Preliminary Study of *Leucaena leucocephala* as Feed for Livestock

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Abstract

The tender shoots and leaves of leucaena (*Leucaena leucocephala*) are high in protein and other nutrients but they also contain the amino acid mimosine which can be toxic to livestock if used inappropriately. Feeding experiments using leucaena showed that 5% leucaena leaf meal could be used in the feed ration for chickens and 10% for pigs, but there was no advantage and a suggestion of slightly reduced liveweight gains and toxicity in chickens. Feeding 30% tender shoots and leaves in fresh forage to cattle increased liveweight gains by 32%.

LEUCAENA (*Leucaena leucocephala*) is a valuable, high quality fodder tree for the tropics. It is capable of producing high yields and in Taiwan it produces 2500–4000 kg/ha dry matter of tender shoots and leaves each year. Leucaena leaf contains 55% total digestible nutrients (TDN), 2.42 Mcal/kg of digestible energy (DE), and 1.98 Mcal/kg of metabolisable energy.

However, leucaena does contain the non-protein amino acid mimosine and if fed in excess, particularly to monogastric animals, adverse effects and even death in serious cases can occur. It is therefore very important to have a good understanding of safe feeding rates. In this context, livestock feeding experiments with leucaena were conducted at Production Team #10, Experimental Farm, Chinese Academy of Tropical Agricultural Sciences (CATAS) during the period 1994 to 1997. Preliminary results are given in this paper.

1. Chicken Feeding Experiments with Leucaena Meal

Materials and methods

Four experiments were conducted over the following periods: April 27 to August 11, 1994; November 31 to December 20, 1994; September 14 to October 14, 1995; and January 23 to February 31, 1996. Treatments and ration formulae are given in Table 1.

The chicken breeds used for the experiments were Xingbuluo, Hongbuluo and Fujian for Experiments 1, 2 and 3 and 4 respectively.

Nutrient analysis of the leucaena meal used in the experiments is presented in Table 2 in comparison with alfalfa.

The chickens were housed in cages in all four experiments where they ate and drank freely under natural sunlight. All birds were drenched for ascarid and innoculated with Xinchengfang vaccine during the pre-experiment period.

Results

There was a suggestion of slightly lower weight gains in treatments containing leucaena compared to the controls (Table 3). Higher levels of leucaena feeding would be necessary to confirm this result.

Observations indicated that chickens fed rations containing 5% or 6.2% leucaena showed some rough feathers, feather shedding and/or pecking in some birds.

Dissection of birds at the end of the experiment showed a darker, yellow skin and flesh, a larger gall bladder and spleen and harder liver in birds fed leucaena. However, no birds died in any of the four experiments.

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Table 1. Chicken feed ration treatment and formulae.

Experiment/Treatments		Maize (%)	Cassava (%)	Rough rice (%)	Wheat bran (%)	Peanut cake (%)	Sesame cake (%)	Fish meal (%)	Rice Bran (%)	Leucaena (%)	ME (Mcal/kg)	Crude protein (%)
Experiment 1	Control	60	–	10	–	20	–	7	–		2.83	18.1
	3.8% treat.	55.8	10	5	–	17	–	7	–	3.8	2.76	17.3
	5% treat.	55.4	9.3	5	–	17	–	7	–	5	2.74	17.3
	6.2% treat.	53.5	10	5	–	17	–	7	–	6.2	2.70	17.6
Experiment 2	Control	56	–	10	–	20	–	12	–	–	2.82	21.8
	3% treat.	53	3	10	–	20	–	12	–	3	2.72	21.5
	6% treat.	53	–	10	–	18	–	12	–	6	2.64	21.4
Experiment 3	Control	58.5	20	–	–	15	–	5	–	–	3.10	15.6
	4.8% treat	5 kg of Leucaena per 100 kg of control feed									3.03	16.0
	6.5% treat.	7 kg of Leucaena per 100 kg of control feed									3.02	16.1
Experiment 4 Phase 1	Ctrl	39	23	–	6	11	12	6	3	–	2.85	18.3
	5%	39	23	–	1	11	12	6	3	5	2.79	18.7
Phase 2	Ctrl	38	30	–	5	11	10	6	–	–	2.87	17.3
	5%	38	30	–	–	11	10	6	–	5	2.84	17.7

Table 2. Nutrient composition (%) of *Leucaena leucocephala*.

	Crude protein	Crude fat	Crude fibre	Crude ash	Extract without N	Ca	P	Mimosine
Leucaena	26.7	5.1	11.40	6.25	50.56	0.8	0.21	5.88
Alfalfa meal	22.5	1.3	28.3	9.0	27.1	1.26	0.25	–

* Source: Pig and Chicken Feed Component and Nutritional Value, compiled by China Society for Study of Animal Nutrition and Animal Husbandry Institute, Chinese Academy of Agricultural Sciences.

Table 3. Chicken weight gain (g).

			Weight gain (g)	Feed consumed (g)	Feed/Conversion ratio
Experiment 1	Control		880	–	–
	3.8% treat.		675	–	–
	5% treat.		843	–	–
	6.2% treat.		801	–	–
Experiment 2	Control		475	1970	4.2
	3% treat.		511	1933	3.8
	6% treat.		440	1910	4.4
Experiment 3	Control		425	1633	3.8
	4.8% treat.		411	1605	3.9
	6.5% treat.		381	1590	4.2
Experiment 4	Phase 1	Control	427		3.1
		5% treat.	405		
	Phase 2	Control	296		3.6
		5% treat.	299		3.6

2. Pig Feeding Experiment with Leucaena Leaf Meal

Materials and methods

Two experiments were undertaken between July 7 and October 8, 1996, and April 14 and November 12, 1997. Treatments and ration formulae are given in Table 4.

All pigs were the F1 generation of Subai × Lingao breeds. They were 75 days-old for Experiment 1 and about 90 days-old for Experiment 2.

They were all injected against swine pest, diamond disease and lung plague and drenched for ascarid in the pre-experiment period.

Results

There was no significant effects of treatment on weight gain of pigs in either experiment (Table 5).

3. Cattle Feeding Experiment with Fresh Leucaena Forage

Materials and methods

The experiment was conducted from August 11 to November 11, 1997 at the Production Team #10, Experimental Farm, CATAS.

There were two treatments, fresh grass forage alone or fresh grass plus 30% fresh leucaena leaf.

Local one-year-old cattle were used for the experiment with one bull and one cow in each treatment.

Results

Inclusion of 30% leucaena forage in the diet increased liveweight gain from 430 g/head/day to 569 g/head/day. There were no adverse effects of the leucaena on the cattle during this period.

Discussion

There was no change in liveweight gain with up to 5% leucaena included in the diet of chickens. At higher levels, toxicity symptoms appeared and there was a suggestion of reduced liveweight gain. There was no change in liveweight gain of pigs fed up to 10% leucaena in the diet. Leucaena fed as 30% of diet increased liveweight gain of cattle.

