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UTILIZATION OF LEGUMES FOR LIVESTOCK PRODUCTION IN BELIZE

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PREFACE

The Belize Livestock Development Project II is a joint effort of the of the United States Agency for International Development (USAID), the Belize Ministry of Agriculture and Fisheries (MAF), and the Belize Livestock Producer's Association (BLPA), to increase the productivity and profitability in the livestock sector.

The goal of the project is to increase agricultural productivity, income and quality of life among Belizean farmers, particularly those producers and entrepreneurs involved in livestock production. The purpose of the project is to improve livestock production efficiency, expand market outlets and increase the volume of livestock products that are price and quality competitive with imported livestock goods.

Protein supply is probably the most limiting factor in livestock feeding systems in Belize. Forage and feed legumes are very important components of the diets of livestock which can provide crude protein at a low cost. Significant work has been done in the country in the identification of legumes adapted to agro-ecosystems in Belize for their utilization in livestock production systems. At the same time recent developments in the Caribbean Basin have been providing information on the subject which might be relevant to Belize for milk and beef production systems.

The purpose of the workshop was to identify forage and feed legumes for utilization in Belize and to learn about their contribution to livestock production systems in the Caribbean Basin, which might have application to conditions in this country. There was also an opportunity to discuss strategies and alternatives to establish links with national and regional research and development institutions for future work and collaboration to evaluate the impact of legumes in feeding systems in Belize.

A total of 84 technical officials, livestock producers, representatives from CIAT (Centro Internacional de Agricultura Tropical), CARDI (Caribbean Agriculture Research and Development Institute), IRI Research Institute, the Ministry of Agriculture and Fisheries (MAF), and other Non-Government Organization involved in agricultural development in Belize, and the Belize Livestock Producer's Association (BLPA), participated actively during the presentations and discussions, making a significant contribution to the success of the meeting.

This publication consists of 5 conferences presented during the workshop. The first paper describes the roles of legumes in livestock feeding systems in the tropics, followed by two presentations on research results and recommendations on forage and feed legumes for Belize, and two conferences presenting results of forage legumes in the Caribbean Basin and Central America, respectively. The summary and conclusions are also included.

The Organizing Committee wishes to express their appreciation to the authors for their efforts to summarize relevant information, which will undoubtedly make a contribution to improve livestock production in Belize, and for preparing the written reports in such a way that it has facilitated the editing of this publication. The efforts of John Carr and Orlando Orio, Chairman and former Executive Secretary of the BLPA, to assist in summarizing the discussions and developing the conclusions of the seminar are also recognized. The Master of Ceremonies, Elias Awe, must be complemented for his contribution to make the presentation of the program enjoyable to the audience. The support of the agencies sponsoring and providing funding for the workshop and travelling expenses for the speakers (MOAF, USAID, BLPA, IRI, CIAT, CARDI and BABCO) must be recognized as an indication of the commitment to the success of the Livestock Development Project. Finally, we deeply appreciate the active participation and involvement of 35 farmers representing all the districts in Belize; this publication is dedicated to them in recognition for their interest to develop the livestock industry throughout the country.

Elide Valencia, Chairman
Luis E. Tergas, Vice-Chairman
Efrain Aldana
Orlando Orio

Belmopan, Belize, November 1989.

THE ROLES OF LEGUMES IN LIVESTOCK FEEDING SYSTEMS IN THE TROPICS

Luis E. Tergas*

INTRODUCTION

In most of the tropical regions of the world, it is a widespread belief that grasses are the only pasture components which are important for grazing cattle (Roberts, 1979). Tropical legumes have been used mainly for cover crops until recent years when there were some indications of its great potential as forage plants (Williams et. al, 1976). Most of the success in the improvement of tropical pastures, especially in Australia, have been due to technology based on utilization of forage legumes (Gramshaw et. al, 1989).

Most of the tropical legumes utilized in feeding system are native plants to tropical America, and significant efforts have been made to collect and evaluate germplasm in Central and South America, including of course, Belize (Schultze-Kraft and Giacometi, 1979; Stassen, 1989). Recent developments indicate the significant contribution of tropical forage legumes adapted to acid soil conditions to pasture improvement for cattle production in the major ecosystems of the tropical American lowlands (Toledo and Nores, 1986).

The objectives of this presentation are to discuss some of the advantages and disadvantages of tropical forage legumes, as well as to illustrate problems and other common causes associated with failure on utilization of pastures on commercial farms. We will also present some suggestions for the implementation of research and pasture management practices which hopefully will help us in Belize to take advantages of the useful characteristics of these plants, rather than adopting an attitude of defeat, which has been the case with some technical personnel as well as farmers in tropical America.

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ADVANTAGES

Legumes are unique among forage plants and in general have several advantages compared to grasses.

1. Atmospheric nitrogen fixation.- This nutritional element which is very important for plant growth is probably the most limiting factor associated with tropical soil fertility. Significant amounts of nitrogen fertilizer are required and, thus, recommended to improve forage production of tropical grasses. However, this is usually not an economical pasture management practice for most livestock production systems in Belize.

   The main source of nitrogen for the manufacture of fertilizers is the atmosphere. The composition of the air is 80% nitrogen and the association of Rhizobium bacteria with legumes allows the biological fixation of significant amounts of this element at low cost. The nitrogen fixation rates in legumes commonly range from 50 - 150 lb/acre/year; although it has been reported as high as 300 lb/acre under favourable conditions (Hubbell, 1979).

   Nitrogen fixation by tropical grasses in association with free-living soil bacteria has been reported by Dobereiner and Day (1975). However, there appears to be no appreciable development of a close relationship between the plant and the micro-organisms which could result in an efficient transfer of nitrogen to the plant (Hubbell, 1979).

2. Supply of high quality herbage.- Due in part to the nitrogen fixation capacity of tropical legumes, the crude protein content of the forage is usually above 15%, even during the dry season. The crude protein content of grasses is normally below 10%; unless heavily fertilized with nitrogen, and it decreases to below 3% during the dry season due to plant maturity and lack of water (Tergas et. al, 1971). Protein supply is probably the most limiting factor in feeding systems in Belize.

   Another important factor to consider in forage quality is voluntary intake of dry matter and digestible energy. Grasses are the main source of energy for livestock; however, the voluntary intake of grasses by cattle decrease when its crude protein content is less than 6%. On the other hand the voluntary intake of forage legumes is usually 28% higher when compared to grasses at the same level of digestibility (Thornton and Minson, 1973).

   Forage legumes also make a contribution to animal mineral nutrition (phosphorus and sulfur) and vitamin A, when properly fertilized.

3. Continuous supply of feed throughout the growing year.- Forage production with tropical grasses decreases significantly during the dry season even under expensive fertilization and irrigation practices. Forage legumes are better adapted to dry conditions and this is the time of the year when they make the greater contribution to livestock production.

4. Prevention of soil erosion and reforestation.- Forage legumes aid in the prevention of soil erosion by providing year-round ground cover under soil fertility conditions which are difficult for the establishment and growth of grasses. Fast growing tree legumes such as Leucaena have been very effective on reforestation programs on hill sides in the tropics. They also enhance the beauty of the environment and promote healthy population of wild birds and mammals.

5. Cover crop and weed control.- Several species of tropical legumes grow very aggressively protecting the ground and competing very effectively with undesirable plants in cropping systems. This characteristic has been recognized for years on oil palm and rubber plantations. There is an excellent opportunity to utilize these plants to reclaim weedy natural pastures which grow after cropping.

DISADVANTAGES

1. Palatability and forage intake.- The grazing animal prefers grasses over legumes for intake of dry matter and energy, provided that the crude protein content of the diet is not a limiting factor. Under certain conditions during the rainy season the botanical composition of the pastures might be legume dominant and animal production might decrease because of diet selection and low energy intake during grazing. However, this situation is seldom encountered during the dry season, except for unpalatable legume species.

   Some legumes species tend to produce and accumulate substances which limit forage intake and to a certain extent make them relatively unpalatable. This is such a case with tannins in Desmodium spp. and Indigotera hirsuta. However, the relatively low palatability of tropical legumes during the rainy season might be an advantage because of greater possibilities for growth and nitrogen fixation and accumulation of good quality forage for the dry season.

2. Toxic substances.- Leucaena is a good example of a highly nutritious forage legume that tend to accumulate a toxic substance, mimosine, which can cause reduction in animal growth and reproduction when grazed for long periods of time. However, under controlled grazing conditions, it does not represent a problem with ruminants that are used to graze Leucaena, such as cattle and goats.

The toxicity by mimosine seldom result in the death of the animals. It must be pointed out that some tropical grasses also tend to accumulate toxic substances such as nitrite, nitrate, cyanide and oxalates, which usually result in animal death.

3. Susceptibility to diseases and insects.- This probably represent one of the most important factors which limit the growth and persistence of forage legumes in the tropics. Specific diseases such as anthracnose in Stylosanthes, and Cercospora in Centrosema can cause severe defoliations which affect growth and persistence. Leaf eating insects can also cause severe damage to the majority of forage legume species. Selection of disease and insect tolerant cultivars is one of the main objectives of any research program in tropical legumes. Native species are usually more tolerant to pests; therefore, they should be taken into consideration in any research and development program to improve pasture utilization.

4. Poor persistence under grazing.- Grasses in general have better growth characteristics than forage legumes to tolerate trampling and grazing. The physiological characteristics of legumes does not allow them to compete effectively with associated grasses, unless other factors such as relative palatability, soil fertility and moisture, limit grass growth. Furthermore, competition for soil moisture and nutrients, insect and diseases, flooding and burning, competition with grass weeds, overgrazing, etc., put severe limitations on legume persistence. Nevertheless, if we could increase the persistence of forage legumes, we will be in a better position to improve livestock production at low cost, which in time will make a tremendous contribution to agricultural development in the tropics. This is the challenge we must accept.

PROBLEMS ASSOCIATED WITH FAILURES AND SUGGESTIONS FOR POSSIBLE SOLUTIONS

1. Pasture establishment.- The most common mistakes in establishing legumes/grass pastures are: a) selection of species which are not well adapted to the environment; b) choosing grass and legume species which are not compatible; c) planting an unbalanced mixture of seeds of each species (Roberts, 1979); d) improper soil fertilization and inoculation of seeds to guarantee a vigorous growth of legume plants to allow them to compete with companion grasses and weeds; e) planting methods which do not favour the growth of legume plants in competition with grasses and weeds.

These are critical problems that must be solved during the establishment phase, because they later determine the life span of the pasture. If you make the wrong decision you cannot correct this situation by grazing management alone. Research information must be available under local conditions before recommendations can be made for utilization on livestock feeding systems.

2. Pasture management.- The main component of a mixed tropical pasture are the legumes; therefore, management practices should favour its growth and persistence rather than to favour the grass component (Roberts, 1979). The most common mistakes affecting persistence of legume are: a) initiation of grazing too early before the legumes have produced seeds in order to accumulate a reserve in the soil. b) grazing management with high stocking rates, and rotational grazing which tend to overgraze the legume component of the pasture; c) the use of mowing, fire and herbicide for weed control; d) lack of pasture fertilization for maintenance; e) not allowing seed production of legumes under grazing to maintain an active growing plant population in the pasture.

