Tropical Animal Production 1972 7:275-282

THE PERFORMANCE OF ONGOLE CATTLE OFFERED EITHER GRASS , SUN-DRIED LEUCAENA LEUCOCEPHALA OR VARYING PROPORTIONS OF EACH

S Wahyuni, E S Yulianti, W Komara, N G Yates[1],
J M Obst[1,2] and J B Lowry[1]

Agency for Development and Application of Technology, Jakarta

Thirty crossbred Ongole bulls were allocated to five dietary treatments. The dietary treatments were : (A) 100% grass ad libitum; (B) 80% grass: 20% leucaena; (C) 60% grass:40% leucaena ; (D) 40% grass: 60% leucaena; (E) 100% leucaena ad libitum. The diets were offered for a period of 26 weeks which was followed by a metabolism period of 7 days. Cattle offered only grass lost 0.015 kg/d. Liveweight gains for diets containing 40 and 60% leucaena (0.544 and 0.587 kg/d)were significantly higher than for diets containing 20 and 100% leucaena (0.292 and 0.306 kg/d) and feed conversion ratios were lowest for the 40 and 60% leucaena diets (12.0 and 11.3). Dry matter intakes were significantly higher for the 20, 40 and 60% leucaena diets (92.8, 95.8 and 94.0g/ kg $LW^{0.75}$/d) than for the 100% leucaena (75.1 g/kg$LW^{0.75}$/d) or 100% grass (77.6 g/kg$LW^{0.75}$/d) diets. Digestible energy intakes were 708, 871, 885, 809 and 774 KJ/kg$LW^{0.75}$/d for diets A to E respectively. Dry matter digestibility was significantly higher for 100% leucaena (51.3%) than for any other diet. Protein digestibility was significantly higher for 100% leucaena (61.9%) compared with 100% grass (53.0%) with other diets having intermediate values. The leucaena had average mimosine and DHP contents of 1.26% and 0.18% respectively. Plasma thyroxine concentrations averaged 53.3 and 52.9 ng/ml at the beginning of the study and after 20 weeks; there were no significant differences between treatments. Only 5% of the ingested mimosine and DHP was excreted in urine and faeces as mimosine and DHP in cattle offered 100% leucaena. Thus while the maximum benefit occurred with a minimum 40% inclusion level of leucaena, no ill effects on animal health were detected when leucaena was offered as a sole diet.

Key words: cattle, liveweight gain, leucaena, mimosine, digestibility

The legume *Luecaena leucocephala* has been shown to be a promising forage for animal production. For example, when used as a protein supplement for pen fed cattle it has given good liveweight gains (Jones 1977) and responses similar to other protein supplements such as meat meal (Siebert et al 1976) or ground-nut cake (Thomas and Addy 1977). It has also been shown to be an effective supplement for intensive beef production using liquid molasses/urea diets (Alvarez et al 1977) and for milk production (Flores - Ramos 1979).

On the other hand diets containing high proportions of leucaena have been shown to cause acute (Hegarty et al 1964; Reis et al 1975; Letts 1963) and chronic (Jones et al 1976; Holmes 1976) toxicities in ruminants. The acute toxicity has been attributed to the effects of mimosine (Jones 1979) and the chronic toxicity to DHP, a breakdown product of mimosine in the rumen (Hegarty et al 1964). The chronic toxicity decreases growth rates and is associated with altered plasma thyroxine levels (Holmes et al 1981;Jones et al 1976).

Clinical signs of toxicity may not always develop (Jones 1981) but the reasons for this are not clear. At present it does not seem possible to predict effects on animal health when animals are offered 100% leucaena . Because leucaena is being used and promoted to an increasing extent for

[1]*Research Institute for Animal Production, P.O.Box 123, Bogor, Indonesia*
[2]*Department of Agriculture, Pastoral Research Institute, Hamilton, Victoria 3300, Australia*

ruminants in Indonesia, a study was carried out to determine the response of cattle to increasing proportions of leucaena in a grass diet and also to determine the nutritive value of a sole diet of leucaena and whether this posed any problems from an animal health point of view.

