PROCEEDINGS

OF THE

26th ANNUAL MEETING

July 29 to August 4, 1990

Mayaguez, Puerto Rico

Published by:

Caribbean Food Crops Society

with the cooperation of the USDA-ARS-TARS

Mayaguez, Puerto Rico

FORAGE PRODUCTION AND UTILIZATION OF *Leucaena leucocephala* IN THE ENGLISH-SPEAKING CARIBBEAN

R.T. Paterson

CARDI
P.O. Box 113, UWI Campus, Mona, Kingston 7, Jamaica

ABSTRACT

Although *Leucaena leucocephala* is naturalized in the Caribbean islands where many ecotypes exist, only the giant types from St. Lucia and Haiti are highly productive. On relatively neutral to alkaline soils, cv. Cunningham and the Hawaiian K8, K28 and K67 have outyielded other lines. CF95 is considered to be moderately tolerant of soil acidity. *Leucaena* is not usually inoculated but scarification (hot water) is often useful. If ample seed supplies are available, direct sowing is effective but most commercial plantings have used seedlings. Under good conditions, yields of 20 t/ha with some 25% CP have been achieved, depending upon soil moisture and fertility. Psyllids are usually controlled by natural predators but occasional spraying may be necessary for maximum yields. Leucaena can be grazed, fed as green chop, ensiled or dried to leaf meal. Giant varieties are used as living fence posts. There are no reports of toxicity in ruminants. A Jamaican process uses fermentation to generate gas for fuel while detoxifying the mimosine. The solid residue can be used in poultry rations. While Leucaena is suitable for both large and small farms where soils range from mildly acidic to highly alkaline, high levels of lime and fertilizer are needed on very acid soils. Other leguminous trees should be developed for these adverse conditions.

ORIGIN AND LOCAL TYPES

It is generally accepted that the centre of origin of *Leucaena leucocephala* is to be found on neutral to alkaline soils in Southern Mexico and Central America. From there it has spread to all the countries of the Gulf of Mexico and to the islands of the Caribbean where it has become naturalized (Gray, 1986).

In the English-speaking Caribbean islands *Leucaena* has been traditionally used as a feed for all classes of livestock, Quintyne (1988) reports that in Barbados *Leucaena* has long been fed to rabbits, and is recognized as preventing pigs from becoming too fat. After moulting, presumably induced by mimosine toxicity, the coat that regrows on horses fed small amounts of *Leucaena* is shiny and attractive. Ruminant livestock find either fresh or dried forage particularly palatable. Despite this, scientific evaluation appears to have started only in the mid

1960's, one of the earliest reports coming from St. Croix in the U.S. Virgin Islands (Oakes and Skov, 1967).

Morphological Types

There is some confusion of nomenclature regarding the distinct morphological types of L. leucocephala. The following scheme (after Batson et al., 1984) will be followed in this review.

1. Hawaiian (also called Common): Highly branched, abundantly flowering weedy shrub growing to about 6m in height, this is the most common type in the world collection. In general, its cultivation is not recommended, although naturally occurring stands may be utilized by livestock or for fuel.

2. Salvador (also known as Arboreal, Guatemala and Hawaiian Giant): Usually erect, up to 20 m in height, these types have large leaves, leaflets, seeds and pods. They tend to be late flowering and this permits high yields of biomass. Brewbaker et al. (1972) warned, however, that they may not be amenable to grazing, being best suited to cut and carry systems at high plant populations (200,000/ha). They also find acceptance as wind-breaks and as living fence posts. El Salvador and Guatemala were two of the earliest commercial cultivars, but good results have since been obtained with the Hawaiian Giant cultivars K8, K28 and K67.

3. Peru: This morphotype is intermediate between Hawaiian and Salvador types, growing to heights of about 15 m. It combines the large leaves and vegetative vigour of the latter with the formation of low branches and reduced, woodiness of the former. Seed yield per plant is reduced, but still more than sufficient to justify commercial production. The variety Cunningham, bred in Australia, is perhaps the most widespread in the Caribbean, although stands of CF95 are to be found particularly in Trinidad, where it is reputed to show some degree of tolerance to soil acidity.