Low stocking rates under continuous grazing (unless the legume is less palatable and too aggressive) with short rest periods during flowering and seed production, maintenance fertilization with potassium and sulfur in the middle of the rainy season, and prevention from fire and mowing and the use of selective herbicide, have resulted in grass legume association which have been productive and persistent for more than 10 years in several tropical countries.

CONCLUSION AND RECOMMENDATIONS

Roberts (1979) concluded that failures with tropical legumes are attributed to over emphasis on the importance of grasses and lack of appreciation of the major roles of tropical legumes. Increased animal production can best be achieved by adopting management practices which favour legume growth and persistence.

Numerous legume species are native or are naturalized and adapted to Belize. We must have a better appreciation for their important roles in the development of livestock feeding systems and start learning more about how to utilize them to their full potential.

The continuity of the research program to characterize legume species for adaptation and compatibility with grasses, seed multiplication, evaluation for forage production, persistence under grazing and utilization on commercial farms, must be considered priorities for a livestock development program for Belize.

LITERATURE CITED

1. Dobereiner, J., and J.M. Day, 1975. Associative symbioses in tropical grasses: characterization of microorganisms and dinitrogen fixation sites. In Proc.I International Symposium on Nitrogen Fixation 2:518-538. Univ. of Washington Press, Pullman.

2. Gramshaw, D., J.W. Read, W.J. Collins and E.D. Carter, 1989. Sown pastures and legume persistence: An Australian overview. In G.C. Marten et. al. (eds) Persistence of Forage Legumes. American Society of Agronomy, Madison, Wisconsin, USA. p.1-21.

3. Hubbell, D.H., 1979. The potential of associative symbioses between nitrogen fixing bacteria and forage grasses. In P.A. Sanchez and L.E. Tergas (eds) Pasture Production in Acid Soils of the Tropics. CIAT, Cali, Colombia. Series 03-EG-5. p.139-144.

4. Roberts, C.R., 1979. Some common causes of failure of tropical legume/grass pastures on commercial farms and suggested remedies. In P.A. Sanchez and L.E. Tergas (eds) Pasture Production in Acid Soils of the Tropics. CIAT, Cali, Colombia, Series 03 EG-5 p.399-416.

5. Schultze-Kraft, R. and D.C. Giacomettii, 1979. Genetic resources of forage legumes for the acid infertile savannahs of tropical America. In P.A. Sanchez and L.E. Tergas (eds) Pasture Production in Acid Soils of the Tropics. CIAT, Cali, Colombia, Series 03 EG-5 p.55-64.

6. Stassen, C., 1989. Native legume distribution and collection. In E.A. Awe (ed) Proc. IDRC/Belize Pasture Legume Research Program Workshop. Ministry of Agriculture, San Ignacio, Cayo, Belize, 1981. p.96-107.

7. Tergas, L.E., W.G. Blue and J.E. Moore, 1971. Nutritive value of fertilized Jaragua grass (Hyparrhenia rufa (Nees) Stapf) in the wet-dry Pacific Region of Costa Rica. Tropical Agriculture (Trinidad) 48 (1):1-8.

8. Thorton, R.F. and D.J. Minson, 1973. The relationship between apparent retention time in the rumen, voluntary intake and apparent digestibility of legume and grass diets in sheep. Aust. J. Agric. Res. 24:889-98.

9. Toledo, J.M. and G.A. Nores, 1986. Tropical pasture technology for marginal lands of tropical America. Outlook on Agriculture 15(1):2-9.

10. Williams, R.J., R.L. Burt and R.W. Strickland, 1976. Plant introduction. In N.H. Shaw and W.W. Bryan (eds) Tropical Pasture Research Principles and Methods. Bill 51, Commonwealth Bureau of Pastures and Field Crops, Hurley, Berkshire, England, p.77-100.

RESULTS AND RECOMMENDATIONS FOR UTILIZATION OF LEGUMES ADAPTED TO BELIZE

Elide Valencia*

INTRODUCTION

The Forage Legume Program was initiated in March 1973, with its main objective being to increase the productivity of Belizean pastures through the incorporation of legumes. This should make cattle raising economical even on the more difficult soils (Lazier 1976).

Two of the major groups of soils of Belize used for pasture development are the planosols (Ultisols), also known as the Pine Ridge soils and the Vertisols (Ahmad 1989). Cattle production is concentrated in Cayo and Orange Districts, mainly on the heavy alkaline clay soils. These soils present several management problems when used for pasture development on account of their ability to swell on wetting and shrink and crack during the dry season. They also have special implications for drainage since infiltration and percolation rates for wet soils are slow (Holder 1989).

This paper will discuss the response of selected legumes and their suitability for pasture improvement on main soil types.

METHODOLOGY

The strategy used by the Belize Forage Legume Program involved the testing of potential pasture legume species collected from within Belize, the Caribbean and Central America, and those obtained from research institutions such as CIAT and CSIRO. The procedure for legume selection is outlined in table 1. Initially, accessions are planted in observation plots and characterized for growth, dry matter yield, flowering, seed production, incidence of diseases and insect attack. Promising species are selected and evaluated for dry matter yield and adaptability in single plant trials on the various soil types and ecological conditions. Legume species which perform well in the development trials are further evaluated by planting in strips on native or established pastures and observing productivity, competitive ability, spread, persistence and palatability. Other types of evaluation consist of pure sward or grass-legume association and grazing management trials.

In the initial phase of testing promising legumes, single plant trials, a large number of accessions were evaluated.

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Table 1. - Stages in legume selection trials

Stage	Management	Objective
1. Collection of germplasm materials	Observe record environmental data	To gather forage suited to the ecological zone.
2. Initial testing of species	Observe and sample	To choose a sub set from a usually large number of cultivars through agronomic evaluation.
(a) Introduction plots	Various soils, replicated	
(b) Single plant trials		
3. Further testing of cultivars	Observe, various soils, unreplicated, graze	To critically chose a smaller subset of cultivars using testing and pasture assessment methods.
(a) Strip trials		
(b) Small grass plots		
4. Pasture evaluation	Sampled for varietal difference and management, grazing, replicated, live weight gains	To assess the cultivar chosen so far in grazing experiment where animal production and grazing management are important factors.
(a) Grass/legume mixture		
(b) Pasture planting		
(c) Management and production trials		
5. Seed production	Sampled	To multiply the chosen cultivar for large scale animal production activities.

Source: Parham, 1982; Osuji, 1982.

Ten single plant trials with up to 200 legumes were tested under various management systems, for yield and persistence on the major soil types occurring in the Belize River Valley, viz the infertile low Pine Ridge soils (Ultisols), fertile alluvial terraces (Inceptisols) and alkaline heavy clays (Vertisols). The legumes evaluated included native, non-native and other commercial lines selected from the introduction plots. To evaluate dry matter yield, legumes were clipped at 15 cm every six weeks. Persistence under clipping was evaluated by taking a plant count or plot cover index every harvest.

Legumes selected from the single plant trials were evaluated further in strips, mixtures and grass/legume associations, with the objective of choosing the better legumes. The selected legumes were planted in strips in native pastures and fertilized with a total of 63 kg/ha/annum of triple superphosphate in three applications each year. Species were assessed in terms of dry matter yield, plant spread, height adaptability, and persistence. General observations for vigour, leafiness and disease/pest damage were also recorded.

RESULTS AND DISCUSSION

1. Legume performance: productivity and persistence.-

Productive legumes for alluvial, heavy clays and Pine Ridge soils have been identified. The grazing trials on alluvial soils and on the Ultisols, demonstrated the increased productivity of improved pastures using legumes as the nitrogen source (Lazier 1985).

Forage legumes with the highest potential included Leucaena leucocephala cv Peru and Macroptilium atropurpurium cv Siratro, which were persistent under clipping and gave high dry matter yields in the dry season.

Legumes selected for the three main soil type are presented in table 2.

Table 2.- Legumes selected at pasture character level.

Legume	Ultisols low pine ridge	Inceptisols Belize River Valley	Vertisols black clay
Acacia angustissima		X	X
Centrosema pubescens	X	X	X
Centrosema plumieri	X	X	X
Centrosema macrocarpum		X	X
Clitoria ternatea		X	X
Desmanthus spp	X	X	X
Desmodium adscendens	X	X	X
Desmodium heterocarpon	X	X	X
Desmodium heterophyllum	X	X	X
Desmodium ovalifolium	X	X	X
Leucaena leucocephala		X	X
Macroptilium atropurpureum	X	X	X
Pueraria phaseoloides	X	X	X
Stylosanthes capitata	X		
Teramnus labialis		X	X
Zornia spp	X		

Source: Parham (1986)

2. Legume performance: strip trials , legume mixture and grass/legume association.

The legumes were assessed for high plot cover, spread, vigour and leafiness. Those which ranked the highest are listed in table 3.

The shrub type legume *Leucaena leucocephala* showed higher adaptability and persistence, while the viney type legumes, *Pueraria phaseoloides* (Kudzu) and *Centrosema pubescens* cv Belalto, exhibited excellent plot cover and persistence.

Table 3.- Legumes with potential in strips trials.

Species	Rating *
Leucaena leucocephala	2,4
Acacia angustissima	1,2,3,4
Clitoria ternatea	1,2,3,4
Desmanthus virgatus	1,2,3,4
Pueraria phaseoloides	3,4
Centrosema pubescens cv Belalto	1,2,3,4
Centrosema macrocarpum	1,2,3,4

* Rating 1 = high plot cover 2 = spread 3 = vigour
4 = leafiness

In trials conducted to assess adaptability, persistence, and tolerance to grazing as legume mixture swards in native pastures, data shows preference for Leucaena leucocephala, while Pueraria phaseoloides was moderately grazed.

In grass/legume association trials conducted on alluvial soils data showed that up to 37% of total dry weight was contributed by the legumes.

The program has identified several legumes that have been proven suitable for soils ranging from acid to alkaline conditions, and for both wet and drier parts of Belize. These legumes are listed in table 4.

3. Legume performance: animal productivity.

A grazing trial on a mixed legume grass sward - Pangola and Stylosanthes guianensis, Centrosema pubescens, Macroptilium atropurpureum cv Siratro and Desmodium intortum involving high and low stocking rate, resulted in live weight gains of 1,018 and 744 kg/ha (908 and 664 lb/acre) for high and low stocking rates, respectively (Parham 1982).

Grazing trials on lowland Pine Ridge with native pasture and Kudzu Pueraria phaseoloides resulted in average daily gain (ADG) of 0.48 kg (1.05 lb) (Parham 1989). Ahmad 1989 reported gains of 0.63 kg (1.39lb) ADG in legume mixtures consisting mainly of kudzu Pueraria phaseoloides, compared to 0.05 kg (0.11 lb) ADG on native pasture on these same soils.