Materials and Methods

Animals, treatment and design: The experiment was conducted at the Research Institute for Animal Production, Ciawi, West Java. Thirty Ongole bulls 14 to 18 months of age with a mean liveweight of 222 ± 22kg were used. They were housed in individual pens, under cover. The animals were allocated to 5 groups of 6 animals by restricted randomization based on liveweight. Five dietary treatments were imposed as follows, on a dry matter basis:

A) 100% grass
B) 80% grass plus 20% leucaena
C) 60% grass plus 40% leucaena
D) 40% grass plus 60% leucaena
E) 100% leucaena

The grass, a mixture of naturally occurring species, was cut daily and offered in a fresh chopped form. The leucaena used was *Leucaena leuco - cephala* cv Hawaiian Giant. The leaves and young stems were chopped into approximately 3 to 4 cm lengths and sun-dried for 3 to 4 days prior to feeding. Dried leucaena was used because of the uncertainty of obtaining fresh material daily.

Management and procedure : The diets were offered for 26 weeks and the animals were then placed in metabolism cages for a 7 day adjustment period followed by a 7 day measurement period. Diets A and E were offer- ad libitum. For diets B, C and D the grass and leucaena were offered separately but at the same time each day (0830 h); the quantities of grass and leucaena offered were adjusted daily to achieve the desired propor - tional intake of each. Samples of feed were taken three times each week for dry matter determination and these results were used to calculate the quantity of grass and leucaena offered to achive the desired proportions on a dry matter basis. Water was freely available.

Feed samples were taken weekly for chemical analysis and blood samples were taken weekly by veni-puncture for packed cell volume and haemo - globin determinations. Blood samples were taken before the study began and after 10 and 20 weeks for plasma thyroxine analysis. The bulls were observed frequently for signs of toxicity from leucaena feeding and thyroid glands were palpated manually from time to time to determine if any enlargement was apparent. Liveweights were recorded weekly.

Metabolism procedures: Weights of feed offered and residues were recorded daily and samples of both were taken,dried at 100°C to determine dry matter percentage,and bulked over the collection period. At the end of the collection period duplicate subsamples of feed and residues were taken for analysis.

The daily output of faeces was recorded for each animal. Each day a sample representing 3% of the output from each animal, was taken and dried at 100°C to determine dry matter percentage. Each day's samples were bulked and at the end of the collection period duplicate subsamples were taken for analysis.

The daily urine output from each animal was collected into a mixture of 200 ml concentrated sulphuric acid and water (1:1). Five percent of bulked samples were stored at -10°C during and after the collection period until required for subsampling and analysis.

Analyses: Prior to analysis of feed, feed residues and faeces samples were ground through a 1 mm screen in a laboratory mill. Feed samples were analysed for nitrogen, calcium, phosphorus, magnesium, fat, energy, crude fibre, ash, mimosine and 3-hydroxy-4-1(H)- pyridinone (DHP). Feed residues and faeces were analysed for nitrogen and energy, and urine for nitrogen. In addition, faeces and urine from cattle offered 100% leucaena were analysed for mimosine and DHP.

Nitrogen was determined by the Technicon Industrial Method No. 344 74 A/A, and energy using a Gallenkamp ballistic bomb calorimeter. Crude fibre was determined by the AOAC (1970) method. Ash was determined by heating at 500°C for 16 minutes. Calcium and phosphorus were determined by acid digestion of all materials followed by atomic absorption spectrometry(calcium) and calorimetry using molybdo-vanadate (phosphorus). Mimosine and DHP were determined using a high pressure liquid chromatography method (Cook and Lowry, unpublished) and plasma thyroxine was determined by radio-immunoassay using kits supplied by the Radio Chemical Centre, Amersham, U.K. Haemoglobin was determined with a haemometer and packed cell volume was determined using a micro-haematocrit centrifuge and micro-capillary tube reader.

Results were analysed by analysis of variance and differences between treatments were tested by least significant differences (LSD).

