The role of multi-purpose trees in integrated farming systems for the wet tropics

by T.R. Preston

INTRODUCTION

Multipurpose trees play a critical role in the intensive integrated farming system based on sugar cane and developed by CIPAV (Preston and Murgueitio, 1992; Figure 1) in close cooperation with local farmers in the Cauca valley in Colombia. This system recognises that renewable biomass is the only sustainable source of fuel, feed and food, and that additionally it can be a medium for reversing environmental degradation.

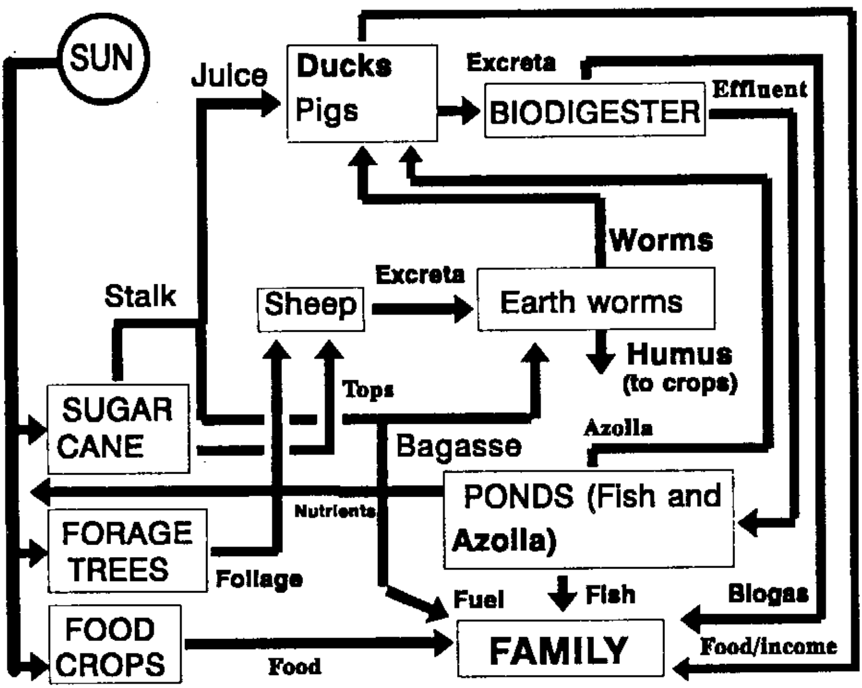
The system is based on sugarcane which provides the carbohydrate feed (the juice and tops) and also fuel (the bagasse). Multi-purpose trees and water plants supply the protein and the trees play other important roles such as controlling erosion, providing sinks for carbon dioxide (the standing biomass) and methane (at the interface between the decaying fallen leaves and the soil) and as a source of biodiversity. Sugar cane and trees have well developed systems of biological pest control, require minimum synthetic chemical inputs and are easily separated into high and low fibre fractions as required for the different end uses of feed for monogastric and ruminant animals and fuel.

The trees which have had most farmer impact are *Gliricidia sepium*, *Trichantera gigantea*, *Erythrina glauca* and *edulis*. The foliage from *Trichantera gigantea* is consumed by pigs; that from the other trees is more appropriate for ruminants.

The preferred animal species are pigs and ducks which adapt readily to the "non-conventional" high-moisture feed resources (cane juice, tree leaves and water plants) and have a high meat:methane production ratio. They are complemented by African hair sheep which derive most of their feed from the cane tops and tree foliage. Buffaloes and/or triple purpose cattle supply draught power as well as meat and milk. All the livestock are managed in partial or total confinement to minimize environmental damage and to maximise nutrient recycling to the crops.

The CIPAV model is flexible as witnessed by the increasing acceptance of many of the elements in the model by both resource-poor and entrepreneurial farmers.