There would appear to be no value in including leucaena in the diet of chickens. There may be a small benefit in feeding leucaena to pigs and there was a definite advantage when it was fed to cattle.

Pelletisation or flavouring of leucaena feed may improve its palatability and reduce feed waste.

Table 4. Pig feed ration treatment and formulae.

		Maize (%)	Cassava (%)	Rough rice (%)	Wheat bran (%)	Peanut cake (%)	Fish meal (%)	Rice bran (%)	Leucaena (%)	ME (Mcal/kg)	Crude protein (%)
Experiment 1	Control	11	33	13	5	19	4	15	–	2.95	15.8
	5% treat.	11	33	13	5	19	4	10	5	2.96	16.8
	10% treat.	11	33	13	5	19	4	5	10	2.96	17.9
	15% treat.	11	33	13	5	19	4	–	15	2.97	18.9
Experiment 2	Control	–	50	5	5	25	5	10	–	2.85	18.3
	5% treat.	–	50	5	5	25	5	–	5	2.79	18.7

Table 5. Pig weight gain (kg).

		Weight gain	Feed consumed	Feed/pork ratio
Experiment 1	Control	165	619	3.8
	5% treat.	161	600	3.7
	10% treat.	166	603	3.6
	15% treat.	162	600	3.7
Experiment 2	Control	418	154	3.7
	5% treat.	422	153	3.6

Milk Production from Ruzi mixed with *Leucaena*, Ruzi Alone and Ruzi Supplemented with *Lablab purpureus*

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Abstract

Three groups of dairy cattle (n=8/group) were compared under different grazing managements, viz., strip-grazed on pure ruzi grass (*Brachiaria ruziziensis*), strip-grazed on a ruzi/leucaena pasture or strip-grazed on pure ruzi in the morning and on lablab (*Lablab purpureus*) in the afternoon. The animals that received the leucaena or lablab in combination with the grass produced higher daily milk yields (14.4 and 13.6 kg/cow) and fat percentages (4.5% and 4.2%) than those on pure grass alone (11.9 kg/cow for milk yield and 4.0% for fat). This advantage is likely to be due to the greater crude protein levels in the legume/grass mix compared with that of pure grass alone. It is concluded that growing tree legumes with grass or sowing of pure herbaceous legumes can be recommended as pasture for dairy cattle in Thailand.

GRASS/LEGUME pastures are not widely used to reduce the cost of milk production in Thailand due to the difficulty of maintaining legumes in mixtures with grasses. In order to overcome this problem, the use of tree legumes such as leucaena (*Leucaena leucocephala*) instead of herbaceous legumes is of practical significance. Sowing of pure legume in a small area and using this for special purposes has also been recommended by Wongsuwan and Watkin (1990). This paper reports a grazing trial in which milk production from ruzi grass (*Brachiaria ruziziensis*) mixed with leucaena and ruzi supplemented with lablab (*Lablab purpureus*) were compared to ruzi grass alone.

Materials and Methods

The experiment was conducted at the Dairy Promotion and Organisation of Thailand, located at Muaklek, Saraburi, 150 km northeast of Bangkok. The soil is a clay loam of moderate fertility with pH 6.5. Climatic conditions at the experimental site are monsoonal with the rainy season extending from May to October with peak precipitation in September and averaging 1012 mm annually. From November to April, the weather is relatively dry. Mean maximum and minimum temperatures are 34.1 °C and 18.7 °C respectively, with a relative humidity averaging 77%. The experiment was carried out for 14 weeks commencing on 7 June and terminating on 14 September 1995. A pre-experimental period of one week was allowed for the animals to adjust.

The experimental area was subdivided into six paddocks ranging in area from 0.80–0.96 ha. Two paddocks were used for each treatment. All paddocks were ploughed and cultivated to produce a fine and firm seedbed before sowing on 10 July 1994. A basal fertiliser (15N-15P-15K) was applied before sowing at the rate of 200 kg/ha. For the mixed pastures treatment (Ruzi/leucaena), leucaena was planted in rows (100 × 50 cm) on 15 July 1994 with approximately 20 000 plants per hectare and ruzi grass was grown between the rows of leucaena by drilling the seeds at the rate of 12 kg/ha. For the pure ruzi grass alone, seeds were drilled in rows (50 cm between rows) using a seeding rate of 24 kg/ha.

Lablab purpureus was sown on March 15, 1995 in rows (50 × 25 cm) at approximately 80 000 plants/ha for the supplementary treatment.

All paddocks, except the *Lablab purpureus* were cut to 15 cm for ruzi grass and 25 cm for leucaena on 28 April 1995 and fertilser (15N-15P-15K) was applied at the rate of 200 kg/ha.

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Twenty-four European crossbred cows in their first-to-third lactation and their first and second months of lactation period were selected. They were balanced for these factors and also the previous milk yield across the three treatments, viz.:

1. Strip-grazed on pure ruzi grass alone for 24 hours daily, apart from twice-daily milking.
2. Strip-grazed on a ruzi/leucaena mixed pastures for 24 hours daily as in group 1.
3. Strip-grazed on pure ruzi grass from 1.00 pm–5.00 am and strip-grazed on pure *Lablab purpureus* from 5.00 am–1.00 pm.

Rotational grazing was adopted, with an average grazing interval of 25–30 days such that there were three grazing cycles in the 98 days of the trial. Pasture was grazed down to 15–25 cm above ground. All cows were also fed with concentrate (14% CP) according to their individual milk production daily, at the rate of 1 kg per 3 kg of milk per day. Pasture production and chemical compositions were measured before and after grazing by using nine quadrats (100 × 100 cm) in each treatment. Pasture intake was calculated as the difference between pasture dry matter on offer at the beginning and end of each grazing period.

Results

Animal production

Animals grazing ruzi and supplemented with lablab achieved the highest average daily milk yield of 14.4 kg/cow, when compared to 13.6 and 11.9 kg/cow in the leucaena/ruzi mixed and pure ruzi pasture respectively (Table 1).

Milk production from the supplemented and mixed pasture treatments remained relatively high throughout the experimental period compared with the pure grass alone (Figure 1). Milk fat percentage showed a noticeable increase in the legume added treatments (2 and 3) compared with the ruzi grass only treatment.

At the end of the experiment, the cows grazing ruzi grass alone, grazing ruzi mixed with leucaena and supplemented with lablab showed weight gains of 99, 66 and 209 gm/head/day respectively (Table 1).

Pasture production and protein content

During the first cycle of grazing, all pasture treatments had 35–50 days regrowth (Table 2) but in the second and third grazing cycles the grazing interval was reduced to 25–30 days. As a result, the amount of pasture on offer was greater in the first cycle but with a lower crude protein content, compared with the lower pasture yield but much higher protein content in the later grazing cycles.