Comparison of a deteriorated and an Improved African Star pasture with legume strips of D. gyroides, Pueraria phaseoloides, Centrosema pubescens and at stocking rate of 2.47 an/ha (1.00 an/ac) resulted in average daily gain of 0.51 kg (1.12 lb) in dry season and 0.65 kg (1.43 lb) ADG in the rainy season for the grass/legume sward versus 0.32 kg (0.70 lb) ADG in the dry season and 0.47 kg (1.03 lb) ADG in the rainy season for the deteriorated pasture.

Table 4.- Some selected legumes for utilization in Belize.

Legume	Description
Leucaena leucocephala cv Peru cv Cunningham	High yielding, small tree, drought resistant, growing on soils ranging from mildly acidic to highly alkaline
Desmanthus virgatus	Very productive and persistent shrubby type suitable for both wet and dry areas. Adapted to soils moderately acid to alkaline
Stylosanthes guianensis cv Cook cv Endeavour	High producing small shrubs, drought tolerant, vigorous, suited for acid, infertile soils and tolerates poor drainage. Susceptible to disease.
Pueraria phaseoloides Kudzu	Very productive viney type legume, deep rooted, vigorous, suited for heavy clay soils, tolerant to acid soils and withstand high soil moisture
Centrosema pubescens cv Centro cv Belalto	Excellent viney type, high yielding, suitable for wet tropics, adaptable to soil type of medium fertility.
Centrosema macrocarpum	Extremely vigorous and productive viney type with high resistance to disease. Adapted to acid, infertile soil, drought tolerant.
Macroptilium atropurpureum Siratro	Excellent viney type, high yielding, suitable for wet and dry areas, widely adapted to moderately acid to alkaline soils. Highly susceptible to disease.

Sources: Ahmed, Mohammed, 1987; Parham, 1986; Valencia, 1989.

Table 5.- Annual liveweight gains as influenced by legumes in Belize

Pasture Grass/legume	Stocking rate	Live weight gain ADG*/animal		ADG/acre	
	an/ac	kg	lb	kg/yr	lb/yr
Native Pasture	0.08	0.05	0.11	1.5	3.3
Native pasture + *P. phaseoloides*	0.25	0.63	1.89	57.5	126.0
Deteriorated pastures	1.00	0.32 (dry season)	0.70	116.8	257.0
		0.47 (wet season)	1.03	171.5	377.0
Pangola + *S. quiananensis* *C. pubescens* *M. atropurpurium*	1.00	0.75	1.65	273.8	602.0
African Star + *P. phaseoloides* *C. pubescens* *D. gyroides*	1.00	0.51 (dry season)	1.12	186.0	409.0
		0.65 (wet season)	1.43	237.0	521.0

* ADG = Average daily gain.
Sources: Parham, 1982; Parham, 1989; Valencia, 1989.

RECOMMENDATIONS

The present high cost of fertilizer and supplementary protein feeds as well as the potential for increasing pasture productivity and animal output, particularly during the dry season, should increase interest in the utilization of forage legumes by livestock farmers.

Legumes with potential for livestock farmers, with their main use is listed in table 6.

Table 6.- Legumes with potential for animal feed in Belize

Scientific Name	Common Name	Rainfall	Use
Pueraria phaseoloides	Kudzu	moderate-high	grass/legume mixture, protein-bank, cut and carry
Centrosema pubescens	Centro	low-high	grass/legume mixture, protein-bank, cut and carry
Leucaena leucocephala	Leucaena	moderate-high	pure sward grazed, grass/legume mixture, protein-bank, cut and carry
Desmanthus spp	Desmantus	low-high	pure sward grazed, mixture, protein-bank, cut and carry

CONCLUSIONS

The main aim of pasture technology must be to stimulate production of low cost, good quality beef (Hutton 1978). Herbaceous legumes Pueraria phaseoloides and Centrosema pubescens are drought resistant and will produce green leaf in the dry season. The deep -rooting shrub legumes, especially Leucaena leucocephala have the ability to produce significant amount of valuable high protein leaf and shoots in the dry season. These legumes can be established as protein banks or in strips in native pasture at very low costs.

Legumes increase animal performance and increase pasture carrying capacity, as well as influencing the economy in the use of nitrogen fertilizer. The latter depends on whether they are nodulated with species capable of fixing nitrogen in the soil, thus making nitrogen available to the grass with which they are associated. However, legumes do require high phosphate fertilization and often need to be supplied with other nutrients such as potassium and sulfur. (Archibald and Adigun, 1975).

The real potential of legumes for increasing livestock production in Belize lies in the development of the livestock industry and the livestock producers adapting the available technology.

LITERATURE CITED

1. Ahmad, N. 1989. The Forage Legume and Pasture Research Project, its aims and objectives, its assessment system and the germplasm. Proc. IDRC/Belize Pasture Research Program, San Ignacio, Belize.

2. Ahmed, B. and E. Mohamed. 1987. Selected grasses and legumes for feeding ruminants in the tropics, Proc. Forage Session, Antigua.

3. Archibald, K. E. and E. O. Adigun. 1975. Potential of forages for ruminants in the Caribbean. Proc. Seminar on Utilization of Local Ingredients in Animal Feed, Division of Livestock, Ministry of Agriculture, Jamaica, W. I.

4. Holder, M. 1989. The major soils of Belize and their suitability for pastures; emphasis on the vertisols and soils of upland Pine Ridge. Proc IDRC - Belize Pasture Research Programme Workshop, Cayo, Belize.

5. Lazier, J. R. 1976. Legume collection and the University of the West Indies Forage Legume Program in Belize. Proc. Regional Forage Legume Workshop, Antigua W. I.

6. Osuji, P.O. 1982. Forage evaluation in the Caribbean. A perspective. Proc. IV Regional livestock meeting, Regional Livestock Development Programme, Georgetown, Guyana.

7. Parham, H. 1984. Interim Technical Report, Phase 111, IDRC/Belize Forage Legume and Pasture Research Program, Nov. 1982 - March 1984, Ministry of Agriculture, Central Farm, Belize.

8. Parham, H. 1986. Evaluation of tropical forage legume for adaptability in Belize. Annual Report, Ministry of Agriculture, Central Farm, Belize.

9. Parham, W.D.J. 1981. Technical Report Phase 11 IDRC Belize Forage Legume and Pasture Research Program Nov. 1979 - Oct. 1981 Ministry of Agriculture, Central Farm, Belize.

10. Parham, W.D.J. 1989. Present status of IDRC/Belize Forage Legume Program. Proc. IDRC/Belize Pasture Legume Research Programme Workshop, San Ignacio, Cayo, Belize.

11. Valencia, E. 1989. Annual Research Report 1987-89, Ministry of Agriculture, Central Farm, Belize.

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PRODUCTION AND UTILIZATION OF SOYBEAN

Eduardo Zetina*

INTRODUCTION

Extensive soybean production and its utilization began in 1986 as a result of the establishment of the Commercialization of Alternative Crops/Belize Agribusiness Company (CAC/BABCO) project, which had identified soybean as a potential crop that could be successfully grown and commercialized in Belize. Previous to this, The Caribbean Agricultural Research and Development Institute (CARDI) was quietly doing basic research in varietal adaptation, fertilization regimes, pre and post emergence weed control and soil suitability studies with the idea of promoting the crop in the future. CARDI, therefore, became the organization with which BABCO liaised to aid in the design and implementation of the soybean project.

Apart from implementing a soybean production package under the auspices and supervision of BABCO, it was also necessary to do research into the utilization of the crop. It quickly became evident that oil extraction could not be done in the near future because of the initial small acreage and production and prohibitive equipment costs. It was, therefore, necessary that experiments be conducted on full fat soybean and on those animals most likely to consume feed using soybean as protein base; namely broilers and pigs. CARDI had started these experiments in 1985 and had obtained satisfactory results. Hence, it did not take very much to expand on experiments that CARDI had initiated. To date results have been very encouraging and it is expected that trials will continue to improve on existing rations.

As is usually the case, grower interest in a new crop takes long to develop and once developed has to be nurtured, especially in a situation where the new crop will be compared economically to the predominant crop, sugarcane in this case. Production and management of the soybean crop is no longer a major problem. However, the project is at a point where more grower participation is required to boost production and encourage other growers to participate. Once this is achieved, crop utilization will follow, particularly in our case where basic utilization research is being conducted.

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PRODUCTION

Production of soybeans involves activities such as land preparation, seed procurement and planting, fertilization, weed control, pest and disease control and harvesting. Other important activities that also have to be taken into account once the soybean crop is harvested are drying and marketing.

Land preparation.- This activity begins with site selection. The land should not be too low or with white marl. If the land is too low, flooding will adversely affect the crop during the rainy season. In land where there is a lot of marl, the plants get chlorotic and unthrifty and in extreme cases die. It is therefore important that the soil pH be in the region of 6.0-6.5 to ensure good growth and high bacterial population.

Once the site is selected, at least two ploughs should be done during the dry season. Harrowing should be done every two weeks after ploughing to get rid of germinated weeds and to pulverize the soil and debris. The last harrowing should be done some 10 days after the first rain to get rid of what will hopefully be the last germinated weeds. In the past, only one plough and harrowing have been done, leaving large soil clogs and organic debris, usually sugarcane stubble, to contend with during planting. Obviously, weeds present serious eradication problems under this situation.

Bed formation should be done in areas where water tends to accumulate. This aids in draining water quicker out of the field and in keeping the plant roots above water level. Bed formation is not necessary in soils where water percolates freely.

Seed procurement and planting.- It is very important that good quality seeds be used when seeding the field. Old seeds that have not been stored properly should not be used, unless a germination test indicates that it is still good for planting. Three varieties are being recommended at present - namely, 4-B-8, UFV-1 and SV-89. All three can be planted in June-July, but 4-B-8 also does well in the November planting. At present CARDI/BABCO produce the seed that is being used, but perhaps in the future some growers may be interested in growing their own.

There are two distinct growing seasons in Belize - June to October/November, which is the main growing season because of the availability of moisture, and November - March/April, at which time it would be more appropriate to grow soybean for seed material. However, in areas where soil moisture is retained into February, soybean can be grown commercially during the second cycle. These areas are limited in the northern districts.

Planting involves the placement of treated seeds, fertilizers and nitrifying bacteria approximately one inch under the finely tilth soil. Usually, in commercial operations, planters are used to facilitate the placement of fertilizers at least one inch away from the seeds. Imported planters have been modified to suit our conditions and except for minor modifications are performing well.

Just before planting, the seed (usually in 55-60 pound batches) is moistened with water and a Molybdenum/Thiram product mixed in to treat the seed. At the same time the nitrifying bacteria is added to the mixture, after which planting is immediately carried out.

Care should be taken to always keep the nitrifying bacteria under cool conditions (e.g. in shade) to avoid death of same.