Caribbean Lines

Keoghan (1980) observed that most of the naturalized lines in the Caribbean were of the Hawaiian type. In a detailed study (Batson, 1987; summarized by Batson et al., 1988) , 295 accessions of Leucaena spp. were collected from Jamaica (66), Antigua (21), Barbados (26), Grenada (103) , St. Lucia (54) and Trinidad and Tobago (25). A representative sample of 174 accessions of L. leucocephala and one L. brachycarpa (from Jamaica) was evaluated together with introduced lines from the University of Hawaii, CIAT (Colombia) and CSIRO (Australia) on a free draining, fertile loam soil of pH 6.0 in Trinidad. On the basis of dry matter production, crude protein content and dry matter digestibility, 15 accessions were selected as being superior to the rest. These included the Salvador types K67, K8 and K6 and the Peru types Cunningham and CF95 together with the bred lines CIAT 17475 (a relatively short _L. leucocephala_) and CIAT 17487 (a tall _L. shannonii_. The only Caribbean accessions to be rated in the elite group were 7 Salvador types from St. Lucia (L 141, 142, 148, 154, 156, 159 and 173) together with one from Barbados (B77). The Hawaiian types from the region were consistently poor in terms of forage production, even though it is noted that naturally occurring populations can make valuable contributions to roadside grazing and household requirements in countries such as Antigua, Barbados and Grenada.

AGRONOMY

Many studies on the basic agronomy of _Leucaena_ were originally conducted elsewhere and then confirmed in the Caribbean region. Much of the information was summarized from internal reports and unpublished data by Proverbs (1985) and by Batson et al. (1987).

Seed Treatment

Freshly harvested _Leucaena_ seed will usually germinate rapidly and well but even short periods of storage will result in the need for scarification (Keoghan, 1980). When seed is in extremely short supply, mechanical scarification can result in germination of over 90 percent. Methods which have been successfully used include nicking the seed coat with a metal file (Barbados, 94 percent), abrasion of seed with coarse sandpaper (Antigua, 90 percent) and shaking with dry sand for 20 minutes (Hawaii, 96 percent). Quantities up to about 2 kg can be treated with concentrated sulphuric acid for 13 to 20 minutes or in 20 percent sodium hydroxide solution for 1 hour before washing in copious water. Both methods are expensive and potentially dangerous to the operator. The most practical methods involve soaking in hot water.

If seed is to be planted immediately, consistently good results have been obtained by pouring water at 800°C over the seed and leaving it to cool. Three days of soaking in the water will see the emergence of most of the radicles and the seed should then be sown without delay. Drying on paper towelling and dusting with a fungicide before planting can prevent damping off of the seedlings. As a variation of this, almost boiling water can be poured onto the seed. Soaking for 3 minutes, followed by air-drying on an absorbent surface will allow the seed to be stored for several weeks before planting, without any loss of viability.

In view of the wide natural distribution of Leucaena through-out the region, it is unusual to find nodulation problems, even where seed has not been inoculated. When seedlings are to be planted into an area where Leucaena has not been previously grown, a small amount of soil from under existing local stands, worked into the potting mixture will ensure good nodulation. In Barbados, 8 week old seedlings grown in this way carried an average of 17 large nodules (5 mm long) per plant (Proverbs, 1985).

Propagation

Like most legumes, Leucaena is notoriously slow growing in the early stages. For this reason, many areas, particularly for use as banks, have been established in the Caribbean as seedlings. Seedlings have been propagated in polythene bags or pots. In Antigua, useful cheap containers have been fashioned from short lengths (7-10 cm) of plastic water pipe (3-4 cm diameter) standing upright in metal trays. In Barbados, square plastic pots have been placed in racks of steel reinforcing mesh. In both cases, a potting mix of equal quantities of sand, peat moss and soil (preferably from under existing Leucaena stands) has been used successfully while in Trinidad, soil, manure and sand in a 3:2:1 ratio has given good results. Germination has been effected under 75 percent shade, reduced to 50 percent after one week. Seedlings are exposed to full sunlight three weeks after germination and transplanted at 6-8 weeks at a height of up to 30 cm. Planting often is done on a 1 m grid pattern.

Direct seeding can take place by either mechanical or manual techniques at a depth of about 2.5 cm. Many planting patterns have been used, depending upon the end use. Where grazing is contemplated, either as banks or as balanced pastures, gaps of 3 m between blocks of Leucaena (up to 5 rows, 50 to 60 cm apart can form a block) allow animal access and improve utilization.