Results

The leucaena used in this study had a similar chemical composition (Table 1) to that reported by the National Academy of Sciences (1977) for

Table 1:

Average composition of leucaena and a mixture of natural grasses offered over a 26 week period (± SE of mean)

	Grass	Leucaena
Crude protein (%)	8.83 ± 1.5	22.28 ± 1.9
Crude fibre (%)	30.7 ± 4.9	25.8 ± 3.8
Ash (%)	15.1 ± 3.0	9.7 ± 2.0
Fat (%)	2.97 ± 1.75	3.29 ± 1.00
Calcium (%)	0.38 ± 0.16	1.85 ± 0.48
Phosphorus (%)	0.20 ± 0.06	0.20 ± 0.07
Magnesium (%)	0.24 ± 0.08	0.30 ± 0.03
Gross energy (MJ/kg)	19.55 ± 2.51	19.80 ± 2.55
Mimosine (% DM)	-	1.26
DHP (% DM)	-	0.18

leucaena meal from Malawi. The average mimosine concentration was about half those reported by Jones et al(1978) and ter Meulen et al (1979). The sun dried leucaena contained 0.18% DHP.

Cattle receiving grass: leucaena ratios of 60:40 or 40:60 gave similar liveweight gains (0.544 and 0.587 kg/d). These were significantly higher than those for 100% leucaena (0.306 kg/d) and for 80% grass : 20% leucaena (0.292 kg/d). Animals receiving grass only lost weight at the rate of 0.015 kg/d (Table 2).

Table 2:

Liveweight gains, dry matter intakes, energy intakes and feed conversion ratios for cattle offered either grass, leucaena or varying proportions of each, over a 26 week period

	Treatments					
	A	B	C	D	E	±SE
Percentage of grass	100	80	60	40	0	
Percentage of leucaena	0	20	40	60	100	
LWG (kg/d)	-0.015^{c}	0.292^{b}	0.544^{a}	0.587^{a}	0.306^{b}	0.043
Digestible energy intake KJ/kg $LW^{0.75}$/d	77.6^{b}	92.8^{a}	95.8^{a}	94.0^{a}	75.1^{b}	3.6
DMI (kg/d)	4.52^{a}	5.85^{b}	6.41^{b}	6.45^{b}	4.92^{a}	0.28
FC ratio	-	23.4^{a}	10.0^{b}	11.3^{b}	18.0^{ab}	2.7
DMI g/kg $LW^{0.75}$/d	708^{a}	871^{a}	885^{a}	809^{a}	774^{a}	81
Dig. energy intake (MJ/d)	40.8^{b}	55.1^{ab}	59.3^{a}	55.7^{ab}	49.1^{ab}	5.2
Dietary crude protein (%)	8.8	11.5	14.2	16.9	22.9	-

[a,b,c] Values with the same superscript are not significantly different at the 5% level

Total dry matter intakes (DMI) were similar for grass:leucaena combinations 80:20, 60:40 and 40:60 being 92.8, 95.8 and 94.0 g/kg $LW^{0.75}$/d respectively. These were significantly higher than for grass alone(77.6 g/kg $LW^{0.75}$/d) or leucaena alone (75.1 g/kg $LW^{0.75}$/d)

The feed conversion ratios (FCR) were significantly lower for the 60% grass:40% leucaena and 40% grass:60% leucaena diets (12.0 and 11.3) compared with the 80% grass:20% leucaena diet (23.4). The feed conversion ratio for the 100% leucaena was 18.0 (Table 2).

The digestibility of energy was similar for all treatments(Table 3) with an overall mean of 47.0%. However, there was considerable variation between animals within all treatments (except the 100% leucaena treatment) which resulted in a high standard error of the means (± 4.3). Thus the digestible energy intake per kg metabolic liveweight was not significantly different among treatments and averaged 809 KJ/kg $LW^{0.75}$/d, though the highest value (885 KJ/kg $LW^{0.75}$/d) was 25% greater than the lowest value (708 KJ/kg $LW^{0.75}$/d) (Table 2).