Fertilization.- The types and amounts of fertilizers used should be dictated by a soil analysis that is done just before planting. Limitations imposed by lack of nearby soil testing facilities, as well as promptness in submitting samples to testing facilities and in receiving results have led to following general recommendations:

At time of planting: 88 pounds 18-46-0
88 pounds 0-0-60
8 pounds micronutrient (prepared and distributed by CARDI)

The above fertilizers are mixed just before planting and applied to 1 acre.

Post plant (side dressing) - At least 50 pounds of ammonium sulphate at 35-40 days after planting banded on the row.

Weed Control.- Weed control starts when the land is being prepared for planting, but becomes even more crucial subsequent to planting. Immediately after planting, and not later than 3 days after, a pre-emergence application of Lasso (Lazo) and Paraquat should be done at rates of 4.0 and 2.0 pints per acre, respectively. Lasso controls grasses germinating from seeds, while Paraquat eliminates recently germinated weeds. It is necessary that the soil have some moisture for Lasso to work well.

Even when a pre-emergence is applied, it is usually necessary to control those weeds that have escaped when the crop is already established. Good results have been obtained using a combination of Fusilade and Basagran at rates of 1.5 and 1.0 pints per acre, respectively. Fusilade controls grasses and Basagran broadleaves. Both herbicides can be sprayed on the crop without ill effects.

For those growers that have equipment such as tines, sweepers and other inter-row cultivators, these can be used to eliminate weeds in the inter-row, but some chemical control will be required on the crop row. Hence, applications of both pre and post emergence can be done on the crop row only and then do mechanical cultivation on the inter-row.

Pest and Diseases.- Insects most likely to damage soybean are those which feed on leaves and, in extreme cases, young pods. In Belize, the more damaging attacks have been observed when the plant is large enough and at which time can withstand up to 30% defoliation. Insects associated with these attacks are loopers, armyworm, mexican bean beetle and stink bugs. All of these insects can be controlled very effectively with Nuvacron (Procron) or Lannate at rates of 14 fluid ounces and 1 pound, respectively, per acre.

A disease that has not been definitely identified has been observed in most fields during the past several years. The first visible signs are plants that seem to be suffering from drought, the leaves then lose turgidity, get chlorotic, fall off and eventually the whole plant dies. If the plant is pulled out, most of the roots stay in the ground, a sign that the root system is damaged. It usually starts at the flowering stage and progresses in a concentric manner until the plants mature. The disease may be contained if infected plants are pulled out and disposed of by burning.

Harvesting and drying.- Soybean is harvested around November for the first crop, and around April for the second crop. Harvest when at least 90% of the pods have turned brown and most of the leaves have been shed. When soybean is harvested under good conditions the seed moisture level ranges from 18-20%, but may go as high as 24% when it is raining. Combine harvesting requires that seed moisture content to be not higher than 20%, otherwise, it is almost impossible to properly set the machine for maximum output. If combine harvesting is attempted with higher moisture content, a lot of the seeds remain in the unopened pods and as a result poor yields are realized.

Small acreage (1 acre) can be harvested manually and threshed with small Brazilian threshers capable of handling approximately 1 acre per day. Though more expensive than combine harvesting, it may be the only available resource for small acreage.

Extensive yield trials, both on small plots and larger strip plots, indicate that a yield of 1700 pounds per acre is an average yield that can be attained. Yields may vary, however, depending on the management intensity given to the crop. Yields in excess of 2100 pounds per acre have been realized. Conversely, some fields have yielded only 900 pounds per acre.

Subsequent to harvesting, it is necessary that seed moisture be reduced to 12-13%; otherwise the seeds may start a process of decomposition. Drying can be accomplished either by sun drying or by placing in a dryer and passing heated air through the seed mass. Either way is fine, but using a dryer is more expensive and may entail trucking the grain to a centrally located dryer.

UTILIZATION

Soybeans are utilized in poultry and swine feed owing to their protein content in terms of amino acid composition (table 1). Soybean meal is the most frequently used protein source in animal ration because of its amino acid and good source of food energy (table 2).

Because of high import costs of animal concentrate, formed mostly from soybean meal, the use of full fat soybean has been investigated. It is absolutely necessary that the raw soybeans be roasted or boiled to eliminate the antienzyme "soyin" that inhibits the availability of trypsin, an important enzyme, necessary for normal growth. To achieve destruction of the antienzyme, the raw soybean must be exposed to 100 C for 30 minutes if boiled and to 120 C for 30 minutes if roasted.

The objective of this part of the paper is to present the results of the soybean utilization work that has been conducted from 1986-1989 by CARDI, under the auspices of BABCO, and to make some general comments.

Experiments in 1986

In 1986, whole fat roasted soybean variety AGS-29 was utilized to formulate three different rations for each of starter and finisher rations (table 3). The starter rations were fed for the first 42 days, thereafter, the finisher rations were given. Those birds that had ration No. 1 as starter ration also had ration No. 1 as finisher ration, and so on.

Results were based on the amount (kg) of feed consumed to produce a kg of dressed weight. Birds fed rations No. 1 and No. 2, both of which had full fat soybean meal, performed better than ration No. 3 which was formulated based on 48% protein commercial feed (table 4). However, it was observed that carcasses of birds raised on full fat soybean meal tended to have more body fat, an undesirable characteristic on the local market.

Table 1.- Amino acid composition of soybean.

Amino Acid	mg/g total N	mg/100 g edible portion
Isoleucine	381	2259
Leucine	542	3214
Lysine	532	3155
Methionine	127	753
Cystine	17	457
Phenylalanine	366	2170
Tyrosine	217	1287
Threonine	327	1939
Tryptophan	76	451
Valine	386	2289
Arginine	491	2912
Histidine	194	1150
% Moisture	6.45	
% Nitrogen	5.93	
% Protein	33.85	

Source: The committee for soybean, 1986.

Table 2.- Amino acid composition of soybean meal.

Amino Acid	%
Arginine	3.20
Lysine	3.20
Methionine	0.67
Cystine	0.66
Tryptophan	0.58
Histidine	1.08
Leucine	3.40
Isoleucine	2.40
Phenylalanine	2.25
Threonine	1.76
Valine	2.21
Crude protein	45.00

Source: The committee for soybean, 1986.

Table 3.- Composition of broiler starter and finisher rations used in experiments during 1986.

Ingredients	Starter rations 1	Starter rations 2	Starter rations 3	Finisher rations 1	Finisher rations 2	Finisher rations 3
	----	kg	----	----	kg	----
Dicalcium phosphate	0.75	-	-	-	-	-
Limestone	0.75	-	-	-	-	-
dL methionine	0.10	0.10	-	0.10	0.10	-
Mineral & vitamin mix	0.12	0.12	-	0.12	0.12	
Common salt	0.20	0.20	-	0.20	0.20	-
Meat and bone meal		-	5.00	-	-	5.00
Roasted soybean	23.00	18.60	-	18.50	14.50	-
Commercial feed (48% protein)	-	-	16.70	-	-	14.30
Corn	25.00	26.00	33.30	30.20	30.50	35.70
Total	50.00	50.00	50.00	50.00	50.00	50.00
% Protein in feed	22.00	22.00	22.00	20.00	20.00	20.00
% Fat in feed	10.00	10.00	3.00	8.00	9.00	3.00

Source: CARDI, Annual Report for 1985 - 1986.

Table 4.- Efficiency of the three broiler rations used as feed in experiments during 1986.

Ration	Total feed consumed	No. of birds raised	Live weight of birds at 8 wk	Feed efficiency feed wt./live wt.
	-- kg --		-- kg --	----- kg -----
No. 1	190.0	40.0	95.9	1.99
NO. 2	177.0	35.0	89.6	1.98
No. 3	207.0	38.0	93.2	2.22

Source: CARDI, Annual Report for 1985 - 1986.

Experiments in 1987

Soybean variety IAC 73-5115 was used to conduct a feed experiment on broilers in 1987. Four different starter and finisher rations were prepared using roasted full fat soybean meal (table 5). Again, starter rations were fed ad libitum for 42 days, after which the finisher rations were provided. Birds that had starter ration No. 1 also had finisher ration No. 1, and so on.

Results show that ration No. 3, which contained full fat roasted soybean as its only source of protein, gave the best conversion efficiency (2.36 kg of feed per kg of live weight). It is worthwhile mentioning that the inclusion of full fat soybean meal with 48% protein in ration No. 2 seemed to enhance the ration's performance when compared to ration No. 4 which contained only 48% protein concentrate (table 6). Based on these results it was concluded that broilers could be raised successfully with whole fat soybean meal providing the major source of protein and that the performance with the mixture of full fat soybean and 48% protein concentrate was better than the performance of the protein concentrate alone.

Table 5.- Composition of broiler starter and finisher rations used in feed experiments in 1987.

	Starter rations				Finisher rations			
Ingredients	1	2	3	4	1	2	3	4
	-----		kg	-----	-----		kg	---
Dicalcium phosphate	-	0.38	0.38	-	-	0.38	0.38	-
Limestone	-	0.38	0.38	-	-	0.38	0.38	-
dL methionine	-	0.05	0.05	-	-	0.05	0.05	-
Mineral & vitamin mix	-	0.06	0.06	-	-	0.06	0.06	
Common salt	-	0.10	0.10	-	-	0.10	0.10	
Roasted soybean	-	3.00	10.00	-	-	3.00	9.00	
Concentrate (42%)	9.20	-	-	-	7.50	-	-	
Concentrate (48%)	-	6.50	-	8.30	-	5.50	7.10	
Corn	4.80	17.0	13.00	16.70	15.0	19.00	15.0	18.90
Total	24.08	27.5	24.00	25.00	22.5	28.50	25.0	26.00
% Protein in feed	21.0	21.0	21.0	21.0	19.0	19.0	19.0	19.0
% Fat in feed	5.0	5.0	10.0	3.0	5.0	5.0	9.0	3.0

Source: CARDI, Annual Report for 1986 - 1987.

Table 6.- Efficiency conversion results of four broiler rations used in a feed experiment during 1987.

Ratio	Average live weight/bird at weeks 2	4	6	8	feed consu.	conv. eff.
	kg					
1	0.39	1.16	1.70	1.95	4.63	2.37
2	0.40	1.12	1.70	1.93	4.65	2.41
3	0.33	1.03	1.76	2.00	4.71	2.36
4	0.40	1.08	1.73	2.07	5.14	2.49

Source: CARDI, Annual Report for 1986 - 1987.

Experiments in 1988

Full fat soybean was again utilized to raise broilers during 1988. Three finisher and starter broiler rations were elaborated to include full fat soybean in varying levels and compared to a commercially available ready made feed and administered ad libitum to the birds (table 7). The only difference between rations No. 3 and No. 4 was the source of dicalcium phosphate used in the feed, the former being imported and the latter coming from a local source. Starter rations were given the first 6 weeks, after which finisher rations were fed the last 2 weeks.

Results show that ration No. 3, prepared from full fat soybean and imported dicalcium phosphate, gave the heaviest birds on average, was consumed the least and therefore ended up with the best conversion efficiency. It should be noted that the commercial ready made feed was consumed the most and had the least conversion efficiency (table 8).