However, the pure ruzi grass alone was still noticeably superior in dry matter on offer to the rest. All legume yields in the mixed and supplemented treatments declined following the second and the third cycles of grazing, but maintained a consistently high crude protein percentage compared to that of the ruzi grass.

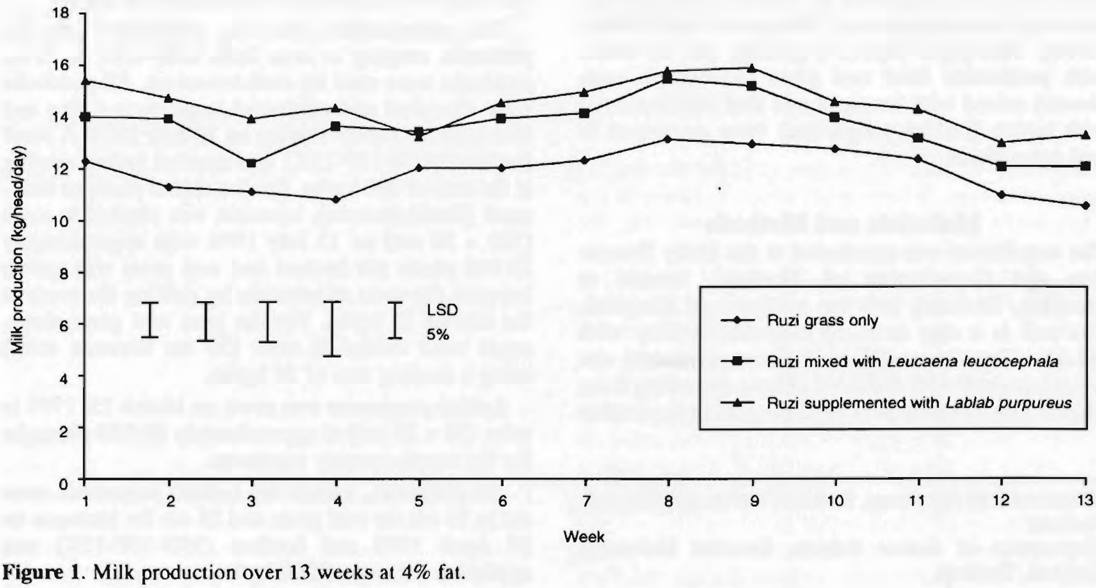

Figure 1. Milk production over 13 weeks at 4% fat.

Table 1. Effect of pasture management on dry matter on offer, on milk production (kg/head/day) and milk fat (%) over 13 weeks.

Treatment	Milk production (adjusted to 4% fat)	Milk fat (%)	Pasture dry matter intake (kg/head/day)	L.W.G. (g/head/day)
1. Ruzi grass alone	11.9 b	4.0 b	8.2	98.9 a
2. Ruzi/leucaena mix	13.6 ab	4.2 ab	10.8	65.9 a
3. Ruzi in the morning, lablab in the afternoon	14.4 a	4.5 a	11.2	208.8 a

Table 2. Pasture on offer before grazing of each grazing cycle (kg/ha) and their protein content.

Treatment		Grass		Legume		Total
		DM	% CP	DM	% CP	
Cycle 1	T1[1]	3056	6.40	—	—	3056
	T2	1831	5.90	688	25.6	2519
	T3	1538	6.30	438	23.4	1976
Cycle 2	T1	2463	12.25	—	—	2463
	T2	1156	12.38	356	27.4	1512
	T3	1088	12.64	744	24.9	1832
Cycle 3	T1	2006	12.73	—	—	2006
	T2	1100	11.51	175	23.4	1275
	T3	969	12.93	375	25.5	1344

[1] T1 Ruzi grass alone; T2 Ruzi mixed with Leucaena; T3 Ruzi supplemented with Lablab.

Dry matter intake of the cows grazing ruzi grass alone, grazing mixed leucaena and grazing ruzi and supplemented with lablab were 8.2, 10.8 and 11.2 kg/head/day respectively (Table 1).

Discussion

The results of this experiment indicate the importance of forage legume inclusions in pastures for dairy cattle production. The animals receiving the legumes through supplementation or mixed with the grass showed higher milk yield and fat levels than that of the pure grass alone.

This advantage was possibly due to the higher crude protein levels (Table 2) and higher forage intake (Table 1) compared with grass alone, as reported by Stobbs (1975) and Muinga et al. (1995). Similar results have been reported by Abdulrazak et al. (1996) in that supplementation with leucaena increased the total DM intake linearly without depressing the intake of napier grass.

The superior milking performance due to legume inclusion was particularly evident during the first four weeks of the experiment, probably due to the poor quality of the ruzi grass in that period. Therefore, the legume added through the mixed grass/legume or as a supplementary feed, is essential to the maintenance of elevated milk yields.

The results of this study also showed that sowing of pure legumes and feeding daily by grazing or cutting in order to provide the cow with high protein forage can be achieved without difficulty. This system also allows the farmer to add more urea and other fertiliser to the pure grass without any problem of suppression of the legume which commonly occurs in mixed grass/legume pastures (Whiteman 1980).

As a result, the supplementary system can achieve higher milk yield and fat percentage than conventional herbaceous mixed grass/legume systems. However, the use of a tree legume, such as leucaena, is of particular interest as it can better withstand grazing pressure and compete well with the grass. From observations, there appeared to be no death of leucaena plants as compared with the severe death of *Stylosanthes hamata* plants reported by Wongsuwan and Watkin (1990).

All treatments declined in milk yield especially under the pure ruzi grass treatments during the last three weeks of the experiment, due probably to the reduction in legume yield and hence forage quality of the legume-based treatments and due to the commencement of the reproductive phase in the grass-only treatment. The animals may have also reached the physiological stage of mid-lactation period (Bryant and Trigg, 1982).

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Comparison of *Leucaena leucocephala* and other Tree Fodders as Supplements for Lactating Dairy Cows

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Abstract

Two trials are summarised in which the forage value of four browse species was evaluated as dried conserved dry season feed for dairying, either as an improved source of forage, or as a cheaper source of homegrown protein substituting for cottonseed meal. Cows were on a basic diet of maize silage and maize grain, plus/minus cottonseed meal. In one trial, 1.5 kg of sundried *Acacia boliviana, Calliandra calothyrsus* or *Leucaena leucocephala* replaced an equal mass of poor quality grass hay, and in the other about 5 kg sundried *Acacia angustissima, Cajanus cajan, C. calothyrsus* or *Leucaena leucocephala* was substituted for 3.3 kg cottonseed meal isonitrogenously. All trial forages were fed together with 2–3 g/kg polyethylene glycol (PEG) or Browse Plus (a commercial PEG-containing digestive modifier). Milk yields (kg/cow/d) in the first trial were: grass hay 11.36, *Leucaena leucocephala* 13.19, *A. boliviana* 11.94 and *C. calothyrsus* 11.14 ($P<0.001$); and in the second trial: cottonseed meal 15.57, *Leucaena leucocephala* 14.36, *C. cajan* 12.79, *A. angustissima* 11.56 and *C. calothyrsus* 8.57 ($P<0.01$). Tree fodder polyphenolic characteristics were assessed in the first trial. Indications were that, despite the forages being fed together with PEG, anti-nutritional factors related to polyphenolic characteristics were still operative, particularly with *A. angustissima*/*A. boliviana* and *C. calothyrsus*. The potential for use of *C. calothyrsus* conserved as hay for dry season feed for dairying would appear to be limited and *A. boliviana* only moderate, whereas *Leucaena leucocephala* and *C. cajan* have good potential for this purpose with respect to forage value.