Protein intake increased with increasing proportions of leucaena. Protein digestibility was significantly higher for 100% leucaena (61.9%) than for 100% grass (53.0%) with the other treatments having intermediate values (Table 3). Nitrogen balances were positive on all treatments and increased

Table 3:

Digestibilities of dry matter, energy and protein, nitrogen balances, packed cell volume and haemoglobin concentrations for cattle offered either grass, leucaena or varying proportions of each over a 26 week period.

	Treatments					
	A	B	C	D	E	±SE
Percentage of grass	100	80	60	40	0	
Percentage of leucaena	0	20	40	60	100	
Dry matter digestibility (%)	41.6^{b}	44.1^{b}	46.4^{b}	44.2^{b}	51.3^{a}	1.7
Protein digestibility (%)	53.0^{c}	56.9^{bc}	58.6^{ab}	56.7^{bc}	61.9^{a}	1.7
Energy digestibility (%)	45.6^{a}	48.1^{a}	47.3^{a}	43.7^{a}	50.4^{a}	4.3
Nitrogen balance (g/d)	13.6^{c}	31.5^{b}	38.8^{b}	42.8^{ab}	53.9^{a}	5.1
Packed cell volume	37.0^{a}	36.5^{a}	38.3^{a}	39.0^{a}	37.1^{a}	1.1
Haemoglobin (%)	14.2^{a}	13.7^{a}	14.4^{a}	14.1^{a}	14.0^{a}	0.[illegible]

[a,b,c] Values with the same superscript are not significantly differentat the 5% level

with increasing proportions of leucaena. Nitrogen balance for animals offered grass only (13.6 g/d) was significantly lower than for grass:leucaena combinations 80:20, 60:40 and 40:60 (31.5, 38.8 and 42.8 g/d respectively) and nitrogen balances for 100% leucaena and 40% grass:60% leucaena were similar (53.9 and 42.8 g/d) (Table.3).

Dry matter digestibilities were similar for all diets containing grass and averaged 44.1%. The 100% leucaena diet had a digestibility of 51.3% which was significantly higher than for any other treatment.

There were no significant differences between dietary treatments in plasma thyroxine concentrations at the beginning of the study, the mean value being 53.3 ng/ml (Table 4). After 10 weeks the plasma thyroxine concentration in animals offered the 40% grass:60% leucaena diet was significantly higher (58.0 ng/ml) than for animals offered the 100% grass (39. 7 ng/ml) or 100% leucaena (38.5 ng/ml) diets. Thus there was no relationship between the proportion of leucaena in the diet and the plasma thyroxine concentration. After 20 weeks there were again no significant differences between treatments and the mean plasma thyroxine concentration was 52.9 ng /ml. There were no significant differences between treatments in packed cell volumes or haemoglobin concentrations (Table 3).

There was no visual evidence of mimosine DHP toxicity and no detect - able differences (by manual palpation) between treatments in the size of the thyroid glands. The average daily intakes of mimosine and DHP during the 7 day measurements period in metabolism cages for cattle offered 100 % leucaena were 66.2 and 12.9 g respectively. Daily faecal excretions of mimosine and DHP were 0.08 and 0.05 g respectively.

Table 4:

Average plasma thyroxine concentrations (ng/ml) in cattle offered either grass, leucaena or varying proportions of each, at the beginning of the study and after 10 and 20 weeks.

	Week		
	0	10	20
100% grass	48.7[a]	39.7[a]	47.1[a]
80% grass: 20% leucaena	48.1[a]	48.3[ab]	51.1[a]
60% grass: 40% leucaena	56.9[a]	51.8[ab]	64.7[a]
40% grass: 60% leucaena	62.9[a]	58.0[b]	59.2[a]
100% leucaena	49.7[a]	38.5[a]	42.5[a]
± SE	5.5	5.5	5.5

[a,b]Values within columns with the same superscript are not significantly different

Discussion

In this study cattle offered a diet of mixed natural grasses ad libitum were not able to maintain their liveweight over a period of 26 weeks. In comparison with NRC (1971) requirements for maintenance , the protein intake of 400 g/d exceeded the maintenance requirement of 283 g/d and the calculated metabolizable energy intake of 33.0 MJ/d (D.E. x 0.81) was slightly higher than the NRC maintenance requirement of 31.1 MJ/d. Though a small liveweight gain might have been expected, based on these figures,the differences are probably too small to draw any meaningful conclusions about the use of NRC values for cattle offered tropical forage.