Visual assessment of the birds' carcasses dic not indicate any difference between the different rations.

A trial to raise pigs using full fat soybean ration was started for the first time in 1988. The full fat soybean ration was compared to a commercial ration which contained imported protein concentrate. The different rations and the weight of pigs at which they were given appears on table 9.

Though the results are preliminary and the trial will be repeated, it indicated that pigs can be raised successfully using full fat soybean meal as the main provider of proteins and can compare favorably with commercial rations (table 10).

Table 7.- Composition of broiler starter and finisher rations used in a feed experiment during 1988.

Ingredients	Starter rations 1	2	3	4	Finisher rations 1	2	3	4
	-----	kg	-----		-----	kg	-----	
Dicalcium phosphate (imported)	-	-	0.16	-	-	-	0.16	-
Dicalcium phosphate (local)	-	0.07	-	0.25	.-	0.07	0.25	-
Vitamin mix	-	0.003	0.01	0.01	-	0.003	0.01	0.01
Trace minerals	-	0.004	0.01	0.01	-	0.004	0.01	0.01
Choline chloride	-	0.002	0.005	.005	-	0.002	0.005	0.005
dl Methionine	-	0.006	0.02	0.02	-	0.006	0.02	0.02
Lime stone	-	0.04	0.16	0.15	-	0.04	0.16	0.15
Mineral salt	-	0.01	0.04	0.04	-	0.01	0.04	0.04
Corn	-	6.32	5.42	5.42	-	6.81	6.00	6.00
Roasted soybean	-	1.12	4.17	4.17	-	1.08	3.60	3.60
Concentrate (48%)	-	1.12	4.17	4.17	-	1.98	-	-
Commercial ready made feed	-	-	-	-	10.0	-	-	-
Total	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
% Protein in feed	21.4	21.3	20.9	20.9	19.0	19.5	19.1	19.1
% Fat in feed	5.1	5.4	11.1	11.1	5.0	5.3	10.1	10.1

Source: CARDI,Annual Report for 1987 - 1988.

Table 8.- Conversion efficiency results of 4 broiler rations used in feed experiments in 1988.

Rations	Average live weight/bird at weeks 3	4	6	8	feed cons.	conv. eff.
	----------		kg	----------		
No. 1	0.66	1.12	1.94	2.48	5.35	2.16
No. 2	0.52	0.91	1.84	2.54	5.30	2.08
No. 3	0.51	0.87	1.89	2.62	4.65	1.78
No. 4	0.40	0.73	1.84	2.45	5.06	2.07

Source: CARDI,Annual Report for 1987 - 1988.

Table 9.- Composition of two swine rations used in a feed experiment in 1988.

	Weight class (kg)					
	10 - 20		20 - 50		50 - 100	
Ingredients	1	2	1	2	1	2
	Kg					
Dicalcium phosphate	0.375	-	0.375	-	0.375	
Salt	0.09	-	0.09	-	0.09	
Lime stone	0.25	-	0.25	-	0.25	
Swine micro mix	0.125	-	0.125	-	0.125	-
Roasted soybean	8.75	-	6.274	-	4.409	
Corn	15.4	-	17.893	-	19.767	-
Commercial ready made feed mix	-	25.0	-	25.0	-	-
Total	25.0	25.0	25.0	25.0	25.0	25.0
% Protein in feed	19.9	-	15.9	14.0	13.6	12.0
% Fat in feed	9.9	-	8.1	3.0	6.7	3.1

Source: CARDI, Annual Report for 1987 - 1988.

Table 10.- Results of swine feed trials conducted in 1988.

Ration	Fat in ration	Initial weight per pig	Final adjusted weight	Conv. eff.	Back fat
	%	kg			cm
No. 1 Full fat soybean	9.0	11.0	87.0	2.71	4.7
No. 2 Commercial feed	3.0	10.0	79.0	2.54	4.2

Source: CARDI, Annual Report for 1987 - 1988.

Experiments in 1989

Broiler and swine feed trials with full soybean continued during 1989. A broiler trial involving four starter and finisher rations were conducted to assess the potential of full fat soybean as a substitute for commercially available feed made from imported protein concentrate. Three of the rations had full fat soybean in varying levels as the main provider of proteins, while the fourth ration was the available commercial feed (table 11).

Ration No. 3 which had comparatively more full fat soybean meal in its composition produced the best result in terms of conversion efficiency. Contrary to expectations, ration No. 1 which included a mixture of full fat soybean meal and 48% protein concentrate, did not perform as expected based on results of 1988 trials (table 12).

Swine feed trials for 1989 involved a comparison of 3 rations to determine the feasibility of substituting full fat roasted ground soybean on a pound per pound basis for a commercially available concentrate (table 13). This particular trial is still in progress at the time of writing, but visual observations seem to indicate that animals fed on full fat soybean are doing well. However, this will be verified when they are slaughtered and carcass quality assessed.

Table 11.- Composition of broiler starter and finisher rations used in a feed experiment in 1989.

Ingredients	Starter rations 1	2	3	4	Finisher rations 1	2	3	4
	kg							
Dical	0.07	-	-	-	0.07	-	-	
Salt	0.013	0.013	0.051	-	0.013	0.013	0.051	
Broiler vitamin mix	0.003	-	-	-	0.003	-	-	
Poultry trace min.	0.004	-	-	-	0.004	-	-	
Choline chloride	0.002	-	-	-	0.002	-	-	
dL Methionine	0.006	-	-	-	0.006	-	-	
Limestone	0.047	0.047	0.002	-	0.047	0.047	0.002	
Corn	6.32	6.32	5.03	-	6.81	6.81	5.82	
Roasted soybean	1.12	1.12	4.65	-	1.08	1.08	3.99	
Concentrate (48%)	2.42	2.42	-	-	1.98	1.98	-	
Oromix	-	0.025	0.025	-		0.025	0.025	
Dairy minerals	-	0.065	0.258	-	-	0.065	0.258	
Commercial feed	-	-	-	10.0	-	-		-10.0
Total	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
% Protein in feed	21.3	21.3	22.1	21.0	19.5	19.5	19.9	19.0
% Fat in feed	4.8	4.8	9.96	5.0	4.8	4.8	8.95	5.0

Source: CARDI, Annual Report for 1988 - 1989.

Table 12.- Results of a broiler feed experiment conducted in 1989.

Ration	No. birds	average live wt.	av. feed consumed	conv. effic.
		Kg		
No. 1	25	2.73	5.15	1.89
No. 2	23	2.83	5.32	1.88
No. 3	25	2.76	4.80	1.74
No. 4	25	2.58	4.92	1.91

Source: CARDI, Annual Report for 1988 - 1989.

Table 13: Composition of three swine rations used in a feed experiment conducted in 1989 -1990.

		Weight class (kg)								
		10 - 20			20 - 50			50 - 110		
Ingredients		1	2	3	1	2	3	1	2	3
		kg								
Dical	0.375	-	-	3.2	-	-	5.6	-		
Salt	0.09	-	0.05	0.75	-	0.05	1.4	-	0.05	
Limestone	0.25	-	0.10	1.9	-	0.10	3.4	-	0.10	
Swine micromix	0.125	-	-	1.1	-	-	1.9	-		
Antibiotic (114 g/227 kg feed)	0.013	-	0.005	-	-	-	-	-		
Roasted soybean	8.75	-	3.64	52.6	-	2.63	66.0	-	1.80	
Corn	15.40	-	6.16	150.0	-	7.17	296.0	-	8.00	
Dairy minerals	-	-	0.253	-	-	0.25	-	-	0.25	
Oromix-6	-	-	0.013	-	-	0.013	-	-	0.013	
Commercial feed	-	25.0	-	-	25.0	-	-	25.0	-	
Total	25.0	25.0	10.2	210.0	25	10.2	374.0	25	10.20	
% Protein in feed	18.6	18.0	18.7	15.5	14	15.7	13.2	12	13.2	
% Fat in feed	8.5	8.5	3.5	7.0	3	7.1	5.9	3.2	5.9	
% Fibre in feed	-	3.0	-	-	3.9	-	-	4.6		

Source: Unpublished preliminary report of swine trials conducted at CARDI Research Station.

GENERAL CONCLUSIONS

Based on results of experiments conducted from 1986 - 1989, it appears that roasted ground full fat soybean meal can be used as a substitute for imported protein concentrate. The amount that will eventually be utilized will depend to a great extent on the acceptance and production by growers of this relatively new crop. Estimates indicate that there is immediate need for approximately 3500 acres of soybean which would reduce the import bill of protein concentrate by some $2.5 million. However, feed experiments should continue to develop rations that can be used by soybean growers who desire to use their product.

At present there is still some uncertainty as to how much full fat soybean should be incorporated in a ration to get maximum utilization. It is the intention to use as much full fat soybean as possible, but amounts will be determined as more experiments are concluded.

There are other avenues of utilization that have not yet been looked into, particularly oil extraction and the meal by-product for animal feed. This is an area that may soon be looked into, and may turn out to be productive from a feeds perspective.

LITERATURE CITED

1. CARDI-Belize Annual Report, 1985-1986. Trial to raise broilers on whole fat soybean. pp 10-15.

2. CARDI-Belize Annual Report, 1986-1987. Trial to raise broilers on whole fat soybean. pp 9-13.

3. CARDI-Belize Annual Report, 1987-1988 (DRAFT). Animal production programme. 5 pp.

4. CARDI-Belize Annual Report, 1988-1989 (DRAFT). Unpublished report.

5. Smith, J.A., 1988. Economic Evaluation of Soybean and Sesame in Belize. A Report Submitted to the Belize Agribusiness Company and United States Agency for International Development. 41 pp.

6. The Committee for Soybean, 1986. The Philippines Recommends for Soybean. Technical Bulletin Series No. 14A, Philippine Council for Agriculture and Resources Research and Development, Los Baños, Laguna, Philippines. 11 pp.

RESEARCH ADVANCES OF THE TROPICAL PASTURE PROGRAM OF CIAT FOR MEXICO, CENTRAL AMERICA AND THE CARIBBEAN

Pedro J. Argel*

INTRODUCTION

Tropical pasture evaluations were initiated in 1987 in three contrasting sites of Costa Rica with the following objectives: to identify and select pasture grasses and legumes adapted to soils of low and moderate fertility of Mexico, Central America and the Caribbean. Field work involves preliminary selections of germplasm, seed multiplication and grazing trials of selected species.

The germplasm screening sites are: a) Guapiles - very humid tropic, 4260 mm total rainfall; b) Atenas - subhumid tropic, 1600 mm rainfall; and c) San Isidro, seasonal evergreen tropical forest, 2950 mm rainfall. The latter has the more acid soils (pH 4.6) and high aluminum saturation (3.3 meq/100 g of soil). Mean temperature variations for the three sites are similar and range between 22.8° and 24.0° C. More soil and climatic details are presented in the 1987 and 1988 Tropical Pasture Annual Report.

GRASSES

Introduced grasses of the genera Panicum, Brachiaria and Andropogon, as well as naturalized Hyparrhenia and Melinis, were established in the three sites.