FIGURE 1. **The CIPAV Farming System.**



THE ROLE OF MULTI-PURPOSE TREES

The role of multipurpose trees in this mixed farming system is as:

- Sources of protein for pigs, ducks, sheep and buffaloes (the leaves)
- Substrate for gasification (the trunks and branches)
- As sinks for CO_2 (the standing biomass)
- Sinks for CH_4 (the decaying organic matter from fallen leaves and unused branches)
- As media for synthesis of ammonia through the action of symbiotic microorganisms attached to, or in free-living associations with, the root layer.
- To control erosion
- To provide construction material and firewood.

The characteristics of multipurpose trees that are sought by farmers relate to the need to minimize inputs and maximise outputs. They require:

- High yield
- Ease of harvesting
- Resistance to pests and diseases
- Animal response to minimal inputs
- Ease of establishment and management
- Availability of different species

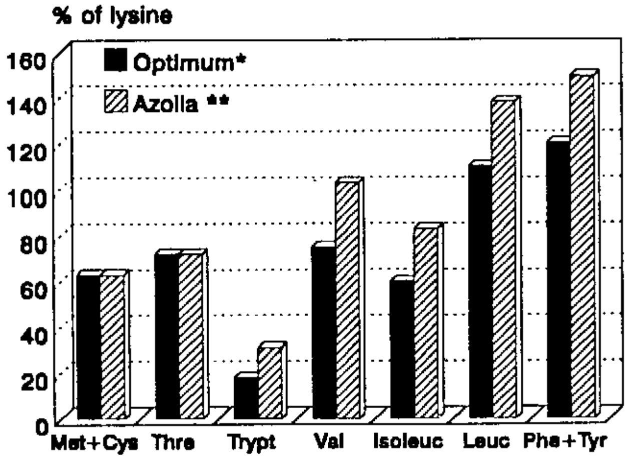
Monogastric animals

When monogastric animals are fed basal diets derived from tropical feed resources such as sugar cane, cassava, bananas, sweet potatoes or oil palm, the supplementary nutrients that are needed are protein, lipids, minerals and vitamins. The usefulness of tree foliages for these species will therefore be a function of their capacity to supply some or all of these nutrients.

The total protein needs of monogastric animals are reduced considerably when low-protein basal diets are fed. This is because the ratio of essential (EAA) to non-essential amino acids in protein supplements such as oilseed meals and tree foliages is close to the optimum. In contrast, when cereal grains are the basis of the diet, there is an inevitable over-supply of non-essential amino acids, and total protein supply must be higher in order to provide the required amounts of EAA.

The new approach to assessing the suitability of a protein supplement for a basic diet low in protein, is to calculate the ratios of each essential amino acid as a function of the amount of lysine, and to compare this with the optimum determined from studies with synthetic amino acids (Wang and Fuller, 1989). On this basis, the aquatic plant *Azolla filiculoides* has an excellent balance of amino acids (Figure 2).

FIGURE 2. **Amino acids in *Azolla*: comparison with optimum**



Source: * Wang and Fuller (1989)
** Buckingham *et al.* (1978)

For ruminant animals, the need is for trees with high production of biomass and high content of protein in a form that will escape the rumen fermentation. Thus the presence of moderate concentrations of tannins could be important as a means of 'insolubilizing' the protein. If the desired tree species is low in tannins, then another approach is to mix with it a species which has a high content of these substances. In order to achieve acceptable intake, tree forage is normally limited to 30% of the diet DM. High digestibility, good balance of essential amino acids and minerals and vitamins are also required from the forage.

Six species are presently being used in ruminant diets. They are:
- *Gliricidia sepium*
- *Trichantera gigantea*
- *Erythrina glauca*
- *Erythrina edulis*
- *Acacia mangium*
- *Prosopis juliflora*