Weed Control

Leucaena is susceptible to weed competition in the early stages, until it reaches a height of at least 1 m, so it is important to provide a good, weed-free seed bed. Several herbicides have been successfully used for this purpose, including paraquat and glyphosate to kill existing vegetation and vernolate, EPTC or trifluralin as pre-plant treatments. Fluazifop-p-butyl is a useful grass killer once the seedlings have reached a height of about 40 cm while directed applications of glyphosate or paraquat can be used between rows with a spray shield.

Pests and Diseases

Leucaena is generally resistant to pests and diseases and natural biological control mechanisms exist for the most important damaging insects. In Barbados, the following are the most common pests. Heteropsylla cubana (psillid) will suck the sap from young shoots, resulting in stunted growth and possible death of growing points. Nymphs and adults are attacked by larvae and adults of ladybird beetles (Cycloneda sanguinea, C. conjugata and Diomus spp.) and by larvae of lacebugs (Chrysopa spp.). Parasitic wasps (Tetrastichus triozae and Psyllaephagus sp. nr. rotundiformis) also attack nymphal stages.

Melipotis famelica (noctuid) is the most common defoliator of Leucaena, the population reaching highest levels in the wet season. Larvae are parasitized by an ichneumon fly (Enicospilus flavus).

The most damaging disease is damping-off of seedlings growing under wet conditions. The selection of well-drained planting sites, or seed treatment with a fungicide will overcome the problem, although seed treatment can delay nodulation. Termites must sometimes be chemically controlled to prevent seedling mortality.

Seedlings can be killed in the early stages by grazing and for this reason they need to be protected until they reach a height of at least 1m. In the dry season, rats will chew the stems when alternative food is scare and this can lead to heavy mortality unless control measures are used.

UTILIZATION

Leucaena has been utilized in many ways in the Caribbean and several alternatives have been described by Proverbs (1985) and Paterson et al., (1987). These are briefly summarized below.

Conventional Pastures

Leucaena can be planted in rows or as hedgerows within a grass pasture and fed on a year-round basis. The problem here is to achieve the balance between grass and legume that will permit long-term grazing. If too much grass is present, the tendency will be use high stocking rates and continuous defoliation can lead to the death of the legume. Conversely too much legume will tend to shade out the grass and lower the Productivity of the pasture. Luxury consumption of Leucaena will not lead to increased animal productivity and may result in milk with a definite taint. Although it is easily removed by pasteurization, such milk is not attractive to buyers.

Banks

Protein banks are comprised of pure legume and are intended to complement poorer quality grass pastures during the dry season. In order to accommodate the whole herd, they should probably occupy from 5-10 percent of the total grazing area, the proportion increasing as rainfall decreases. Protein energy banks are designed to provide a balanced protein and energy diet during the dry season and are combinations of a highly productive grass (Guinea grass, Panicum maximum or Elephant grass, Pennisetum purpureum) with the legume. They are usually planted in alternate rows or blocks and to accommodate the whole herd, they should cover up to 25 percent of the farm in the drier areas of the Caribbean. Direct grazing of either type of bank will reduce efficiency of usage by about 20 percent when compared with cutting.

When banks are grazed, Leucaena should be cut back once per year, at the end of the utilization period, to prevent it from growing out of the reach of the animals. Cattle will walk over year-old stems, bending them with the body in order to reach the leaves. Goats, however, have a tendency to ring-bark trees if they cannot get to the foliage. It is best not to direct graze Leucaena with small ruminants. Banks have been used with success in Antigua, Barbados, Grenada (including Cariacou) Montserrat, St. Kitts-Nevis, St. Lucia, St. Vincent and Trinidad and Tobago (Proc. First International Conference on Leucaena 10-13 July, 1989, Port of Spain, Trinidad, in prep.) while work has recently been undertaken in Jamaica. In a number of these countries, information being collected since 1987-88 include physical and financial inputs and outputs. Clearly, with a long-term technology such as that under discussion, production parameters will have to be measured over a period of several years before economic data can be usefully computed.