Guapiles

Panicum spp

A two year trial was concluded in Guapiles with 50 accessions of P. maximum, one local check and 2 accessions of P. coloratum. High variability was found among species and accessions, mainly for parameters of dry matter yield, digestibility, leaf: stem ratio and crude protein.

Table 1 shows that the best accessions of P. maximum yielded 50.4 metric ton of dry mater (DM)/ha (25.2 ton/ac) or more in cuts carried out every 4 weeks. The accessions CIAT 16051, 16028, and 16061, had a high leaf:stem ratio, besides a significant DM yield. Among the outstanding accessions, CIAT 6299 (cv. Tobiata) was also present. All of them are similar to the Hamil type.

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Table 1.- Accumulated dry matter yields of the best P. maximum accessions established in Guapiles, Costa Rica, 1989.

CIAT No.	Dry matter yield*	
	M.ton/ha	ton/ac
16051	59.4	29.7
16017	59.7	29.7
16028	59.7	29.7
6215	54.0	27.0
16061	54.0	27.0
622	52.2	26.1
6299	50.4	25.2
6177	50.4	25.2
6983	50.4	25.2
6095	50.4	25.2

* Accumulation of 18 cuttings, every 4 weeks.

Accessions of the Embu type showed poor adaptation to Guapiles conditions, and produced significant lower dry matter yields ($P<0.05$). Diseases (mainly caused by Cercospora) and sucking insects were more severe on these accessions compared to Hamil, Common and Green Panic ecotypes.

In general terms, a considerable number of accessions of P. maximum, similar to Hamil, Common and Green Panic ecotypes, showed good adaptation to soil and climatic conditions of Guapiles. In part, this occurred because high and well distributed rainfall throughout the year, high soil organic matter content (10.8%), and acceptable levels of Ca (5.44 meq/100 g), Mg (2.30 meq/100 g), K (1.27 meq/100) and P (8.3 ppm).

Brachiaria spp

Fifty seven accessions of Brachiaria, from a total of 290 accessions, terminated to two year period of evaluation in Guapiles. A total of 15 cuts every six weeks intervals were made. Table 2 shows dry matter yields for this group, indicating high variability among species and accessions.

Accessions of the species B. decumbens (2), B. brizantha (3), B. ruziziensis (2), yielded above 63.0 metric ton DM/ha (31.5 ton/ac). B. decumbens CIAT 16497 produced the highest yield, an accession of semierect growth habit, low leaf:stem ratio, early flowering but acceptable levels of crude protein (11.8%). On the other hand, the accessions CIAT 667, 606 26175, 26170 and 664, have better quality parameters, high number of rooted nodes, and low susceptibility to pest and diseases. However natural insect pressure of spittle bug is low in Guapiles.

Table 2.- Accumulated dry matter yields of the best Brachiaria spp. accessions established in Guapiles, Costa Rica. 1989.

Species	CIAT No.	Dry matter yield *	
		M.ton/ha	ton/ac
B. decumbens	16497	76.5	38.2
B. brizantha	667	75.0	37.5
B. decumbens	606	70.5	35.2
B. ruziziensis	26175	69.0	34.5
B. brizantha	16305	69.0	34.5
B. ruziziensis	26170	69.0	34.5
B. brizantha	664	63.0	31.5

* Accumulation of 15 cuttings, every 6 weeks.

So far, accessions which correspond to commercial varieties, have shown good performance, such as B. decumbens CIAT 606 (cv. Basilisk), B. brizantha CIAT 6780 (cv. Marandu), B. dictyoneura CIAT 6133 (cv. Llanero) and B. humidicola CIAT 679 (cv. Humidicola). However, the final selection of the more productive Brachiaria will only be made at the conclusion of the evaluation period early in 1990.

Atenas and San Isidro

An agronomic evaluation trial of grass accessions of the genera Andropogon, Brachiaria and Panicum was finalized in San Isidro. These were compared with local accessions of Melinis minutiflora and Hyparrhenia rufa.

Table 3 shows accumulated dry matter yields of 11 cuts for a period of 2 years. Higher yields were produced by A. gayanus accessions, followed by Brachiaria and Panicum. Local accessions were the poorest in yield, and shows lack of adaptation of these materials to acid soils with high aluminum saturation. B. decumbens CIAT 606, suffered recurrent attacks of the insect pest spittle bug (Prosapia simulans), but recovered afterwards. High population of the insect were observed as well in B. dictyoneura CIAT 6133 and B. humidicola CIAT 6369 but without apparent effect on these plants.

Table 3.- Accumulated dry matter yields of the best grass accessions established in San Isidro, Costa Rica, 1989.

Species	CIAT No.	Dry matter yield *	
		M.ton/ha	ton/ac
Andropogon gayanus	6053	20.8	10.4
" "	621	20.3	10.1
" "	6766	18.3	9.1
Brachiaria humidicola	679	15.3	7.6
B. dictyoneura	6133	14.7	7.3
B. brizantha	6387	14.4	7.2
"	6780	14.2	7.1
B. decumbens	606	13.1	6.5
P. maximum	622	12.0	6.0

* Accumulation of 11 cuttings, every 6-7 weeks.

A larger number of Andropogon and Brachiaria accessions have been simultaneously evaluated in Atenas, as shown in table 4. Higher yields have been recorded in A. gayanus, including the commercial variety that correspond to CIAT 621. Atenas has better soils (Inceptisols) than San Isidro, but a more prolonged dry period; these facts account for lower plant regrowth during this part of the year.

Table 4.- Accumulated dry matter yields of the best grass accessions established in Atenas, Costa Rica, 1989.

Species	CIAT No.	Dry matter yield *	
		M.ton/ha	ton/ac
Andropogon gayanus	6207	48.7	24.3
" "	6697	39.4	19.7
" "	6368	38.9	19.4
Brachiaria decumbens	606	28.0	14.0
B. dictyoneura	6133	27.2	13.6
B. brizantha	667	22.3	11.1
B. humidicola	679	13.5	6.7

* Accumulation of 11 cuttings, every 6-8 weeks.

B. decumbens CIAT 606 produced in Atenas twice the yield of San Isidro, but in the latter had more production during the dry season, despite the spittle bug recurrent attack; on the other hand, B. dictyoneura CIAT 6133 performed well in Atenas as compared to the best A. gayanus accessions.

LEGUMES

A large number of pasture legumes are being evaluated in San Isidro, Guapiles and Atenas. Accessions of the genera Stylosanthes, Desmodium and Centrosema, form the bulk of the collection. Other pasture legumes are Flemingia macrophylla, Cratylia floribunda, Codaryocalyx gyroides, Arachis pintoi, Zornia latifolia, Aeschynomene americana. Macroptilium atropurpureum, Vigna adenantha, Chamaecrista rotundifolia, Calopogonium mucunoides, Pueraria phaseoloides, Pueraria motana and Desmanthus virgatus.

Effect of site on yields

In addition to recording incidence of pests and diseases and other phenologic characteristics, legume evaluation has been carried out practicing periodical cuttings, which add up to 11 in San Isidro, 9 in Guapiles, and 12 in Atenas as of October 1989. In spite of the uneven number of cuttings, it is possible to make yield comparisons among species and accessions common to the three localities, using as a reference the weighted average dry matter yield per month (table 5) and applying the Scheffe test for comparison among groups with a different number of observations.

Stylosanthes spp

Among this genera, S. guianensis accessions represent the largest number of legumes evaluated; for example, 6 accessions were shared by Guapiles, Atenas, and San Isidro, and 26 accessions by Guapiles and Atenas.

High variability in adaptation has been observed among species and accessions; however, as a group, S. guianensis accessions have been the most productive in the locality of Guapiles, in comparison with Atenas and San Isidro. The latter site soils are poorer as mentioned before, in addition of having marked dry period each ear from December to April. However, Atenas, with a more prolonged dry period but with better soils, showed intermediate yields, though significantly inferior ($P<0.05$) to those observed in Guapiles. Another favorable factor in the later site has been the lower incidence of foliar diseases, which will be further discussed later on.

Table 5.- Comparisons based on weighted average of monthly dry matter yields of forage legumes established in different sites , Costa Rica, 1989.

Species	Sites					
	Atenas		Guapiles		San Isidro	
	kg/ha	lb/ac	kg/ha	lb/ac	kg/ha	lb/ac
C. acutifolium	152	136	543	484	314	280
	194	173	601	536		
C. brasilianum	271	242			260	232
C. macrocarpum	444	396	839	748	327	292
C. pubescens	167	149	462	412	134	120
	152	136	419	374		
D. ovalifolium			694	619	576	514
S. quianensis	734	655	1,036	924	497	443
	648	578	1,081	964		
S. capitata	166	148			375	334

The highest yielding accessions of S. quianensis belong to the morphological groups of the var. quianensis (common type), including cv. Pucallpa (CIAT 184), as illustrated in table 6. This cultivar was outyielded only in Guapiles by CIAT 136. The contrary was true in Atenas, at the same time that performance of the two accessions was similar ($P<0.05$) in San Isidro, but with better summer regrowth for CIAT 136. This is indicative of the broad range of adaptation of these accessions. Also outstanding were CIAT 21, 191, 1175, 11362, 11374 and 11375.

Seven accessions of S. capitata confirm their superior adaptation to acid soils with high aluminum content, as are the soils of San Isidro in comparison with those of Atenas (table 5). Much less affected by conditions were CIAT 1280 and 2031 accessions of S. quianensis var. pauciflora, which had similar yields in Atenas and San Isidro.

Table 6.- Accumulated dry matter yields of the best *Stylosanthes guianensis* accessions established in Atenas, Costa Rica, 1989.

CIAT No.	Dry matter yield *	
	M.ton/ha	ton/ac
184 cv. Pucallpa	25.8	12.9
1175	24.2	12.1
11362	21.9	10.9
21	20.8	10.4
191	19.7	9.8
11374	19.1	9.5
11375	18.1	9.0
136	17.4	8.7

* Accumulation of 18 cuttings, every 4 weeks.

Desmodium spp

The largest number of accessions of this genera were established in Guapiles (53) in comparison to San Isidro (12). Table 5 indicated that yield differences ($P<0.05$) were not observed for the six *D. ovalifolium* accessions shared by the two sites (CIAT 350, 3784, 3788, 3776, 3673, and 3781). This demonstrates the species good adaptation to both humid tropic as seasonal forest with acid soils having a high aluminum content.

Centrosema spp

Of this genera, 61 accessions were established in 1987 in Atenas, 56 in Guapiles, and 37 in San Isidro, for adaptation evaluation. *C. macrocarpum* was the species with the greatest number of entries; however, only 11 accessions were shared simultaneously by the three sites: CIAT 5065, 5452, 5620, 5674, 5713, 5733, 5735, 5744, 5887, 5957, and 15014.

Overall, conditions in Guapiles have been the most favorable for growth and dry matter yield of all *Centrosema* species (table 5), with the exception of *C. brasilianum* which was not planted at this site due to the species known susceptibility to foliar blight by *Rhizoctonia*.