FEED supply is a major limiting factor for smallholder dairy production in Zimbabwe, particularly during the dry season. Fodder trees are seen as a cheaper source of protein than dairy concentrates and several introduced species have proved reasonably well adapted. However, many browse species have high levels of polyphenolic compounds, including condensed tannins (proanthocyanidins — PAs), which can have negative effects on protein availability, palatability and digestibility (Woodward and Reed 1989). It is therefore essential to conduct feeding trials for accurate nutritional evaluation of tree fodders.

Two studies were undertaken to evaluate the forage value of four species when used to supplement dairy diets, either as an improved source of forage (Maasdorp et al., in press), or as a homegrown substitute protein source (Dzowela et al., in press). The forage was cut at the end of the growing season and sun dried, a practice suggested by Dzowela et al. (1995) to avoid dry season leaf loss due to moisture stress and frost.

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Materials and Methods

Trial 1: As improved forage

Fodder of *Acacia boliviana* (progeny of CPI 40175), *Calliandra calothyrsus* (OFI 9/89) and *Leucaena leucocephala* cv. Cunningham was used to replace, and compare with, 1.5 kg of poor quality roughage (Rhodes grass hay, *Chloris gayana*), given to Holstein-Friesian cows on a basic diet of maize silage (30 kg), cottonseed cake (2 kg), crushed maize (8 kg), with access to ad libitum grass hay after 12 noon.

The trial forages were all mixed with 5 g of Browse Plus, a digestive modifier containing polyethylene glycol (PEG), and fed mid-morning. There were three cows in each feeding group. Milk yield was recorded for two weeks following a 2-week adaptation period and using the 7-day pre-trial milk yield as a covariate. Forages underwent proximate analysis and were assessed for polyphenolic characteristics.

Trial 2: As a substitute for cottonseed meal

The species evaluated were *A. angustissima*, *C. cajan*, *C. calothyrsus* and *Leucaena leucocephala*. Friesian cows were fed maize silage (22 kg), maize meal (5 kg on average), and either 3.3 kg cottonseed meal or 5 kg (on average) tree fodder (amounts of maize meal and tree fodder adjusted so as to feed 10 kg of an approximately isonitrogenous mixture).

The cows were also dosed daily with 20 g PEG and had access to Star grass (*Cynodon nlemfuensis*) pasture. The experiment was conducted as a balanced latin square with groups of four cows, with 2-week adjustment and one week true response periods.

Pre-treatment average milk yield was used as a covariate for milk yield. Tree fodder crude protein (CP) content and in vitro organic matter (OM) digestibility (Tilly and Terry 1963) were determined.

Results and Discussion

Practically all of the test fodder was consumed. Browse Plus/PEG at the rate of about 2–3 g/kg fodder was therefore adequate to ensure good intake of these dried tanniferous forages.

Milk yields, OM digestibility and polyphenolic characteristics are presented in Tables 1 and 2.

Considering both trials, milk yield response was highest for *Leucaena leucocephala*, intermediate for the *Acacia* species, and lowest or nil for *C. calothyrsus*. Milk yield of cows supplemented with *Leucaena leucocephala* was not significantly different (NSD) from that of cows fed cottonseed meal, though it did result in a lower fat corrected milk (FCM) yield ($P<0.05$). The response to *C. cajan* as a cottonseed meal substitute was NSD from that

Table 1. Tree fodders used as a substitute for grass hay: milk yield and forage in vitro organic matter digestibilty and polyphenolic characteristics.

	Acacia boliviana	*Calliandra calothyrsus*	*Leucaena leucocephala*	Grass hay
Milk yield (kg/cow/day)	11.94b	11.14c	13.19a	11.36c
OM digestibility (g/kg)	572c	509d	879a	624b
Soluble phenolics (g/kg DM)	189.2b	232.4a	160.0c	6.99d
Soluble PAs (AU_{550}nm/g DM NDF)	113.5a	69.5b	63.5b	0.48b
Insoluble PAs (AU_{550}nm/g DM)	24.77b	29.20a	17.38c	0.37d
Polyphenolic PPC (mm^2/g DM)	697a	557b	339c	nd

Means in the same row followed by different letters are significantly different ($P \leq 0.05$). OM — organic matter; PAs — proanthocyanidins; PPC — protein precipitating capacity; AU — absorbance units at 550nm; nd — not determined. Source: Maasdorp *et al.* (in press).

Table 2. Tree fodders used as a replacement for cottonseed meal: milk yield and forage in vitro organic matter (OM) digestibility.

	Cottonseed meal	*Acacia angustissima*	*Cajanus cajan*	*Calliandra calothyrsus*	*Leucaena leucocephala*
Milk yield (kg/cow/d)	15.57a	11.56bc	12.79ab	8.57c	14.36ab
Fat corrected milk yield (kg/cow/d)	14.55a	9.93b	10.48b	6.89c	11.34b
OM digestibility (g/kg)	–	341	443	334	455

Milk yield means followed by different letters are significantly different ($P \leq 0.05$). Source: Dzowela et al. (in press).

of *Leucaena leucocephala*. OM digestibility was also similar. *C. calothyrsus* was of no benefit as a replacement for grass hay and depressed milk yield by 45% and FCM by 53% when substituted for cottonseed meal isonitrogenously.

In these trials, milk yield responses to *Leucaena leucocephala* and *C. cajan* were substantial, viz. 1.86 kg from 1.5 kg sundried *Leucaena leucocephala* instead of grass hay, and yield reductions NS when substituted isonitrogenously for 3.3 kg cottonseed meal. This supports the view of Muinga (1993) and Muinga et al. (1995) that favourable milk yield responses depend on the presence of adequate dietary energy.

The OM digestibility differences between the tree forages were not related to crude protein, neutral detergent fibre or acid detergent fibre, as *A. boliviana* and *C. calothyrsus* were not inferior with respect to these parameters. In these mature tree fodders (without PEG) soluble polyphenolic content and insoluble PA content (trial 1) were strongly negatively associated with both OM digestibility and milk yield. Polyphenolic PPC was also negatively related to these parameters. This would indicate that, despite the forages being fed together with PEG, anti-nutritional factors related to polyphenolic characteristics were still operative, particularly with *A. angustissima*/*A. boliviana* and *C. calothyrsus*.