Leaf Meal (LLM)

Keoghan (1980) refers to the lopping of Leucaena branches for drying on racks either in the sun or under a roof to protect them from rain. Leaves can then be shaken or beaten from the stems which can be used as bean poles etc. The leaflets and petioles at about 13 percent moisture content or less can be bagged for safe storage. Quintyne (1988) describes a simple solar drier which constitutes a low cost refinement of the above technique. It consists of a concrete floor covered by a clear, rigid plastic roof. The northern and eastern sides are enclosed to prevent rain from blowing in, although ventilation is provided on those sides. Two or three days in this drying shed is sufficient to reach safe storage moisture levels in Barbados. Hales et al. (1988) propose the pneumatic separation of chipped Leucaena biomass. A proportion of the woody material would be used in a furnace to generate sufficient heat to dry the (lighter) leaf and petiole fractions. Such a technique is designed to operate with the large scale processing of LLM and therefore has a planned capacity of 10 tons per day of dry material (see below). Capacity is therefore beyond the requirements of individual livestock producers.

Silage

In Barbados, in preliminary studies (Quintyne, 1988), *Leucaena* was successfully ensiled with or without molasses in small plastic containers holding about 30 kg of chopped leaf. In subsequent work, this was extended to 208 litre steel drums and to trench silos, both using about 10 percent by weight of molasses. In all cases, the material ensiled without difficulty but mechanical harvesting with a forage harvester on about an 8 week cycle collected a high percentage of woody material (up to 42 percent) which reduced the CP content of the silage to about 12.5 percent. While this may represent an engineering, rather than an agronomic problem, it is clearly a limitation to the large-scale use of *Leucaena* as silage. The work of Alli et al. (1983) showed that *Leucaena* alone did not ensile as well as alfalfa, requiring acidification or the addition of molasses to produce high quality silage. While the Barbados work reported above produced well preserved material which was readily accepted by all classes of livestock, potential ensiling problems could compound the difficulty of mechanical harvesting. In view of its ability to stand in the field over a relatively long, hard dry season without substantial leaf loss or drop in quality, it may be that *Leucaena* is better suited to use as green chop or LLM than silage.

Processing

In Jamaica, attention has been paid to the fermentation of LLM to remove the mimosine content. The resultant meal is then safe for use in rations for non-ruminants. The process has been internationally patented and has attracted attention in Guyana, Barbados, Haiti and Antigua and Barbuda. The following details are summarized from Minott (1988).

Dried *Leucaena* leaves are milled to not less than 0.5 mm to increase the efficiency of the fermentation process. They are then mixed with water to form a slurry which is macerated and pumped to fermentors containing an anaerobic bacterial inoculant. Fermentation proceeds at pH 8.5 and a pressure of 40 psig. The gas which is produced contains a mixture of methane and hydrogen (about 71 percent) together with carbon dioxide (about 29 percent). This is known as energas and can be used for the generation of electricity or as household fuel. The solids are separated from the liquids by filtration. The filter cake, fermented *Leucaena* leaf meal (FLLM), is dried and milled and typically contains about 32 percent crude protein with negligible levels of mimosine (Lewis, 1988). Some of the liquid is recycled to the fermentors while some can be drawn off for use as an organic fertilizer which has a N:P:K ratio of 13:4:35 on a dry basis. The process uses only about 10 percent of the gaseous fuel which is produced. The first plant, built in Kingston, Jamaica, has a capacity of 180 tons per year of FLLM and 40 KW of electrical power for eight hours per day, together with an unspecified amount of liquid fertilizer. Adjusting the concentration of total solids and retention time in the fermentors will vary the balance between gas and FLLM production.

This process clearly has great potential for the production of both fuel and a high protein feed suitable for use with monogastric animals and should find commercial application in countries where importations of these commodities represent a continuous drain on reserves of foreign exchange. This reviewer, however, cannot feel enthusiasm for plans to utilize all aspects of the technology on acid, infertile soils of Guyana since the soil ameliorants required to grow Leucaena under these conditions will mitigate against the financial viability of the project. Alternative leguminous trees or shrubs such as Flemingia macrophylla, Erythrina spp. etc. should be considered that are better adapted to these soil conditions than is L. leucocephala (see below).

Other Uses

While this review is concerned with Leucaena planted primarily for livestock production, other uses will be mentioned for the sake of completeness.

Living Fences: Salvador types will frequently produce trunks which are unbranched for the first 2 to 4 m, and under good growing conditions, they will reach breast-height diameters of 10 to 15 cm in two or three years. Such trees can readily support fencing wire at that stage while the tops call be lopped to produce LLM or dry season grazing. This is particularly useful on small farms where they can also provide shade if planted along all fence lines.