However, the high productivity of the *Centrosema* accessions in Guapiles is due in part to the low incidence of diseases up to date and to a sustained growth practically during the whole year thanks to favorable moisture conditions. On the other hand, San Isidro was the site where *C. macrocarpum* and *C. pubescens* showed the lowest yields, while yields in Atenas have been intermediate

for these species. The latter site has been the least favorable for C. acutifolium accessions (table 5), particularly due to bacteriosis and foliar damage by Cylindrocladium.

Accessions of the species C. plumieri, C. capitatum, C. schottii, C. virginianum, C. brachypodum, C. vexillatum, C. grazielae, and C. schiedeanum have been outstanding in Atenas, San Isidro and Guapiles. Accessions CIAT 5066 of the latter species occupied the lowest rank in terms of yield in Atenas (294 t DM/ha accumulated over 12 cuttings); on the other hand, C. arenarium CIAT 5236 and C. tetragonolobum CIAT 15087 had intermediate yields in Guapiles.

Other legumes

In comparison to Atenas, Guapiles has also proved to be a more favorable site for growth of Cratylia floribunda CIAT 18516 (8.6 and 24.7 t DM/ha of yield accumulated over 12 and 9 cuttings, respectively, at each site); something similar has happened with Flemingia macrophylla accessions CIAT 17403, 17407, 17400, 7184, and 801 which have accumulated yields from 42.9 to 51.7 t DM/ha in Guapiles, in comparison to a range from 1.8 to 5.1 t DM/ha in Atenas. Crude protein content of Flemingia accessions has been around 20%, but IVDMD is considerably low (28% for CIAT 17400 and 7184, 26% for 17407, and 33% for 17403); therefore the forage value of this legume is not considered to be high.

Codariocalyx gyroides CIAT 3001 has a poor performance in Atenas, San Isidro, and Guapiles; accumulated yields in almost 2 years of evaluation have been 2.6, 8.8, and 5.4 t DM/ha, respectively for the three sites. High plant mortality due to the root rot nematode was observed in San Isidro; the plant also seems to be very susceptible to defoliation during the dry period, as has been observed in Atenas.

Arachis pintoi CIAT 17434 had an accumulated yield of 10.9 t DM/ha over 9 cuttings in Guapiles, and 2.6 in San Isidro over 11 cuttings. Other accessions evaluated in Guapiles were CIAT 18744. CIAT 18751, IRFL 2273 (CIAT 20693), CIAT 18746, and 18745, with yields of 10.5, 10.5, 8.5, 6.4, 3.8, and 3.7 t DM/ha, respectively, over 9 cuttings. CIAT 17434 has shown severe chlorosis in evaluation plots in both localities, which seems to be associated with a loss of effective nodulation or with other nutritional problem not yet identified. It has been interesting to observe that this chlorotic condition is slight or nonexistent when the mentioned accession is associated with a grass; thus the accession continues to be considered as a promising forage species, particularly for its high competitive ability - derived from the stoloniferous growth habit - and for its favorable quality factors - 25% crude protein and 58% IVDMD. Accessions CIAT 18744 and 18748 have been free of chlorosis to date.

Aeschynomene americana and A. villosa accessions have been poor yielding and showed low persistence in Guapiles (cuttings every 8 weeks). The greater yield observed has been that of IRFL 1725 with 9.3 t DM/ha (accumulated over 11 cuttings), while A. villosa accessions (IRFL 2927 and 2331) have practically disappeared due to their poor recovery after cuttings and low competitive ability with invading weeds. Something similar has happened to Alysicarpus vaginalis IRFL 3240.

Desmanthus virgatus IRFL 99474 and IRFL 1857 have been more persistent and productive in Guapiles. Accumulated yields over 9 cuttings have been 35.4 and 24.4 t DM/ha, respectively, which are comparable with outstanding accessions of C. macrocarpum and D. ovalifolium at the same site. Performance of Pueraria montana CIAT 17277 has been similar (28.4 t DM/ha for the same evaluation period). This has been Pueraria's most productive and persistent species in Guapiles. Another 21 accessions, including P. phaseoloides CIAT 9900 (Kudzu) have had persistence problems, probably due to very low cuttings (less than 1-0 cm height), in addition of being the legume species with the greatest indices of foliar diseases - chlorosis and defoliation - probably caused by Rhizoctonia.

In San Isidro, production of Calopogonium muconoides CIAT 8118 and Canavalia brasiliensis CIAT 18515 has been very low (1.9 and 4.8 t DM/ha, respectively, accumulated over 11 cuttings). The most outstanding have been Chamaecrista rotundifolia CIAT 8202 and 8201 and Dioclea guianensis CIAT 7801 and 7351 with accumulated yields of 9 t DM/ha on average; yet, other quality factors reduce this species value as a promising forage.

Leaf Diseases

The first grass-legume germplasm to be established in Atenas, San Isidro and Guapiles was planted two years ago. Leaf diseases in legumes caused by Cercospora, Rhizoctonia, Cylindrocladium, and bacteriosis, were reported to have greater incidence in San Isidro, but the degree of severity in the most susceptible legumes was not superior to 20% of damage (for example, C. acutifolium CIAT 5657; Chamaecrista rotundifolia CIAT 8201 and 8202, P. phaseoloides CIAT 9900; S. guianensis CIAT 1280; and C. macrocarpum CIAT 5065, 5452, 5713, 5733, 5735, and 5740). Besides severe bacteriosis in C. acutifolium CIAT 5277 in Atenas, other diseases with high incidence were not reported at this site nor in Guapiles.

Except for the last site, the incidence of leaf diseases has increased during 1989 affecting both grasses and legumes in San Isidro and Atenas. Foliar blight caused by Rhizoctonia is the most severe disease in San Isidro. Damages are estimated between 25 and 50% of foliar death in several accessions of Centrosema (C.

macrocarpum CIAT 5735, 5674, 5744, 5737, 5713, 5365, 5733, 5740, 5957, 5887, 15014, and 5452; C. brasilianum CIAT 5234, 5487, 5687, 5671, 5657, 5810, and 5514; C. acutifolium CIAT 5256 and 5277).

Incidence has been lower in grass accessions (P. maximum CIAT 6000, 622 and 673; B. decumbens CIAT 606 and B. brizantha CIAT 6780). Other grass accessions such as those of A. gayanus, B. dictyneura CIAT 6133, and B. humidicola CIAT 679 and 6369 have shown lower incidence of this disease. The accession CIAT 6705 of the latter species has shown moderate to high incidence of rust caused by Uromyces setaria-italicae; for this reason it is not considered to be promising at the moment.

A simultaneous complex of diseases, as has been observed during the last year in Atenas, is common under field conditions. Practically all herbaceous legumes (Stylosanthes, Centrosema) have had high incidence of Mycoplasma (little leaf), bacteriosis, anthracnose, Cylindrocladium, and Rhizoctonia. The little leaf disease is more severe in C. macrocarpum CIAT 5713 and C. pubescens CIAT 438 seed multiplication plots, while anthracnose damage has increased in S. guianensis CIAT 184. It is obvious that the reaction of these legume species differs among pathogens, but this needs to be studied in more detail.

SEED PRODUCTION

Multiplication plots of promising germplasm seed were established since 1987 in the localities of Atenas, San Isidro, and Guapiles. Besides the physical production of seed, the latter has served to characterize phenology of the species in relation to flowering (initiation and maximum), maturation period, and potential seed yield.

Table 7 shows seed production and yields of species of Centrosema, Desmodium, P. phaseoloides CIAT 9900, and S. guianensis CIAT 184. In Atenas, with a well defined dry period starting in November, greater seed yields of C. brasilianum CIAT 5234 and C. macrocarpum CIAT 5713 (641 and 189 kg/ha, respectively) have been obtained; San Isidro is less favorable for the reproduction of Centrosema. On the other hand, D. ovalifolium flowers and sets seed abundantly under Guapiles conditions, where high environmental humidity predominates practically all year round. CIAT accession 350 has the highest yield (232 kg/ha), which is significant superior to that harvested in San Isidro (69 kg/ha). S. guianensis CIAT 184 suffered severe attacks by the budworm (Stegasta sp.) in Atenas, thus explaining the low seed yield observed.

Table 7.- Total harvested and pure seed yields of forage legumes established in different sites in Costa Rica, 1988.

Species	CIAT No.	Site	Yield			
			Pure seed		Total	
			kg/ha	lb/ac	kg	lb
C. brasilianum	5234	Atenas	641	572	178	392
C. macrocarpum	5713	Atenas	189	168	75	165
" "	5452	San Isidro	51	45	9	20
" "	5620	" "	17	15	2	4
" "	5957	" "	8	7	1	2
C. pubescens	438	Atenas	75	67	21	46
D. ovalifolium	350	San Isidro	69	62	59	130
		Guapiles	232	207		
" "	3788	"	143	128	10	22
" "	13089	"	118	105	7	15
P. phaseoloides	9900	San Isidro	67	60	22	48
S. guianensis	184	Atenas	6	5	10	21
		San Isidro	51	45		

Species of Brachiaria and A. gayanus CIAT 621 represent the grass germplasm established for seed multiplication. Table 8 presents seed yields and total seed harvested; overall, San Isidro has proven to be more favorable than Atenas and Guapiles for flowering and seed setting among these grasses, with the exception of B. decumbens CIAT 606, which suffered recurrent spittlebug attacks in San Isidro affecting its reproductive capacity. Noteworthy is the high seed yield of B. dictyoneura CIAT 6133 in San Isidro (247 kg/ha), in comparison with Guapiles where spikelets were severely attacked by birds, or Atenas where the cutting of uniformity was performed too late (June 8) in terms of the onset of flowering (June 23 of the same year).

Table 8.- Total harvested and seed yields of forage grasses established in different sites in Costa Rica, 1988.

Species	CIAT No.	Site	Yield			
			Pure seed		Total	
			kg/ha	lb/ac	kg	lb
A. gayanus	621	Atenas	111	99		
		San Isidro	148	132	158	348
B. brizantha	6780	Atenas	83	74		
		San Isidro	81	72	84	183
B. decumbens	606	Atenas	70	62		
		San Isidro	14	12	24	53
B. dictyoneura	6133	Atenas	7	6		
		San Isidro	247	220		
		Guapiles	40	36	61	134
B. humidicola	679	San Isidro	160	143	2	4
" "	6369	" "	55	49	21	46

FUTURE PRIORITIES

The program has established the following priorities in the short and medium term. These priorities are in line with CIAT general Tropical Pasture Program's objectives for the 90's that search for increasing animal production as well as developing sustainable legume-grass pasture systems. These are:

A. Seed multiplication of selected pasture grasses and legumes in close collaboration with Ministry of Agriculture and other institutions.

B. Validation of new pasture alternatives at the farm level, initially for the Humid Tropic in close collaboration with CATIE and Ministry of Agriculture.

C. Grazing trials and agronomic evaluation continuation of selected pasture species jointly with Ministry of Agriculture and CATIE.