The poor responses to dried *C. calothyrsus* in these trials contrast with positive results reported for the feeding of fresh *C. calothyrsus* foliage (Paterson et al. 1996; Palmer et al. 1995). Drying of *C. calothyrsus* and some other tanniferous tree forages has been associated with decreased intake and digestibility (Palmer and Schlink 1992) and decreased soluble tannin content (Ahn et al. 1989). This is thought to be related to increased tannin polymerisation and binding with proteins and cell wall carbohydrates (Reed 1986).

Conclusion

Sun dried *Leucaena leucocephala* and *C. cajan*, fed together with 2–3 g PEG/Browse Plus per kg and with adequate dietary energy, have good potential for dry season feeding of dairy cows, providing an improved source of forage and homegrown substitute for expensive dairy concentrates. *A. angustissima*/*A. boliviana* would appear to be of intermediate forage value for this purpose.

By contrast, the potential use of *C. calothyrsus* as a dried conserved dry season high protein feed for dairying is limited, apparently related to its high polyphenolic content. Further feeding trials are required to determine rate responses and to establish and quantify sygnergistic effects between these more promising tree fodders and affordable amounts of cottonseed meal.

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Use of *Leucaena* in Feeding Pigs

P. Argenti[1] and F. Espinoza[1]

Abstract

When leucaena leaf meal (LFM) was substituted for 10% or 20% of the normal corn-soybean ration of pigs, the digestibility of all components of the diet except fibre was reduced. The added LFM increased fibre content in the diet. Digestible energy was severely reduced by the addition of LFM. However, in a feeding trial comparing 0 and 20% LFM, there was no difference in feed consumption, daily weight gain or feed use efficiency. There was no pathological damage to visceral organs or carcasses of the pigs. Although these results indicate the potential usefulness of LFM in pig diets, there is a need to assess both the long-term effects of LFM on pigs and the economic aspects of feeding LFM. If LFM is to be used, it should be kept as free as possible from small stems, in order to reduce fibre content.

THE PIG sector in Venezuela has been hit by a number of difficulties in the past few years, particularly due to the high cost of concentrate foods. Protein is one of the more expensive components, and comes mainly from imported sources. Therefore, there is a need to study alternative protein sources that can be produced within the country with high yield and relatively low cost. *Leucaena leucocephala* (leucaena) is a versatile leguminous plant adapted to tropical conditions. It has been estimated (Shelton 1996) that there are between 2 and 5 million hectares of cultivated leucaena throughout the world.

Venezuela has large areas of acidic infertile soils, to which leucaena is not well adapted. However, annual yields of leucaena of 2500 kg dry matter per hectare (DM/ha) with a protein content of 20%–31% have been obtained (Espinoza et al. 1992). This species therefore presents an alternative not only for feeding ruminants but also non-ruminant species such as the pig. Leucaena may be able to partially substitute for soybean and corn in balanced diets. The present work was undertaken to determine, in pigs, the apparent digestibility of diets that included leucaena foliage meal (LFM) and to evaluate the acceptance of these diets in growing animals.

Materials and Methods

Two experiments were carried out in the swine unit of the Instituto de Investigaciones Zootécnicas, Centro Nacional de Investigaciones Agropecuarias (CENIAP). In the first experiment, 12 hybrid pigs, averaging 30 kg liveweight housed in individual metabolism cages, were assigned at random to either of three treatments: T1: control diet (corn and soybean); T2: substitution of the control diet by 10% of LFM; T3: substitution of the control diet by 20% LFM. All the diets were balanced to be isoproteic and isoenergetic to give 18% crude protein (CP) and 3800 kcal/kg (Table 1). After 10 days of adaptation to the cages and diets, total collections of faeces and urine were made daily at the same hour for six consecutive days.

Table 1. Chemical composition of the three feeds in the first experiment.

Component	Treatment		
	0% LFM	10% LFM	20% LFM
Moisture content	8.7	7.6	7.5
Crude protein	18.1	18.1	18.6
Crude fibre	1.9	4.1	6.1
Ether extract	2.1	6.8	8.8
Nitrogen free extract	74.8	65.7	60.2
Ash	4.2	5.40	6.1
Energy (kcal)	3544	3816	3931

In the second experiment, 12 hybrid pigs of 45 kg liveweight were assigned at random, 2 pigs per pen, to either of 2 treatments: T1: control diet (corn and soybean); and T2: substitution of control by 20% LFM. The experiment lasted 2 weeks, and feed

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intake, initial and final liveweight were recorded. At the end of the experiment, 2 pigs were killed and visceral organs and carcasses were investigated for pathologies in the Instituto de Investigaciones Veterinarias, CENIAP, Venezuela.

Results and Discussion

Table 2 shows the digestibility values for the different treatments in the first experiment. Highly significant differences were observed for all components except crude fibre (CF), with digestibility decreasing with increasing LFM content. The protein digestibility coefficients are similar to those reported by Guerrero and Castellanos (1984), with a decrease in digestibility as more LFM was added to the diet. Although there were no differences in fibre digestibility the diets containing LFM have a higher fibre content (Table 1) because the leaf meal used comprised the rachises as well as the pinnae. It is of some concern that the digestibility of energy greatly decreased with increased LFM content, leading to considerably less digestible energy in the LFM rations.

Table 2. Apparent digestibility coefficients (%) of chemical components of the three feeds. Within a row, means followed by different letters are significantly different (P<0.01).

Component	Treatment		
	0% LFM	10% LFM	20% LFM
Dry matter	96.4a	91.5a	80.2b
Crude protein	87.3a	77.6b	69.8c
Crude fibre	53.2	51.1	50.6
Ether extract	68.0a	65.3a	59.1b
Nitrogen free extract	96.1a	81.8b	68.3c
Energy	90.3a	63.0b	40.0c

In the second experiment, there was no significant difference in feed consumption either in per head (2.2 kg for 0% LFM, 2.1 kg for 20% LFM) or per pen (61.6 kg and 58.8 kg respectively). These values are similar to those reported by Rodriguez (1989) who observed consumption in fattening pigs of between 2.13 and 2.78 kg/day for diets which included LFM at levels of 20% and 5% respectively.

The average daily weight gains (795g for 0% LFM and 780g for 20% LFM) did not differ significantly. These figures are higher than those reported by Rodriguez (1989) for similar diets, and also higher than the results of Salas and Castellanos (1986) feeding 10% LFM.

Feed efficiency was the same for both treatments (0.36 and 0.37). These values are considered normal for this growing period (NAP 1988), but are higher than those implied by Rodriguez (1989).

There was no pathological damage to the visceral organs or carcasses of the pigs. However, the feeding period was only short and may not have been long enough to affect the animals physically. More research is needed over a longer time. As a positive sign, it was indicated that there was smaller fat content and more muscular mass from those pigs fed with 20% of LFM than the control (Rodriguez 1989).