Fence Posts: Leucaena wood is close-grained and easily worked but readily takes up wood preservatives. If untreated, it quickly rots in the soil, but with adequate treatment it is suitable for posts. Thin branches can be used as fence spacers or as bean poles in crop.

Erosion Control: Experience in Barbados shows that Leucaena is able to stabilize slopes prone to soil slippage (Paterson, 1988). Clearly, when used in this way care must be taken to employ management practices that do not aggravate the danger of soil erosion. Salvador types are also useful as windbreaks and shelter belts although this objective cannot be fully realized if the trees are heavily exploited for animal feed.

Green Manure and Soil Fertility: Alley-cropping as developed at IITA in Nigeria has not yet been commercially used in the Caribbean but the potential for the use of Leucaena in this technique has been demonstrated elsewhere. The effect of Leucaena on soil fertility has been noted in Barbados and Antigua where the growth of shade-tolerant Guinea grass is better under Leucaena than in the open away from the trees (Paterson, 1988).

Fuel: Salvador types produce wood with an average density of about 0.54 g/cc and heating values of about 4,000 Kcal/kg compared with Hawaiian types at about 0.7 g/cc and 4,600 Kcal/kg. All Leucaena varieties make good charcoal with a heating value of about 7,000 Kcal/kg.

Miscellaneous: Leucaena wood is suitable for blending with long fiber pulp to make printing and writing paper. It can also be used for the production of rayon and cellophane. In some countries young pods, leaves and flower buds are used as vegetables or in soups and stew for human consumption. Roasted ripe seeds are eaten as snacks or pounded into a meal.

FORAGE PRODUCTION

In the earliest report of critical work with Leucaena on neutral to alkaline soils (St. Croix), Oakes and Skov (1967) measured annual forage yields ranging from 11.2 t/ha DM (1671 kg/ha CP) from a local Virgin Islands accession to 20.8 t/ha DM (2856 kg/ha CP) from a line imported from Guatemala. In Jamaica, when total production was limited by low rainfall, cv Cunningham grown from either seed produced in Australia or in Antigua averaged 11.6 t/ha DM (2,600 kg/ha CP) (Logan, 1979, J. L. Logan, personal communication). Work over a number of years in Antigua (Keoghan, 1980) measured cv Cunningham forage yields at 10 to 15 t/ha DM (2,500 to 3,750 kg/ha CP) without irrigation. The yields varied with rainfall, the long term average in Antigua being 1,000 mm. Experience in several islands of the Eastern Caribbean led to the generalized conclusions presented in Table 1.

Table 1. Expected annual forage yields (t/ha DM) from Cunningham Leucaena banks in the Caribbean (after CARDI, 1980, Proverbs, 1985)

Soil Type	No irrigation no insect control	No irrigation good insect control	Irrigation good insect control
Good cropping soil[1]	10-15	12-18	20-28
Marginal cropping soil[2]	8-13	10-16	18-25
Cracking clays[3]	7-13	9-15	16-22
Skeletal soils[4]	4-10	5-12	not relevant

1. deep calcareous clays and clay loams, deep volcanic loams
2. shallow calcareous clays and clay loams, shallow volcanic loams
3. heavy soils with some drainage impedance
4. Terra nova and skeletal volcanic soils

The nutritive quality of Leucaena, like that of any plant, depends upon soil fertility and the stage of growth of the parts sampled. Typical figures from the Eastern Caribbean are presented in Table 2.

Table 2. Chemical composition of Leucaena (after Quintyne, 1988)

Plant part	Source	CP	ADF	NDF	ASH
leaflet	Barbados	33.4	19.0	32.0	12.4
petiole	Barbados	20.8	44.1	62.7	10.3
whole leaf	Barbados	31.8	21.6	36.8	10.9
whole leaf	Antigua	27.4	18.5	31.0	13.6

On the neutral to alkaline soils of islands such as Antigua and Barbados, the results outlined above have been achieved with little or no fertilizer applied to the Leucaena, although the plants may have benefitted in some cases from the residual effects of fertilizer applied to earlier crops.