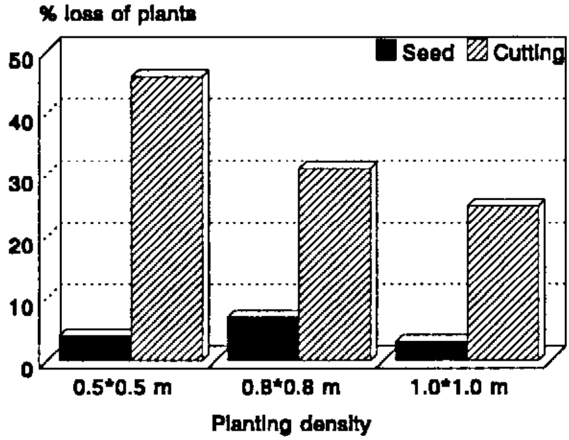
The choice of a particular tree will be decided by climatic and soil considerations. Thus *Erythrina glauca* is specifically adapted to acid soils with a high water table, and a propensity to flooding. *Acacia mangium* is especially tolerant of acid soils saturated with aluminium. *Leucaena leucocephala* is not normally used as it is least tolerant of all the species to acid soils. Where leucaena can be grown, it is outyielded by gliricidia, which is also more resistant to insect attack and is more easily harvested. The latter is important in 'cut and carry' systems which is the usual practice on small farms.

GLIRICIDIA SEPIUM

The traditional way of establishing *Gliricidia* as a 'live' fence is by planting a stake in the ground. However, when the aim is to produce forage for intensive harvesting it is essential to develop it from seed. Survival of trees established from seed is much higher than when stakes are used (Figure 3). Production of biomass is higher when *Gliricidia* is established from seed (Figure 4). Biomass yields of *Gliricidia* are consistently high, especially when established at high plant densities. However, in practice, with only 50 cm between rows, harvesting is made difficult and present recommendations are to plant at 1 m between rows and 50 cm between plants.

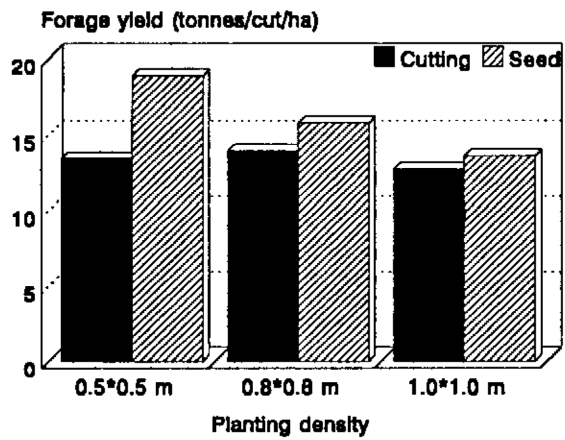
It seems that the origin of *Gliricidia sepium* is in Guatemala. Certainly, there are differences among provenances according to where the seed was collected. The provenances from Guatemala and from Colombia seem to be the highest producers in the series of trials carried out in Colombia, using seed collected and provided by the Oxford Forestry Institute, UK (Figure 5).

FIGURE 3. **Effect of plant density and method of establishment on survival of *Gliricidia sepium***



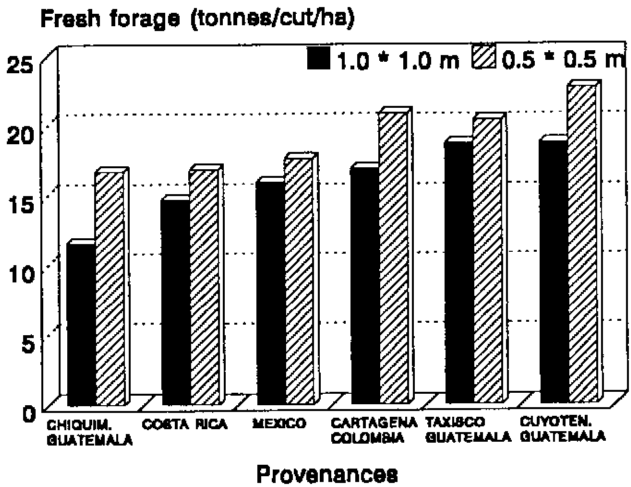
Source: El Hatico (unpublished)

FIGURE 4. **Effect of plant density and method of establishment on yield of *Gliricidia sepium***