Conclusions and Recommendations.

The values obtained in the first experiment indicate that to reach the nutritional requirements of the pig with these diets, a bigger food consumption will need to be stimulated possibly through low cost flavour enhancement or higher balanced protein and energy content. It is therefore important to examine the costs of various rations, in particular, the decrease in costs when higher proportions of LFM are included. It is also important to examine the use of very fine sieves so that only the less-fibrous pinnae are included in the diet, thus increasing the digestibility.

The second experiment suggests that LFM could be considered as an alternative resource to feed pigs, with daily weight gains and feed efficiencies similar to those obtained when feeding corn-soybean, and without risk to the animals' health. However, it is important to carry out experiments where LFM is provided at all stages of the animal's growth, possibly including higher proportions of LFM in the diet to obtain a more comprehensive understanding.

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The Effect of *Leucaena* Leaf Meal on Egg Quality and Growth of Broiler Chickens

Tu Quang Hien[1] and Nguyen Duc Hung

Abstract

The effect of leucaena leaf meal (LLM) on egg quality and chicken growth was studied by supplementing the mixed diet with LLM. Adding 4% of LLM into the diet of laying hens increased egg weight and quality and reduced the cost of chick production. Supplementing the ration of broiler chickens with LLM increased live weight gain and decreased the cost of production. It appears that 4% LLM could be close to the optimum level of LLM supplementation as there was some indication that higher levels were not as effective.

LEAF meal of legumes has often been used as a component of mixed feed fed to layer and broiler chickens. The quality of leucaena leaf is generally similar to that of other legume species, with good levels of protein and vitamins. Two experiments were conducted to assess the effect of feeding leucaena leaf meal (LLM) on egg quality and growth of broiler chickens.

Experiment 1

To identify the effect of LLM on egg quality
Three diets were compared: Control (mixed feed), mixed feed + 4% LLM in diet, and mixed feed + 6% LLM in diet. All diets were the same in terms of metabolisable energy (ME) (2837 Kcal/kg) and crude protein (19.4%). Each diet was fed to 50 laying chickens (breed HV35), with three replications (total 450 birds). Six hundred eggs were selected from each group for incubation, and assessment of embryos, hatching and chick quality. The results are shown in Table 1.

Chickens fed with LLM produced bigger eggs with a higher proportion of yolk than the control. Eggs from those fed 4% LLM were bigger but had a smaller proportion of yolk, than from those fed 6% LLM.

Diets containing LLM produced a higher proportion of eggs containing embryos than the control diet. The percentage of eggs hatching and the class I chicks were also higher. There was no difference between the two LLM diets.

Table 1. The effect of leucaena leaf meal (LLM) on egg quality and feed cost in laying chickens.

Variable	Diet		
	Control	4% LLM	6% LLM
Egg weight (g)	56.7	58.2	57.5
Yolk %	31.1	32.3	33.9
Incubated eggs with embryos (%)	89.2	91.5	93.3
Incubated eggs that hatched (%)	70.5	78.0	78.2
Class I chickens/total incubated eggs (%)	69.2	77.7	77.8
Feed cost/10 eggs (VND)	14208	12526	12516
Feed cost/class I chicken (VND)	2054	1613	1608

Thus the use of leucaena leaf meal has a good effect on egg production and quality. Feeding 4% LLM should result in a higher proportion of Class I chicks for sale.

If feeding LLM is to be practical, it must be economically efficient. A financial analysis of the feed cost to produce 10 eggs and one chicken is shown in Table 1. The cost of egg production was reduced by 12%, and as the proportions of hatching and class I chicks produced by layers fed LLM were higher than the control, the feed cost to produce one chicken reduced by 22%.

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Experiment 2

To identify the effect of LLM on the growth rate of broiler chickens

Again, three diets were compared: control (mixed feed), mixed feed + 3% LLM for the first 28 days and 5% thereafter, and mixed feed + 4% LLM for the first 28 days and 6% thereafter. All three diets were the same in terms of ME and CP: for the first 28 days, 3074 Kcal/kg and 23.6% CP, thereafter 3158 Kcal/kg and 21.4% CP.

The three diets were each fed to 100 broilers (breed HV35), replicated 3 times (total 900 birds). Liveweight gain was measured after 56 days, and the results are shown in Table 2.

The liveweight of chickens at 56 days was higher for those fed LLM than for the control group, but the lower proportion of LLM produced the greater gain. The feed efficiency of the group fed LLM was higher than that of the control group, leading to a reduction in production cost of 7% for the 3% and 4% LLM diet and 5% for the 4% and 6% LLM diet.

Conclusions

A mixture 4% of LLM into the diet of laying hens increased egg weight and quality and reduced the cost of chicken production. Supplementing the ration of broiler chickens with LLM produced increased LWG and decreased the cost of production. It appears that 4% LLM could be close to the optimum level of LLM supplementation as there was some indication that higher levels were not as effective.

Table 2. The effect of leucaena leaf meal (LLM) on live weight gain, feed use efficiency and cost of production in broiler chickens.

Variable	Diet		
	Control	3% and 5% LLM	4% and 6% LLM
Liveweight gain 56 days (g)	2062	2242	2122
Consumed feed/chicken (kg)	4.93	5.04	4.92
Feed intake (kg/kg gain)	2.39	2.25	2.31
Energy efficiency: Kcal/kg LWG	7,488	6,932	7140
Protein efficiency: g LWG/g protein	1.62	1.72	1.67
Feed cost/chicken (VND)	18720	18910	18350
Cost/kg LWG (VND)	9078	8434	8647

The Effect of Supplementing the Diet of Broiler Chickens with *Leucaena* Leaf Meal and $FeSO_4$

Tu Quang Hien[1] and Nguyen Thi Inh[2]

Abstract

Chickens fed 3% leucaena leaf meal (LLM) for 28 days and 4% from days 28 to 56 had higher weight gains, better feed intake efficiency and lower costs per kg LWG than control birds. Using a higher rate of LLM (5 and 6%) without $FeSO_4$ supplementation reduced LWG and decreased feed intake efficiency. Supplementation with $FeSO_4$ restored the LWG and feed intake efficiency to levels similar to those attained with the lower intake of LLM.

LEAF meal made from leucaena (*Leucaena leucocephala*) (LLM) is rich in proteins and vitamins and is often used as a component of mixed feeds for various forms of animal production. However, this material contains mimosine, a toxic amino acid which can have a detrimental effect on animal health, particularly in non-ruminants.

One way to negate the effect of mimosine is to supplement the ration with $FeSO_4$. This paper reports the results of an experiment where the diet of broiler chickens was supplemented with LLM and $FeSO_4$.

Materials and Methods

Four diets were compared. They were identical in terms of metabolisable energy and protein.