Although animals offered leucaena as a sole diet had a similar dry matter intake to those offered only grass, liveweight gain was significantly higher for leucaena. However, the maximum liveweight gain occured with a minimum 60% inclusion of leucaena in the diet. Furthermore, there was a significant reduction in the feed conversion ratio from 23.4 to 12.0 when the proportion of leucaena was increased from 20 to 40%. The liveweight gain of 0.544 kg/d for animals offered the 40% leucaena: 60% grass diet was similar to that for Ongole cattle offered Elephant grass (*Pennisetum purpureum*) ad libitum plus 4 kg/d rice bran (0.52 kg gain/d) (Moran 1982) and compares with a liveweight gain of 0.65 kg/d gain for Ongole cattle offered a diet of 70% Elephant grass : 30% concentrate (Moran 1980).

The significant improvement in performance of animals offered 40% leucaena, compared with those offered 20% leucaena was not associated with any significant differences between the two dietary treatments in any of the measurements recorded. However,the trend in most of the data suggests that the better performance of animals offered 40% leucaena was due to the cumulative differences in the attributes measured.

The data for animals offered 100% leucaena has provided information on its nutritive value for cattle amd established that animal health problems did not arise when leucaena was fed continuously for 6 months. In relation to the first point, no comparative information could be found in the literature where leucaena had been fed for a long period of time but, over a shorter period of time, Jones et al (1978) recorded an average dry matter intake of approximately 70 g/kg $LW^{0.75}$/d and a liveweight gain of 0.18 kg/d for cattle. Though the dry matter intake recorded in this study was similar to that recorded by Jones et al (1978) the liveweight gain was 70% higher (0.306 vs 0.18 kg/d).

Evidence from frequent visual observations, manual palpation of the thyroid glands and plasma thyroxine concentrations indicated that there were no problems associated with mimosine or DHP toxicity. Although the plasma thyroxine concentrations in animals offered 100% leucaena tended to decline after 10 weeks and then recover at 20 weeks, there was a similar trend in animals offered 100% grass which suggests that factors other than the diet were responsible for the trends observed.

Results from previous studies suggest that both mimosine intake and the ability to degrade mimosine and DHP in the rumen are important in determining whether ruminants develop clinical signs of toxicity when offered leucaena diets (Jones et al 1978; Jones 1981). Furthermore , there appears to be threshold concentration of DHP circulating in the blood , above which animals develop signs of toxicity. Thus ruminants without the ability to degrade DHP like those in Australia (Jones personal communication) do not develop signs of toxicity provided mimosine intakes are low, but in ruminants which are able to degrade DHP, like those in Hawaii (Jones 1981) mimosine intakes can be high without causing toxicity.

It has been shown that local cattle have the ability to degrade DHP in the rumen (Tangendjaja - personal communication). In the present study cattle offered 100% leucaena excreted only 5% of the ingested mimosine and DHP in the faeces and urine. It is suggested that signs of toxicity did not develop because of the extensive degradation of mimosine and DHP which occured, and that the circulating level of DHP was too low to affect thyroid function. Although mimosine intake was relatively low, because of the low mimosine content of the dried leucaena ,it seems unlikely that DHP toxicity would develop with higher mimosine intakes because of the animals ability to degrade DHP and thus maintain low circulating DHP levels and normal thyroid function.

Conculsions

This study has shown the benefits to be derived from the inclusion of varying proportions of leucaena in a grass diet and has also provided information on the nutritive value of sun dried leucaena for cattle. From a practical point of view the maximum benefits from leucaena were achieved with a minimum 40% inclusion in a grass diet. Though we are hesitant to generalize on the results for 100% leucaena because of adverse effects observed by others, under the conditions of this study the animals gained weight and showed no signs of toxicity from mimosine or DHP.