Source: El Hatico (unpublished)

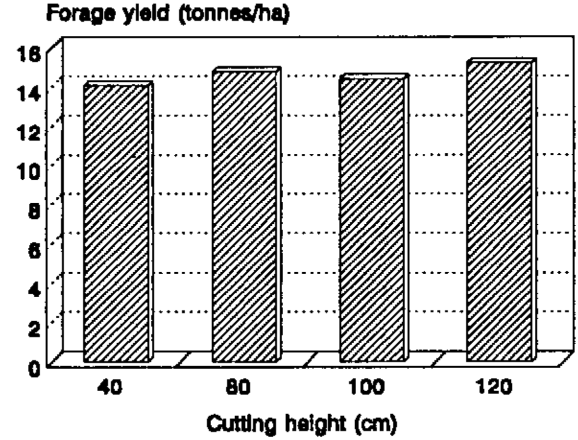
FIGURE 5. **Edible forage yield of six provenances of *Gliricida sepium* (total of 10 cuts at 3 month intervals).**



Source: El Hatico (unpublished)

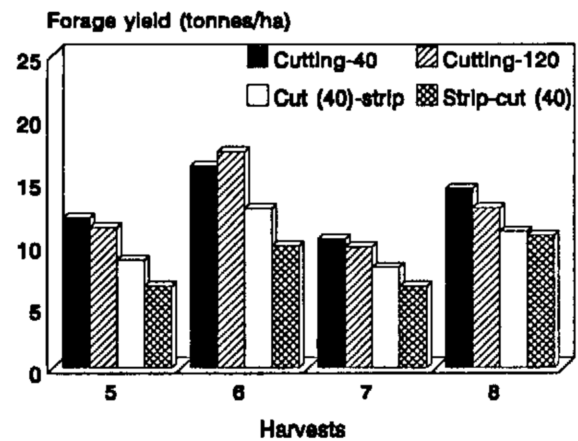
The height above ground level at which *Gliricidia* is harvested has little effect on biomass yield. However, it has been observed that cutting at about 1.2 m gives better weed control and is also more convenient for the person doing the harvesting (Figure 6). There are two ways of harvesting the foliage from *Gliricidia*. One is by cutting the branches with a knife or machete; the other is to strip by hand the leaves and petioles from the stems. The former is recommended as it stimulates the appearance of more buds which in turn results in a higher biomass yield (Figure 7).

FIGURE 6. **Effect of cutting height on forage yield of *Gliricidia sepium*.**



Source: El Hatico (unpublished)

FIGURE 7. **Effect of harvesting method (cutting *vs.* stripping) on forage yield of *Gliricidia sepium*.**



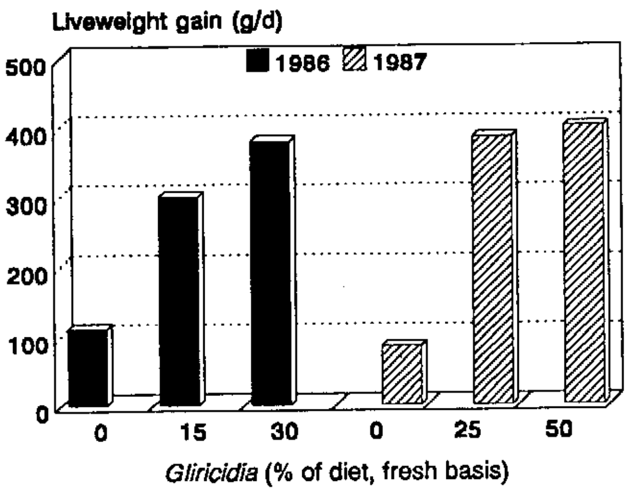
Source: El Hatico (unpublished)

Nutritive value

Foliages from multi-purpose trees play a dual role in ruminant feeding. They help to provide an improved ecosystem in the rumen, which is reflected in increased microbial activity which in turn leads to an increased rate of digestion of the fibrous basal diet. In certain cases, especially when tannins are present in moderate amounts, the protein in the leaves may partially escape the rumen fermentation and contribute amino acids directly at the level of the intestine.