For the first 28 days:

Group 1: (control) — basal feeding only (BS I).
Group 2: 97% of BS I + 3% LLM.
Group 3: 95% BS I + 5% LLM.
Group 4: 95% BS I + 5% LLM + $FeSO_4$.

BS I contained 3100 Kcal ME/kg and 23% protein.

For days 29–56:

Group 1: (control) — basal feeding only (BS II).
Group 2: 96% of BS II + 4% LLM.
Group 3: 94% of BS II + 6% LLM
Group 4: 94% of BS II + 6% LLM + $FeSO_4$.

BS II contained 3200 Kcal ME/kg and 21% protein.

Each diet was fed to a group of 60 broiler chickens (breed BE88), with three replications. Over a 56-day period, the following observations/calculations were made:

- Health of the chickens.
- Liveweight gain (LWG)on a weekly basis.
- Feed consumption/chicken and feed intake/kg LWG.
- Economic efficiency: cost of feed/chicken and cost of feed/kg LWG.

Results

Health of the chickens

In all groups the health situation was good. There were no differences in death rates between the groups.

The LWG, feed intake and economic data are summarised in Table 1.

Liveweight gain

From the third week, the weight of chickens in Group 3 (fed 5% LLM) was lower than the weights of the chickens in the other three groups, suggesting a negative effect of the LLM.

After 8 weeks, Groups 2 and 4 were significantly different from Groups 1 and 3, having higher LWG. This indicates that supplementation with lower levels of LLM, or higher levels of LLM plus $FeSO_4$, is effective in increasing weight gain in chickens.

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Table 1. Liveweight gain (LWG), feed efficiency and economic efficiency when supplementing the diet of broiler chickens with leucaena leaf meal (LLM) and $FeSO_4$.

Variable	Diet			
	Group 1 Control	Group 2 3% and 4% LLM	Group 3 5% and 6% LLM	Group 4 5% and 6% LLM + $FeSO_4$
Chicken liveweight at 4 weeks (g)	918	927	852	930
Chicken liveweight at 8 weeks (g)	2299	2442	2242	2450
28-day feed consumption/chicken (g)	1516	1523	1500	1526
56-day feed consumption/chicken (g)	5474	5475	5393	5378
Feed intake/kg LWG (kg)	2.38	2.24	2.40	2.20
ME intake/kg LWG (Kcal)	7553	7112	7630	6962
LWG/protein intake	1.93	2.07	1.96	2.15
Food cost/chick (VND)	21886	21900	21930	21514
Food cost/kg LWG (VND)	9520	8968	9781	8781

Feed conversion efficiency
Up to 28 days, feed consumption was similar in all treatments. However, from 28 to 56 days the chickens from Groups 1 and 3 ate more feed than the others, to the extent of between 50 to 100 g/chicken. Groups 2 and 4 had lower intake/kg LWG and are therefore considered to be more efficient in feed conversion.

Energy and protein use efficiency
Again, Groups 2 and 4 (fed either smaller amount of LLM or larger amounts of LLM and $FeSO_4$) were more efficient in using both energy and protein, by about 8%, compared to Group 1 (control) and Group 3 (high LLM).

Cost of production
The total cost of food was similar for Groups 1, 2 and 3, but about 2% cheaper for Group 4. Based on the cost of producing 1 kg LWG, group 3 cost 103% of the control, group 2 cost 94% and group 4 cost 92%.

Conclusion

Chickens fed 3% LLM for 28 days and 4% from days 28 to 56 had higher weight gains, better feed intake efficiency and lower costs per kg LWG than control birds. There is no need to use $FeSO_4$ to reduce mimosine toxicity at this level of feeding.

Using a higher rate of LLM (5% and 6%) without $FeSO_4$ supplementation reduced LWG and decreased feed intake efficiency. Supplementation with $FeSO_4$ restored the LWG and feed intake efficiency to levels similar to those attained with the lower intake of LLM.

Farming Systems

Presented Papers

Leucaena in Smallholder Farming Systems in Asia: Challenges for Development

F.A. Moog[1], P. Bezkorowajnyj and I.M. Nitis

Abstract

The current use and scope for development of leucaena in smallholder farming systems in Asia are described and socio-economic constraints and challenges discussed. Psyllid infestation halted development activities in the region but renewed interest in the species is slowly increasing. The promotion of leucaena in the holistic context of farming systems should identify socio-economic constraints of farmers, and lead to discovery of practical and working alternatives that can be implemented by farmers themselves.

SMALLHOLDER crop and livestock production is a common feature of Southeast Asian agriculture. Farming families, either cultivating food crops or engaged in plantation crops, keep one or several species of animals (both ruminants and non-ruminants) which are integral parts of their farming systems. Land holdings in the region are small. Most farm families cultivate less than 1 ha and only a small proportion owns more than 3 ha. In Bali, Indonesia, 98% of farmers own areas of only 0.11–0.46 ha. In upland farms in Batangas (Philippines), farmers operate small parcels of land cultivating an area of less than 2 ha while 76% of farmers raising buffalo in rice-growing areas have 3 ha or less and only 24% have more than 3 ha (Alviar 1987). In Thailand, farming families cultivate less than 1 ha and only a small proportion owns more than 2 ha.

Livestock are an important component of the production system for many reasons. Draught animals, generally cattle and buffalo, and use of crop residues, weeds and cultivated fodder for supplementary feeding, are common features of the system.

Leucaena or Ipil-ipil *Leucaena leucocephala* (Lam.) de Wit has been the most popular fodder tree species in the region because of its multiple uses. It is generally used as a source of fodder and fuelwood. In the Philippines, it is used for poles, leaf meal and as living fences. Other Asian countries like Thailand, India, Sri Lanka and Vietnam use it in soil erosion control, alley crops and green manure, and the young shoots as a vegetable. In East Java (Indonesia), it is an important component of the 'taungya' silvicultural system for establishing teak plantations.

Leucaena's popularity was at its peak in the 1970s and early 1980s. No other tree legumes had been given as much attention as leucaena. However, with the psyllid infestations in the mid-1980s, most of the plantations were damaged and its popularity waned. This paper presents a brief review of current use and development perspectives for leucaena, based on the authors' observations and experiences and selected case studies in the region.

Current Use of Leucaena

In general, the multiple uses of leucaena in Southeast Asia remain. There has been a significant reduction in psyllid infestation but the use of leucaena has not been as intensive as in the 1970s. Throughout the region, thickets of leucaena plantations can be observed. These standing plantations, which seem unutilised, are occasionally harvested for timber and fuelwood, and stabilise the soil in hilly and mountainous areas.