In contrast, on acid, infertile soils in Trinidad, heavy rates of fertilizer are needed to ensure establishment. García (1986) has outlined the fertilizer regime as employed at the Sugarcane Feeds Centre to establish the CF 95 variety (Peru type) on Piarco Fine Sand. It has a pH of about 4.0 in the virgin state, but the effect of the soil ameliorants on acidity is not recorded.

Lime at 5 t/ha incorporated into the soil at the preparation stage.

Poultry manure at 10 t/ha applied to some plots and worked in.

11:11:11 compound fertilizer, 890 kg/ha when seedlings were transplanted, followed by another application two months later.

With this heavy fertilizer regime, annual yields of 9 t/ha DM were estimated from intensively managed small plots while on a larger (2 ha) scale, Neckles (1987) reported yields of only 8 t/ha fresh material in the absence of a strict cutting cycle. Garcia (1988) showed that CP, ash and DE fell from 34.2 percent, 8.6 percent and 10.6 MJ/kg DM in 3 month old plants to 19.4 percent, 5.5 percent and 6.0 MJ/kg respectively in 6 month old plants going through the dry season.

In Belize, Lazier (1978) obtained 2.6 t/ha of dry forage on an alluvial soil of pH 6.4, compared with 0.9 t/ha on a vertic ultisol of pH 5.8 using the variety Peru. In Suriname on an acid, sandy loam (pH 5.3) relatively low yields of 4.5 to 9.0 t/ha DM were measured from a range of Leucaena varieties including Cunningham, CF95, K8, K28, K67 and local ecotypes (Callebut and Kerkhoff, in press). These data would appear to underline the need to choose fertile soils in order to obtain high forage yields. L. leucocephala shows little adaptation to acid infertile soils, although crosses with L. diversifolia have sown promise in Brazil (Hutton, in press)

MIMOSINE TOXICITY

In view of experiences in Australia with mimosine toxicity in animals fed high levels of Leucaena over extended periods, there has been a certain amount of reluctance in some quarters to introduce the plant into production systems. An experiment was conducted in Barbados in which Blackbelly lambs were fed Cunningham Leucaena for four months (Quintyne, 1988). Although weight gains were modest due to inadequate ME levels, animals fed exclusively on Leucaena, either as fresh (frozen) or dried fodder, showed no symptoms of mimosine toxicity. At slaughter, no internal lesions were observed and only one animal out of 12 showed a slight enlargement of one throid gland. In Grenada, 6 Blackbelly sheep were kept on a 100 percent Leucaena diet for over 4 years without signs of toxicity. Three females gave birth to 16 lambs, of which only 3 died (Buckmire, in press). These experiments, together with the absence of any reports of apparent mimosine toxicity in the region would suggest that Caribbean ruminants carry gut flora capable of degrading the toxic element. An investigation is currently underway in Jamaica to test this theory (G. Ruegsegger, personal communication).

ANIMAL PRODUCTION

Although there is a dearth of data from formally designed animal production experiments in the Caribbean, there is a growing body of information from observations which support findings from other regions. Taken together these observations underline the high quality of Leucaena forage for feeding ruminants.

In Antigua, a locally formulated block containing 41.5 percent LLM, 50 percent molasses, 5 percent urea and 3.5 percent minerals was used to supplement unimproved native pastures during the dry season. Senepol bull calves consumed 0.9 kg per day of this block and gained 0.49 kg per day. An expensive imported block containing 21 percent protein mainly from cottonseed, soybean and urea consumed at 1.2 kg per day produced 0.57 kg per day LWG (Keoghan, 1980). Considering the difference in consumption, the local block was just as effective as the imported material.

In Jamaica, steers grazing Pangola grass (Digitaria decumbens) alone gained 0.40 kg per day over a period of 371 days (746 kg/ha) compared with 0.47 kg per day (875 kg/ha) on the same grass associated with a low population of Leucaena (Logan and Jennings, 1987). Quintyne (1988) in Barbados reports LWG of Holstein steers of 0.57 kg per day when fed about half their diet as relatively woody Leucaena silage, while Garcia (1988) in Trinidad showed LWG of Holsten bulls of over 1.0 kg per day with 20 percent of the diet as dehydrated Leucaena. At the sugarcane Feeds Centre, where the aim is to maximize the use of sugarcane (Neckles, 1987), Leucaena could satisfactorily replace up to 100 percent of the soybean meal in the diets of milking cows (6 to 20 percent Leucaena on a dry matter basis). Leucaena also increased the LWG of calves even in the first five weeks of life, after weaning at 7 days.