Gliricidia foliage appears to provide bypass protein since there is a marked stimulation of growth rate when it is fed as a supplement to a basal diet of low digestibility, in this case King grass harvested during the dry season. In the experiment shown in Figure 8, growth rate of recently weaned calves responded to *Gliricidia* levels in the diet equivalent to 5% of liveweight.

FIGURE 8. **Growing steers on a King grass diet supplemented with *Gliricidia* foliage.**



Source: ICA (see Preston and Leng, 1987)

Gliricidia has proved to be an excellent supplement to a basal diet of sugar cane tops for African hair sheep managed in total confinement (Table 1). Levels of performance of the sheep fed cane tops, *Gliricidia* foliage and a mixture of poultry litter and rice polishings (9:1) together with urea-molasses blocks have been highly satisfactory (Table 2).

TABLE 1. **Mean values for the feed intake of a flock of tropical hair sheep (July to December 1990).**

Diet components	Fresh basis (kg/d)	Dry basis (%)
Gliricidia	0.777	9.3
Sugarcane tops	5.640	72.4
Multinutrient block	0.121	6.2
Poultry litter	0.204	10.6
Rice polishings	0.021	1.0
Total dry matter* (kg/d):		1.735
(proportion of live weight):		(0.045)

* For a sheep unit (1 ewe of 25 kg and 1 lamb of 14 kg)
Source: Mejía *et al.* 1991.

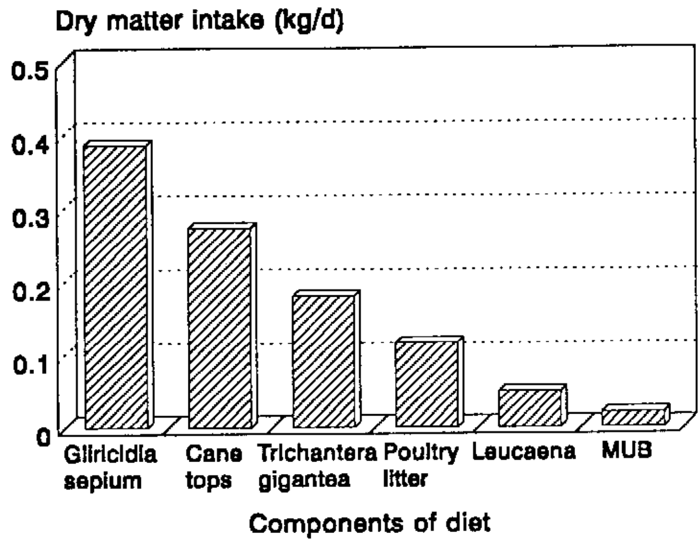
TABLE 2. **Productivity and reproduction of the flock of African hair sheep (December to March 1991)**

	Mean	Standard deviation	n
Live weight (kg)			
Birth	2.32	0.52	167
Weaning	14.90	2.62	84
Weight gain to weaning (g/d)	106	33.6	84
Age at weaning (days)	129	45.5	84
Lambing interval (days)	284	85.3	44
Litter size*	1.16		44
Lambs per ewe per year**	1.49		44
Mortality (% of all births)			
Perinatal	5.5		
Birth to weaning	10.4		

* Number of lambs born per parturition
** Mean number of lambs born per ewe per year
Source: Mejía *et al.* (1991)

It is sometimes reported that *Gliricidia* is not very palatable even to ruminants because of the presence of secondary plant compounds. In this trial with sheep, admittedly accustomed to previously to consuming *Gliricidia*, it was selected in preference to all the other feeds including *Leucaena*.

FIGURE 9.
Diet preference by sheep. (Cafeteria trial; 3 groups; 21 days).

