 10 and 12 weekly cutting intervals. The cumulative protein yield of leaf per year ranged from 4 635 to 5 140 kg/ha in 40-1-18, and 4 314 to 5 000 kg/ha in 62-6-8 (Figure 2).

The decrease in crude protein content of leaf with increased cutting intervals agreed with the result of Osman (1980). He stated that this could be due to a dilution effect of the greater dry matter yield and the advanced age of the tissues (Cobbina 1998).

The mean value of crude protein of leucaena leaf in 40-1-18 was 25.17% and in 62-6-8 between 8–12 weeks (Wong and Devendra 1982).

### Table 1. The dry matter yield of leaf and stem of two leucaena hybrid lines cut at three cutting intervals

<table>
<thead>
<tr>
<th>Leucaena lines</th>
<th>Cutting intervals (weeks)</th>
<th>Mean cumulative leaf dry matter yield (kg/ha)</th>
<th>Leaf yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Per harvest</td>
<td>Per year</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Leaf</td>
<td>Stem</td>
</tr>
<tr>
<td>40-1-8</td>
<td>8</td>
<td>2 995e</td>
<td>2 554e</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>3 692c</td>
<td>4 263c</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>5 094a</td>
<td>4 978a</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>3 927</td>
<td>3 932</td>
</tr>
<tr>
<td>62-6-8</td>
<td>8</td>
<td>2 673f</td>
<td>1 710f</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>3 494d</td>
<td>4 016d</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>5 021b</td>
<td>4 639b</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>3 729</td>
<td>3 455</td>
</tr>
<tr>
<td>LSD</td>
<td></td>
<td>63.6</td>
<td>54.7</td>
</tr>
</tbody>
</table>

Values in the same column having different letters are significantly different within each line at $p <0.05$. 

intervals, respectively (Figure 1). Similarly, 62-6-8 also showed a similar trend with 2 673, 3 494 and 5 021 kg/ha at the respective cutting intervals. It was estimated that an average leaf percentage of dry matter yield was about 50 and 53 in line 40-1-18 and 62-6-8, respectively.

The increase in total dry matter yield with the increase in cutting interval was in agreement with the results of Guevarra et al. (1978) and Ferraris (1979) which stated that cumulative yield increases with prolonged cutting intervals. This could be attributed to the development of more growing points and built up of food reserves that contributed to the growth of the plants before the main stem or coppice stem was cut. While at shorter cutting intervals, the recovery would be slower resulting in a lower rate of dry matter production (Cobbina 1998; Anon. 2002).

At longer cutting interval it is expected that there will be a decrease in leaf to stem ratio resulting from an increase in stem portion as the plant ages. However, in this study, the leaf dry matter yield continued to increase from 8, 10 to 12 weekly cutting intervals. Catchpool et al. (1985) found that cutting frequency ranging from 7–18 weeks has little effect on leaf dry matter yield. The optimum time for defoliation would be between 8–12 weeks (Wong and Devendra 1982).
Dry matter productivity and nutritive quality of leucaena was 26.93%. The values obtained in this study were comparable to the values reported elsewhere (NAS 1977; Cobbina 1998; Guodao and Dongjing 1998). The mean crude protein yield per crude protein content of leucaena exceeds the requirement of both beef cattle and dairy cows, where about 11% is required by beef cattle and about 16% by dairy cattle. The value of crude protein in leucaena was also higher than stylo (16%), glyricida (18%) and cassava (16%) (Wong and Aminah 1999) as well as kenaf (20%) (Mohd. Najib and Noor Ismawaty 2001). The high crude protein in leucaena could therefore be utilized for animal production.

Table 2. The ADF, ash and mineral contents (%) of two leucaena hybrid lines at 3 cutting intervals

<table>
<thead>
<tr>
<th>Leucaena lines</th>
<th>Cutting intervals</th>
<th>CP</th>
<th>ADF</th>
<th>Ash</th>
<th>Ca</th>
<th>P</th>
<th>Mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>40-1-8</td>
<td>8</td>
<td>28.77b</td>
<td>39.82d</td>
<td>6.52a</td>
<td>0.52c</td>
<td>0.21b</td>
<td>0.25b</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>25.11d</td>
<td>50.61c</td>
<td>6.33c</td>
<td>0.52c</td>
<td>0.19e</td>
<td>0.25b</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>25.17d</td>
<td>55.47a</td>
<td>5.02e</td>
<td>0.42e</td>
<td>0.18c</td>
<td>0.25b</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>26.35</td>
<td>48.63</td>
<td>5.96</td>
<td>0.49</td>
<td>0.19</td>
<td>0.25</td>
</tr>
<tr>
<td>62-6-8</td>
<td>8</td>
<td>29.60a</td>
<td>38.82e</td>
<td>6.29c</td>
<td>0.58b</td>
<td>0.21b</td>
<td>0.25b</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>26.28c</td>
<td>50.87b</td>
<td>6.43b</td>
<td>0.66a</td>
<td>0.23a</td>
<td>0.26ab</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>24.90e</td>
<td>50.60c</td>
<td>5.78d</td>
<td>0.46d</td>
<td>0.19e</td>
<td>0.27a</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>26.93</td>
<td>46.76</td>
<td>6.17</td>
<td>0.57</td>
<td>0.21</td>
<td>0.26</td>
</tr>
<tr>
<td>LSD</td>
<td></td>
<td>0.07</td>
<td>0.06</td>
<td>0.07</td>
<td>0.02</td>
<td>0.01</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Values in the same column with different letters are significantly different at \( p < 0.05 \)

Chemical composition of the leucaena

The acid detergent fibre (ADF) and ash were significantly different \( (p < 0.05) \) with increased in cutting intervals while Ca was not significant at 8 and 10 weekly, but reduced significantly \( (p <0.05) \) at 12 weekly cutting interval (Table 2). Phosphorus contents were not significant at the 10 and 12 weekly cutting intervals, but significant at 8 weekly cutting interval. Magnesium was not significantly affected by the cutting intervals in line 40-1-18. A similar trend was observed in leucaena line 62-6-8 (Table 2).

As a general rule, plant maturity is characterized by increased fibre and decreased crude protein content. This is proven in this study where the increased ADF with longer cutting intervals denoted increases in fibre, cellulose and lignin in the plants. As ADF increases, digestibility of forage usually decreases. This may affect the palatability of forage by the animals, which consequently affects animal production. The contents of crude protein, ADF, ash, Ca, P and Mg obtained in this study showed that they are sufficient to meet the nutrient requirements of ruminants.

Conclusion

High dry matter productivity and high crude protein yield were obtained from leucaena under local environment, indicating that the new hybrid lines of leucaena namely

Figure 2. Cumulative dry matter and crude protein yield of leucaena leaf meal for two selected lines

was 26.93%. The values obtained in this study were comparable to the values reported elsewhere (NAS 1977; Cobbina 1998; Guodao and Dongjing 1998). The mean crude protein yield per crude protein content of leucaena exceeds the requirement of both beef cattle and dairy cows, where about 11% is required by beef cattle and about 16% by dairy cattle. The value of crude protein in leucaena was also higher than stylo (16%), glyricida (18%) and cassava (16%) (Wong and Aminah 1999) as well as kenaf (20%) (Mohd. Najib and Noor Ismawaty 2001). The high crude protein in leucaena could therefore be utilized for animal production.
the 40-1-18 (Bharu) and the 62-6-8 (Rendang) have great potential to be used as protein sources for livestock. Their high yield in leaf dry matter and crude protein under repeated cutting frequency give them the possibility to be processed into leaf meal for utilization in livestock feed formulation and production.

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