Acknowledgements

The authors would like thank Mr.A.Day for his assistance in the growth and metabolic studies, Mr.I.Barchia for his advice and help with statistical analyses, and also the personel of the Agricultural Service of the Research Institute for Animal Production for their laboratory analyses.

References

Alvarez F J, Wilson A & Preston T R 1977 *Leucaena leucocephala* as a combined source of protein and roughage for steers fattened on molasses/urea Tropical Animal Production 2:228-91

AOAC 1970 Official methods of analysis 11tn Ed Association of Official Agricultural Chemists Washington D C

Flores-Ramos J F 1979 *Leucaena leucocephala* for milk production: effect of supplementation with leucaena on cows grazing pastures Tropical Animal Production 4:55-60

Hamilton R T, Donaldson L E & Lambourne L J 1971 *Leucaena leucocephala* as a feed for dairy cows: direct effect on reproduction and residual effect on the calf and lactation Australian Journal of Agricultural Research 22:681-692

Hegarty M P, Schinkel P G & Court R D 1964 Reaction of sheep to the consumption of *Leucaena glauca* Benth and to its toxic principle mimosine Australian Journal of Agricultural Research 15:153-165

Holmes J H G 1976 Growth of Brahman cross heifers grazing leucaena Proceedings Australian Society of Animal Production 11:453-456

Holmes J H G, Humpry J D, Walton E A & O'Shea J D 1981 Cataracts, goitre and infertility in cattle grazed on an exclusive diet of *Leucaena leucocephala* Australian Veterinary Journal 57:257-261

Jones R J 1977 CSIRO Division of Tropical Crops and Pastures Divisional Report 1976-77 p 46-47

Jones R J 1979 The value of *Leucaena leucocephala* as a feed for ruminants in the tropics World Animal Review FAO 31:13-23

Jones R J 1981 Does ruminal metabolism of mimosine explain the absence of leucaena toxicity in Hawaii? Australian Veterinary Journal 57:55

Jones R J , Blunt C C & Holmes J H G 1976 Enlarged thyroid glands in cattle grazing leucaena pastures Tropical Grasslands 10:113-116

Jones R J, Blunt C G & Nurnberg B I 1978 Toxicity of *Leucaena leucocephala*; the effect of iodine and mineral supplements on penned steers fed a sole diet of leucaena Australian Veterinary Journal 54:387-392

Letts G A 1963 *Leucaena glauca* and ruminants Australian Veterinary Journal 39:287-288

Moran J B 1980 Performance of Indonesian beef breeds under traditional and improved management systems First Asian-Australasian Animal Science Congress Selangor Malaysia Sept 1980

Moran J B 1982 The response of Zebu cattle and swamp buffalo to graded levels of rice bran supplementation of an elephant grass diet I Feed intake utilization and growth rates Journal of Agricultural Science Cambridge (submitted)

National Academy of Sciences 1977 Leucaena: promising forage and tree crop for the tropics Ruskin F R(ed) National Academy of Sciences Washington D C

NRC 1971 Nutrient requirements of beef cattle NAC-NRC Washington D C

Reis P J, Tunks D A & Hegarty M P 1975 Fate of mimosine administered orally to sheep and its effectiveness as a defleecing agent Australian Journal of Biological Science 28:495- 501

Siebert B D, Hunter R A & Jones P N 1976 The utilization by beef cattle of sugarcane supplemented with animal protein, plant protein or non-protein nitrogen and sulphur Australian Journal of Experimental Agriculture and Animal Husbandry 16:789-794

ter Meulen U, Struck S, Schulke E & El-Harith E A 1979 A review on the nutritive value and toxic effects of *Leucaena leucocephala* Tropical Animal Production 4:113-126

Thomas D & Addy B L 1977 Tropical pasture legumes and animal production in Malawi World Review of Animal Production 13(3):47-52

Received 24 th November 1982