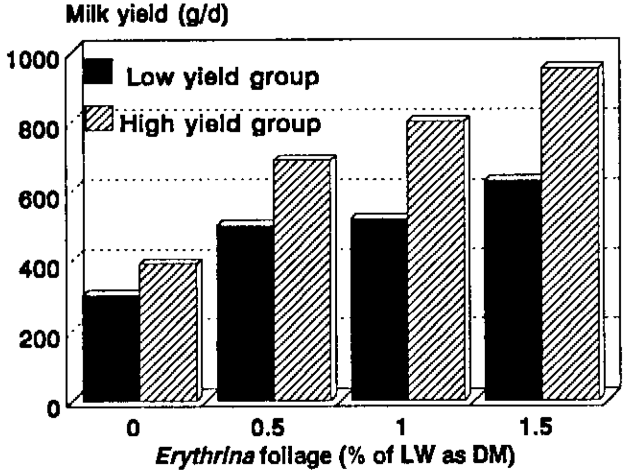


Source: Mejia et al. 1991

ERYTHRINA POEPPIGIANA

Goats fed a basal diet of King grass and reject banana fruit responded with linear increases in milk production when offered increasing levels of foliage of *Erythrina poeppigiana* (Figure 10).

FIGURE 10. **Milk production of goats fed King grass. Effect of giving *Erythrina* tree foliage.**



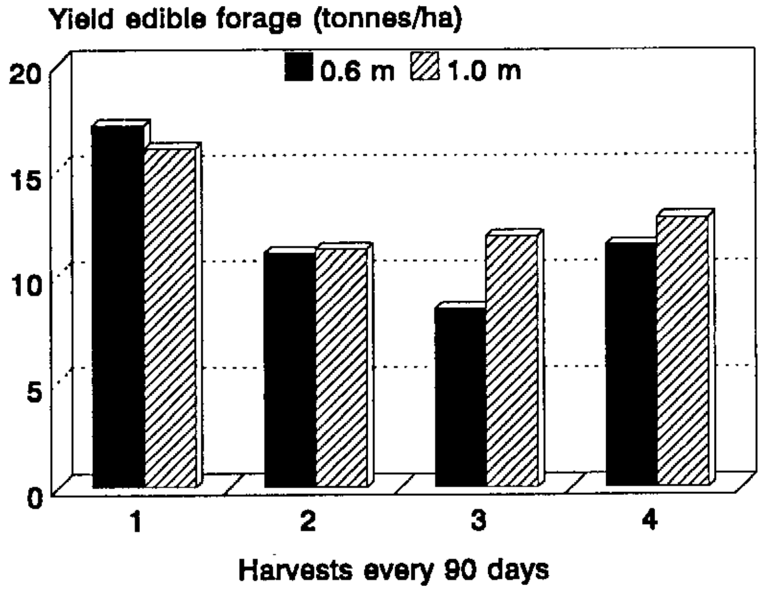
Source: Esnaola and Rios (1990)

TRICHANTERA GIGANTEA

This tree is native to the Andean foothills in Colombia. It is not a legume but its vigorous regrowth even with repeated cutting and without fertilizer applications indicates that nitrogen fixation occurs in the root zone either through the action of mycorrhiza or other organisms. Nacedero (*Trichantera gigantea*) responds in a similar way to height at cutting. The yield is slightly higher when it is harvested at about 1-1.2 m above ground level (Figure 11).

The advantage of this tree is that the leaves are consumed quite readily by pigs. Results from replacing 75% of the soyabean meal in cane juice diets for pregnant sows have been very encouraging (Figure 12). Results with growing pigs have been less satisfactory. Performance was reduced at all levels of substitution of soyabean meal by *Trichantera* (Figure 13).