In densely populated areas of Luzon, Philippines, where swine and poultry are concentrated, fresh leucaena leaves are harvested for feeding pigs in the villages. In upland farms and rainfed rice-growing

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areas, it is grown to establish land ownership boundaries and trees are harvested for poles and fuelwood. While intensive cattle fattening in Batangas province has significantly reduced due to industrialisation, leucaena remains a significant part of the cattle ration in upland and coastal villages of the province. In commercial feedlots, operators are buying fresh and dried leaves of leucaena from villagers. Some feed mills have resumed buying dried Ipil-ipil leaves for leaf meal and for incorporation in commercial poultry and swine feeds. Feed production reports in the Animal Feed Standard Division of the Bureau of Animal Industry showed that one of the feed mills in Cebu produced 232 and 180 tons in 1996 and 1997, respectively. However, a feed mill in San Carlos City, Negros Oriental, ceased operation in February 1997, because its buyers reduced or stopped incorporating leucaena in their feed formulations due to availability of cheaper substitutes.

In Indonesia, leucaena is commonly used for forage and fuelwood but has been planted for various distinctive roles in different provinces. In Timur and Flores, it is planted to stabilise eroded hill slopes and in Sulawesi, Sumatra and Nusa Tenggara Timur it is a common shade tree species in coffee and cocoa plantations (Toruan-Mathius et al. 1994).

In Vietnam, leucaena is extensively used as an intercrop with coffee, pepper, and oranges and when leaves of leucaena are used as a green manure and mulch, coffee bears fruit earlier and with higher yields (Khoa and Ha 1994). It is also a good source of village wood. Growing, harvesting and processing of leucaena employs women, youths and children. Planting and management of leucaena in Vietnam is a concerted effort of both the government and village communities.

In Thailand, leucaena is mainly used as source of leaf meal for poultry to colour egg yolks and broiler skins, and as living fences (Sampet et al. 1994). It is also grown for wood, soil erosion control, soil improvement on steep lands and other uses like turnery and parquet flooring.

In Laos, leucaena is commonly grown in home gardens with young shoots and seeds used as a vegetable by the villagers. Leucaena was extensively used in the Forest Development and the Watershed Management Project in the northern provinces in agroforestry (FAO 1991).

In Myanmar, leucaena is grown in the dry zone, particularly in Magway, mainly as a windbreak.

Leucaena was introduced to India in the 1950s to be used as a green manure and for soil reclamation, but it was not until the 1970s that the Indian Council of Agricultural Research (ICAR) promoted leucaena as a high quality fodder and fuelwood. In addition, social forestry programs began to encourage farmers to grow leucaena as a substitute to eucalyptus as a small timber, and later as a source of pulp for the paper industry (Hegde and Gupta 1994). Today it is found throughout India, and after a few set-backs including the psyllid (*Heteropsylla cubana*) infestation of the 1980s, is still used as a source of fodder, fuelwood and small timber.

A more detailed account of the use of leucaena in specific locations of the Philippines, Indonesia and India is outlined in Table 1.

Challenges and Constraints

There are two broad challenges facing leucaena development for smallholders in Asia: (1) the technical issues; and (2) the socio-economic issues. Both broad issues are important to consider but the focus of this paper is on the socio-economic issues.

Production challenges

The technical or production issues are covered in detail by other authors in these Proceedings. Psyllid infestation has been significantly reduced, yet most farmers still find that leucaena does not produce the biomass that it used to. Due to the psyllid, farmers reduced the number of animals raised or stopped raising cattle (Moog and Sison 1986)

Leucaena does not thrive in acidic soils and in regions subject to frosts.

Socio-economic challenges

Farmers' perception

In the Philippines, recent interviews with 71 coconut farmers in Quezon province indicated that both crops and livestock are important in their farming systems; crops provide a steady income throughout the year and livestock provide the 'bonus' income which comes in bulk when they sell animals. While 49 (69%) of the farmers interviewed have leucaena in their home gardens or farm lots, only 22 feed leucaena to their animals. They claimed to have enough feed and if shortages occur during the dry season, they use banana stems and coconut fronds or travel several kilometres to gather grasses and other tree leaves. Although those farmers consider livestock valuable in the farming system and even though a number of them claimed they knew from their parents or experiences that leucaena was a good feed, they are still passive about its use.

A participatory 3-year research project on fodder and fuelwood improvement conducted in the highly degraded tribal areas of southern Rajasthan where fodder and fuelwood are particularly scarce gave interesting results (Bezkorowajnyj 1998). The people in these remote villages had no previous experience with leucaena and participated in testing several

Table 1. Use of existing leucaena plantations in selected Asian countries.

Leucaena plantation	Country		
	Philippines	Indonesia	India
Home gardens	Leucaena is generally found in most homelots as fencing and support to trellises for viny vegetables. In Batangas, it is a valuable cut-and-carry fodder in smallholder farms.	As fencing around homelots only, other space devoted for vegetables and medicinal plants.	As hedges along boundaries and in backyards.
Hilly to mountainous areas	In Cebu, Leyte and Negros islands, leaves are harvested and sold by villagers to feedmillers and processed into leaf meals. In other areas, leucaena is harvested for fuelwood.	As guard row and cluster in sloping land not used for crop production.	
Roadsides/communal areas	In Masbate and General Santos City, harvested dried leaves are sold to feedlot operators as supplement to fattening animals. In most areas, leucaena is occasionally cut for fuelwood.	As fences to separate farm areas along roadsides and as cluster in communal grazing areas.	In the plains of Assam and along the irrigation canals of Rajasthan.
Upland and rainfed areas	To establish boundaries of landownership. In Tarlac and other provinces of Luzon and Visayas islands, leucaena is cut in summer months of February to May for fuelwood	As fences, guard rows and cluster for fodder and fuelwood in Kuta, Bali. For shade, soil protection, green manure and fodder in Petang, Bali.	Grown in conjunction with soil and water conservation measures for fodder and fuelwood productions.
In plantation crops	In coconut growing areas in Southern Luzon and Mindanao, leucaena is sparsely planted and used as living fences and as poles. Leaves are harvested as green feed.	As trellise for vanilla and pepper; as shade for coffee and clove; and, as intercrop with coconut. As fence-boundary in small plantations.	Use for fodder, fuelwood and pulpwood in South India and Andra Pradesh.
In alley cropping	Leucaena is one of the species used along with corn and other upland crops in Mindanao.	As alley crop for fodder and green manure in semi-intensive dryland farming in Amarasi, Flores.	
Forestry/fuelwood lots		As alley crop in taungya system; as shade in young forest; and, source of fuelwood.	

newly introduced species. Farmer group discussions (FGDs) conducted during the 3-year project revealed that farmers were very impressed by both the palatability of the leafy matter, and the rate of biomass regeneration, particularly after livestock had entered and browsed some of the patch plantations within the villages.

During the third year of the project, household interviews (H) were conducted to determine the quality of leucaena wood as a fuel for food preparation. Several opinions were expressed by household members, especially the women who are responsible for the gathering of fuelwood and cooking meals.

Results of the interviews showed that most of the household members believed that the wood burned longer than most other species presently used for cooking, resulting in the need for less fuelwood to cook the same amount of food. Other typical