Concern has often been expressed about the effect of incipient mimosine toxicity on herd fertility. In Barbados, a group of 30 Jamaica Red Polls grazing Leucaena banks in conjunction with other grass - legume pastures (no concentrates) had 87 and 90 percent calving over a two year period (Proverbs, 1985). Clearly, there were no serious fertility problems amongst these cows.

Data on small ruminants are even fewer than for cattle but Neckles (1987) reports LWG for male crossbred sheep in the range of 0.18-0.25 kg per day at 20 percent Leucaena feeding at the Sugarcane Feed Centre. Relatively woody silage (12.5 percent cp) gave 0-13 kg per day LWG in male Blackbelly sheep in Barbados (Quintyne, 1988). The ration was formulated assuming much higher quality from the silage so the relatively low growth rates are not surprising.

In general, the performance of Caribbean animals given access to Leucaena has been comparable with data in the literature from other parts of the world as quoted by Proverbs (1985).

CONCLUSIONS

In its rightful environment of relatively fertile soil ranging from slightly acid to highly alkaline, Leucaena leucocephala is a highly productive plant which can be used in a multiplicity of ways. It can fit into both large and small scale ruminant production enterprises and after fermentation to remove the mimosine, it can find a role in the nutrition of monogastrics. Sufficient information exists to confidently recommend its use throughout the region, since some degree of local experience is available in almost all Caribbean countries.

The major problem with Leucaena is that it has distracted attention from other potentially valuable leguminous trees and shrubs. It has been hailed as a miracle plant that is a panacea for all areas of the tropics. This is clearly not the case since as shown above on acid, infertile soil as found in Belize, Trinidad, Guyana and Suriname for example, its productivity is drastically reduced, even with high levels of fertilizers. Concentration on Leucaena has hindered the study of other species which are better adapted to unfavourable conditions (Gliricidia, Flemingia, Erythrina, Desmanthus, Prosopis, Acacia, to mention but a few genera). Without detracting in any way from the success of Leucaena in terms of productivity, persistence and versatility in its area of adaptation, it is to be hoped that its limitations will also be recognized and alternative species studied under adverse conditions such as poor drainage, rainfall below 700mm, excessive acidity, aluminum toxicity and high altitude.

REFERENCES

Alli, I., Baker, B.E., and García, A. 1983. The ensilage of chopped, whole plant Leucaena. Proc. World Conf. Anim. Prod. Tokyo, Japan, August, 1983.

Batson, H.F. 1987. Classification and evaluation of indigenous and introduced Leucaena germplasm in the Caribbean. M. Phil. Thesis, Univ. of the West Indies, St. Augustine, Trinidad.

Batson, H.F., Ferguson, T.U., and Archibald, K.A.E. 1984. Variability in Leucaena and its potential in the Caribbean. 2nd Annual Meeting of OAS/Caribbean Leucaena Project, Kingston, Jamaica.

Batson, H.F., Ferguson, T.U., and Archibald, K.A.E. 1987 Cultivation of Leucaena with special reference to the Caribbean. CAEP, Univ. of the West Indies, St. Augustine, Trinidad.

Batson, H.F., Ferguson, T.U., and Archibald, K.A.E. 1988. The evaluation of Leucaena accessions in Trinidad. In: Lewis, C.E. (Ed) Proc. 1st Carib. Leucaena Industries Symp. 11-14 August 1987, Kingston, Jamaica. Enerpl... Ltd. Kingston, Jamaica. pp. 27-31.

Brewbaker, J.L., Plucknett, D.L., and Gonzáles, V. 1972. Varietal variation and yield trails of Leucaena leucocephala in Hawaii. Hawaii Agric. Expt. Stn., Univ. of Hawaii Research Bull. 166.

Buckmire, K.U. Leucaena for livestock production: The Grenada The Grenada experience. 1st Internat. Conf. on Leucaena. 10-13 July 1989. Port of Spain, Trinidad. (In press.)

CARDI. 1980. Forage legume and pasture utilization project. Ann. Rep. 1980. CARDI, St. John's, Antigua.

Callebut, María and Kerkhoff, P. Feed production of Leucaena leucocephala (Lam.) de Wit cultivars on the acid sandy loams of the Zanerij formation in Suriname: some observations concerning yields. 1st Internat. Conf. on Leucaena. 10-13 July 1989. Port of Spain, Trinidad. (In press.)