FIGURE 11. **Cutting height and biomass (edible forage) yield of *Trichantera gigantea*.**



Source: Gomez and Murgueitio (1991)

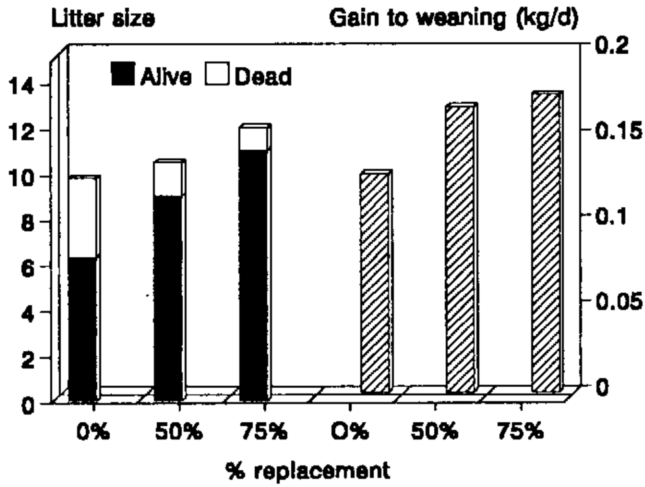
CHEMICAL TREATMENT OF TREE FOLIAGE

There are interesting possibilities for improving the digestibility of tree foliages by simple methods of chemical treatment. Ensiling with acetic acid has given promising results when applied to the foliage of *Trichantera* (Figure 14).

Ensiling can be used to neutralize other secondary plant compunds, as in this case the cyanogenic glucosides in the leaves of cassava (Table 3).

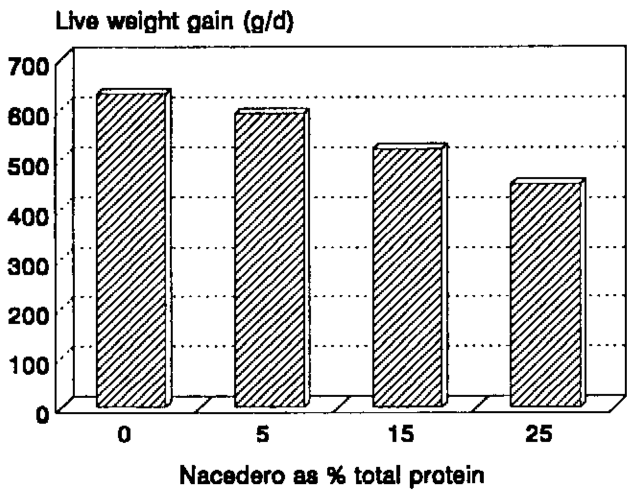
The treatment of tree foliage to improve their nutritive value, to remove secondary plant compounds and to enable the longer term storage of feed material is now a high priority for future research.

FIGURE 12. Foliage of *Trichantera gigantea* as replacement for soyabean meal in cane juice diets for pregnant sows.



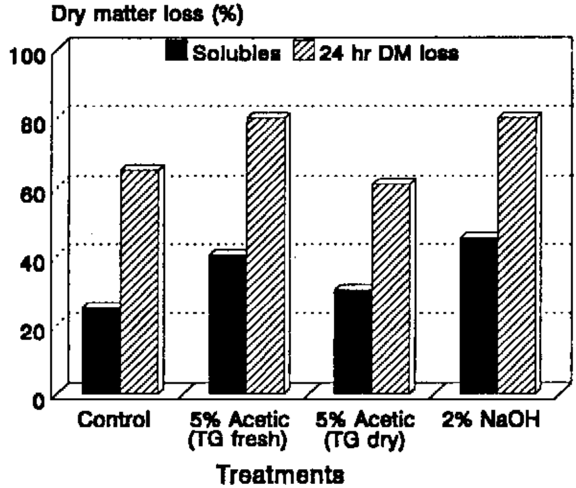
Source: Sarria *et al.* (1991)

FIGURE 13. Foliage from Nacedero (*Trichantera gigantea*) as replacement for soyabean meal in growing pig rations.



Source: Sarria *et al.* (1991)

FIGURE 14. **Effect of acetic acid and sodium hydroxide on degradability of *Trichantera gigantea* (*in situ* rumen nylon bags).**



Source: CIPAV (unpublished)

TABLE 3.
Effect of ensiling or drying cassava leaves on HCN content.

	HCN content (mg/kg DM)
Fresh cassava leaves	863
Cassava silage	33
After sun-drying for 4 hours	261
Sun-drying 4 hours then ensiling	32
After drying 2 days in shade	274
Drying 2 days in shade then ensiling	34
Dried cassava leaf meal	80

Source: Chinh *et al.* (1991).

CONCLUSIONS

Multi-purpose trees play an important role in an integrated system based on sugarcane, developed in Colombia. They provide feed for pigs, ducks and small ruminants (sheep and goats). Buffalo and triple purpose cattle are preferred to single-purpose beef or dairy cows. The use of renewable biomass also supplies a sustainable source of fuel and reverses environmental degradation.

The species include the legumes *Gliricidia sepium, Erythrina poeppigiana, E. glauca* and *E. edulis*, and *Trichantera gigantea* (family: *Acanthaceae*).

Plant survival and biomass production were highest when *Gliricidia* was established from seed, planted at 50 cm spacing with 1 m between rows. A number of provenances have been tested, of which the seed from Guatemala and Colombia were most productive. Cutting at a height of 1.2 m is recommended as the method of harvesting.

Gliricidia provides bypass protein for ruminants and is fed as a supplement to low-digestibility basal feeds (King grass and cane tops). Contrary to reports elsewhere, there were no problems of acceptability of *Gliricidia* to animals and sheep showed preference for this feed in a cafeteria trial. Good animal performance has been obtained with cattle and sheep.

Similarly, milk production of goats responded to the inclusion of *Erythrina* foliage in a diet of King grass and bananas.

Trichantera gigantea is a new candidate for inclusion in integrated systems and grows well with repeated cutting and without fertilizer input. Its particular value is as a protein supplement for monogastrics (pigs) and it has replaced up to 75% of soyabean meal in pregnant sow diets.

A future priority is the treatment of tree foliage to improve the nutritive value and remove secondary plant compounds.

Bibliography

Buckingham, K.W., Ela, S.W., Morris, J.G. and Goldman, C. 1978. Nutritive value of nitrogen-fixing aquatic fern *Azolla filiculoides*. *Journal of Agriculture and Food Chemistry* 26: 1230-1234.

Chinh, B.V., Ly, L.V., Tao, N.H. and Minh, D.V. 1991. Ensiled cassava leaves as partial replacement of the protein supplement in final "C" molasses-based diets for pigs. In: Proceedings of a Regional Workshop on *Increasing livestock production by making better use of local feed resources*. FAO/SAREC, Hanoi, November 1991 (In press).

Esnaola, M.A. and Rios, C. 1990. Hojas de 'Poro' (*Erythrina poeppigiana*) como suplemento proteico para cabras lactantes. *Livestock Research for Rural Development* 2(1): 24-33.

Gomez, M.E. and Murgueitio, E. 1991. Efecto de la Altura de Corte sobre la producción de biomasa de Nacedero (*Trichantera gigantea*). *Livestock Research for Rural Development* 3(3): 14-23.

Mejía, C.E., Rosales, M., Vargas, J.E. and Murgueitio, E. 1991. Intensive production from African hair sheep fed sugar cane tops, multinutritional blocks and tree foliage. *Livestock Research for Rural Development* 3(1): 53-58.

Preston, T.R. and Leng, R.A. 1987. *Matching Ruminant Production Systems with Available Resources in the Tropics and Subtropics*. Penambul Books, Armidale NSW, Australia.

Preston, T.R. and Murgueitio, E. 1992. Sustainable systems of intensive livestock production for the humid tropics using local resources. *World Animal Review* (In press).

Sarria, P., Villavicencio, E. and Orejuela, L.E. 1991. Utilización de follaje de nacedero (*Trichantera gigantea*) en la alimentacion de cerdos de engorde. *Livestock Research for Rural Development* 3(2): 51-58.

Wang, T.C. and Fuller, M.F. 1989. The optimum dietary amino acid pattern for growing pigs. 1. Experiments by amino acid deletion. *British Journal of Nutrition* 62:77-89.