García, G.W. 1986. The role of forage legumes in the sugar cane feeding programme at the Sugarcane Feeds Centre. Proc. CARDI-EDF Seminar, Potential for pasture production in acid tropical soils. 22-24 June 1986. Univ. of the West Indies, St. Augustine, Trinidad. CARDI, St. Augustine, Trinidad. pp. 61-68.

García, G.W. 1988. Production of Leucaena (Leucaena leucocephala) and cassava (Manihot esculenta) forages and their nitrogen utilization by growing dairy cattle fed sugarcane based diets. Ph.D. thesis, Univ. of the West Indies, St. Augustine, Trinidad.

Gray, S.G. 1986. A review of research on Leucaena leucocephala. Trop. Grasslds. 2:19-30.

Hales, A., Minott, D., and Butterfield, D. 1988. Agricultural and other engineering issues in the commercial processing of Leucaena. In: Lewis, C. E. (Ed) Proc. 1st Carib. Leucaena Industries Symp. 11-14 August 1987, Kingston, Jamaica. Enerplan Ltd., Kingston, Jamaica. pp. 32-42.

Hutton, E.M. Genetic improvement in Leucaena. 1st Internat. Conf. on Leucaena 10-13 July 1989. Port of Spain, Trinidad. (In press.)

Keoghan, J.M. 1980. Leucaena leucocephala: An amazing, multipurpose tree for the tropics. Proc. 26th Canadian Soc. Agron. Meetings, Edmonton, Canada.

Lazier, J.R. 1978. Forage potential of selected legumes under Belize conditions. Ph.D. Thesis, Univ. of the West Indies, St. Augustine, Trinidad.

Lewis, C.E. 1988. Leucaena products: Some critical needs for biochemical and nutritional research. In: Lewis, C.E. (Ed.) P/oc. 1st Carib. Leucaena Industries Symp. 11-14 August 1987, Kingston, Jamaica. Enerplan Ltd., Kingston, Jamaica. pp. 20-26.

Logan, J.L. 1979. Grass-legume for animal production. Proc. Livestock Research Seminar, Forages in Livestock Production in Jamaica. 27 June 1979. Min. of Agric., Jamaica. pp. 39-45.

Logan, J.L., and Jennings, P.G. 1987. Forage legumes research in Jamaica: Potential applications. Conf. Science and Technology. 27-29 April 1987. Scientific Research Council, Kingston, Jamaica.

Minott, D.A. 1988. Commercial scale fermentation of Leucaena foliage: The Enerplan process in a young industry. IN: Cynthia E. Lewis (Ed) Proc. 1st Carib. Leucaena Industries Symp. 11-14 August 1987, Kingston, Jamaica. Enerplan Ltd., Kingston, Jamaica. pp. 43-46.

Neckles, F.A. 1987. Ruminant feeding from agricultural products and industrial by-products at the Sugarcane Feeds Centre. In: Paterson, R.T. (ed.) Proc. Forages Session, joint CFCS-CAES meeting. 23-28 August 1987. St. John's, Antigua. CARDI, St. Augustine, Trinidad. pp. 11-17.

Oakes, A.J., and Skov, O. 1967. Yield trials of Leucaena in the US Virgin Islands. J. Agric. Univ. of Puerto Rico 51: 176-181.

Paterson, R.T. 1988. The use of Leucaena to control soil erosion. In: Lewis, C.E. (ed.) Proc. 1st Carib. Leucaena Industries Symp. 11-14 August 1987. Kingston, Jamaica. Enerplan Ltd., Kingston, Jamaica. pp. 75-79.

Paterson, R.T., Proverbs, G.A., and Keoghan, J.M. 1987. The management and use of forage banks. CARDI, St. Augustine, Trinidad. 19 pp.

Proverbs, G. 1985. Leucaena: A versatile plant. CARDI, St. Michael, Barbados. 30 pp.

Quintyne, R.C. 1988. Utilization of Leucaena leucocephala as a livestock feed in Barbados. In: Cynthia E. Lewis (ed.) Proc. 1st Carib. Leucaena Industries Symp. 11-14 August 1987. Kingston, Jamaica. Enerplan Ltd., Kingston, Jamaica. pp. 10-14.