D. Strengthen research capabilities of the national institutions through formal and informal training of research personnel.

E. Strengthen collaboration and pasture development technologies throughout the region by means of active country participation in the International Network of Pasture Research and Development (RIEPT).

PASTURE RESEARCH AND DEVELOPMENT: THE ANTIGUA EXPERIENCE

Robert. T. Paterson*

INTRODUCTION

During the 1960's and 1970's when oil prices were low on the world market, considerable attention was paid to maximizing the yields of tropical grass pastures through the application of heavy and frequent doses of nitrogen. This approach was typified by the work of Vicente-Chandler et al (1964) in Puerto Rico, but also had its adherents in CARICOM countries such as Trinidad and Jamaica. Heavily fertilized grass pastures are capable of supporting high stocking rates but lack the nutritive quality necessary for high levels of productivity per animal. The deficiency was overcome by the use of imported concentrates based on corn and soya bean, mainly for USA, leading to the development of commercial production systems that were heavily dependent on extra regional supplies of both fertilizers and animal feeds.

As oil prices increased during the 1970's, so did the cost of the imported inputs. Faced with this situation, many governments in the region applied subsidies to fertilizers and/or concentrates in order to reduce the prices of animal products to the consumers. This short-sighted political expediency reduced the need to seek more relevant techniques for animal production. Recent economic crises within CARICOM, have seen the removal of these subsidies with consequent adverse effects on the grazing industry. It is the opinion of the writer that if subsidies were necessary, they should have been applied to the establishment of high-quality permanent pastures, rather than to the supply of inputs which were required on a continuing basis.

LEGUMES IN THE SYSTEM

There is no doubt that if the aim is to maximize productivity of pastures, the appropriate technology is the use of heavily fertilized grasses in conjunction with concentrates. In most parts of the world, however, with existing prices of inputs, this approach is recognized as uneconomic. In developing countries with balance-of-payments problems, importation of such inputs for ruminant livestock is a luxury which the economy cannot afford. In order to both optimize profitability for the farmer and to reduce the drain on foreign exchange, ruminant animal production must be based on high quality pasture together with the strategic use, where necessary, of locally available concentrates such as crop residues and by-products. In this regard, the distinction must be clearly drawn between maximum productivity and maximum

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profitability, since while fertilized grasses can supply the former, the use of legumes to produce pasture quality at low cost will satisfy the latter criterion.

Previous speakers at this seminar (Tergas, 1989) have emphasized the advantages and disadvantages of legumes for livestock production. It remains to be stated that legumes can be incorporated into the farm in a number of ways, the choice of which will depend upon the physical and financial resources available, the existing production system and the plans and preferences of the farmer. Some of the ways which have been successfully used in either the Caribbean region or in tropical South America are as follows:

a. Perennial legumes in permanent or semi permanent areas

   (i) Conventional pastures of grasses and legumes

   (ii) Strip planting of legumes into existing grassland

   (iii) Protein banks or reserves - as special plantings or under tree crops such as coffee and coconut (for either cutting or grazing)

   (iv) Living fence posts which also provide shade and forage

b. Annual legumes as temporary areas

   (i) Under annual crops such as corn or sorghum, for grazing after crop harvest

   (ii) After annual crops such as cotton, to grow as a catch-crop on the moisture in the soil at the end of the wet season.

It is obvious that no single legume species will serve all of these purposes. From the large range of tropical legumes now available, appropriate species and varieties must be selected in accordance with the proposed management system. As an extension to this argument, it should be remembered that Belize is blessed with a large population of native legumes, several of which have potential as pasture plants. Work by the Central Farm group at Monkey Bay (Parham, 1984) showed a large increase in animal production from native pastures when the application of phosphate fertilizer stimulated the growth of naturally occurring legumes. The productive potential of these plants must not be ignored, for while the growth rates of exotic introduced legume species may be higher than those of the native types under optimum conditions, the native legumes will show a high degree of adaptation to the environment since they have evolved under the existing conditions of soils, climate, pest and diseases.

PASTURE WORK IN ANTIGUA

In 1974, at the time when the University of the West Indies (UWI) with Canadian financial assistance started the Forage Legume Project in Belize, it also started a further project in Antigua. The initial aims and objectives were similar, but the approach, termed "Investigative Development" by its initiator, Dr. J. M. Keoghan, was different in that promising pasture material was tested on private farms at the earliest opportunity. The Antigua project passed from UWI to CARDI in 1979 and since 1980 has received financial support from EEC.

A brief description of the project follows. It is in no way intended as a criticism of the programme in Belize which has generated large amounts of useful experimental data. It is recorded here only to demonstrate that a different programme philosophy has led to very different results in two projects that started at the same time and from the same initial situation.

In Antigua, over 100 grasses, mainly of African origin, and 800 legumes, many from the Yucatan Peninsula in Mexico, were sown at five contrasting sites. Care was taken to achieve good establishment of the new accessions in the first year by careful weeding and lenient cutting regimes. This was necessary because some lines were left to compete with any invading herbaceous species. Some two years after sowing, the plots were subjected to rational grazing. After a period of good management, occasional over-grazing was deliberately imposed to assess the ability of the introductions to withstand a degree of abuse. Measurements made throughout the whole testing period included dry matter yields, plant vigour, spread, insect and disease attack, utilization by small ruminants, persistence under grazing and contribution to sward composition.

The best 10 or 12 lines to emerge from this testing programme were then sown on private farms in a series of demonstrations. They were introduced on a paddock scale and managed by the farmer in consultation with project personnel who continued to monitor the performance of the pastures. Some lines were eliminated at this stage, leaving a cadre of superior accessions which were then taken into a commercial scale seed production phase. These lines have subsequently shown their adaptability and production potential on neutral to alkaline soils from Tobago through to Puerto Rico, Haiti and Jamaica. Species recommendations were published by Keoghan (1980) while the techniques utilized were evaluated by Keoghan (1985).

SEED PRODUCTION IN ANTIGUA

Since 1980, considerable attention has been paid to pasture seed production, largely with financial assistance from EEC. Those useful grasses which are propagated by vegetative means (Star, Bermuda, Elephant, Dwarf Elephant grasses) have been established in nurseries in all of the countries in the Eastern Caribbean, where farmers can obtain planting material. Seed of both grasses and legumes has been produced in Antigua for distribution throughout the region. The major varieties are described below.

A. Grasses

Panicum maximum (Guinea grass) This species is well known in Belize. It is an erect, bunch-type grass growing to a height of from 4 to 6 feet (1.2 - 1.8 m), which is of good palatability and is relatively high in digestibility. It is drought tolerant but susceptible to water logging. It is persistent when well managed but quickly disappears under excessive grazing pressure.

One excellent variety, Likoni, was selected as being the best pasture type in the Eastern Caribbean. Seed production has always presented problems, however. It has been impossible to synchronize flowering in order to produce a heavy crop, and as a result, the cost of seed production is high. This variety is now only recommended for vegetative planting and nurseries have been established in most countries. Seed is produced of two varieties, Green Panic and local type. In small plots, these yielded slightly less forage than Likoni, but in terms of animal production, the difference is not great.

Chrysopogon sp. (no common name at present) This is a low growing species (to about 3 ft or 0.9 m) which shows extreme drought tolerance while being highly productive. It is an erect, bunch type grass which is highly compatible with a range of legumes. It is generally well accepted by livestock, but they seldom graze it lower than 4 to 6 in. (10 - 15 cm). This is a characteristic which helps persistence.

B. Legumes

Macroptilium atropurpureum (Siratro) This is a large leafed trailing legume which is fast to established and is tolerant of a range of soils from moderately acid to highly alkaline. Under wet conditions it is sometimes attacked by rhizoctonia, a disease which causes leaves to fall. The disease is usually more severe in pure stands in ungrazed plots than when mixed with grasses in a paddock situation. It is well accepted by livestock, particularly in the dry season when it is of much higher quality than any tropical grass variety in present use.

In Antigua, two varieties have been used, true Siratro which was bred in Australia, and Mexican Macro (or Y - 61), a naturally occurring variety from the Yucatan Peninsula of Mexico. The Mexican type is slightly faster to recover after grazing and is a better seed producer under Caribbean conditions.

Neonotonia wightii (Perennial soybean) This trailing legume is well adapted to fertile loams and clay loams which range from slightly acid to highly alkaline. Although relatively slow to establish, it is highly persistent under fertile conditions and is a legume of high nutrient value. Insects may occasionally attack the plant, but it is resistant to most plant diseases in the region.

The variety recommended in the Eastern Caribbean has been named Keoghan, after the initiator of the programme in Antigua. The Australia variety Tinaroc is not greatly inferior to Keoghan.

Teramnus labialis (Rabbit vine) This is trailing legume which produces its buds very close to the level of the soil. Cattle cannot graze close enough to the soil surface to destroy it, although heavy grazing with sheep and goats will eventually eliminate it. It is less productive than the others noted above, but shows extreme tolerance of drought. The Antiguan selection is called Roja, because of the red colour of the seed, which it produces in large quantities.

As noted, each of the trailing legumes has its own advantages and disadvantages. In many instances in the Eastern Caribbean seed of the three has been mixed in the ration of 2 parts of Siratro to 2 parts of Glycine to 1 part of Rabbit Vine, and planted together. The Siratro is the first to get away, while by the second or third year, Glycine becomes dominant. The Rabbit Vine is there as an insurance policy against drought.

Leucaena leucocephala (Leucaena) This is a tree legume which is ideal for use in protein banks. If cut back close to ground level once per year, it will not grow higher than about 10 - 13 ft (3 - 4 meters). At this height, the stems are flexible enough for cattle to walk over them, or to lean against them in order to reach the leaves. Leucaena is very high in protein (20 - 30 percent crude protein in green stems and leaves respectively), but it can also contain large amounts of a toxic substance called mimosine. Mimosine poisoning starts to show itself as the loss of hair from the back and tail of grazing animals. They become listless and eventually the throat swells into goitre. Weight loss follows and animals may die unless changed to a diet free of mimosine. Monogastric animals (poultry, pigs, horses) are more susceptible than ruminants to mimosine, but with care, Leucaena can be used up to the following quantities for all animals without danger:

2% of diet for laying hens will ensure good yolk colour
8-10% of diet for growing pigs
occasional free access for horses, dry season free access for sheep and goat
30% of diet for cattle.

It is highly likely that ruminants in the Caribbean have an organism in the rumen which can change mimosine into harmless substances and so prevent mimosine toxicity, even at high levels of feeding of Leucaena. When given a choice, however, animals will seldom exceed a level of 30% of Leucaena in the diet, so in a grazing situation there is no danger of mimosine toxicity unless Leucaena is the only forage available.

Two varieties are produced in Antigua. Cunningham tends to branch close to the ground and is more suitable for use as a protein bank. K-8 usually branches at greater than 6 ft (1.8 m) and is ideally suited to living fence posts. Both varieties produce good fuel wood, charcoal and forage which can be fed either fresh or as dried leaflets.

The varieties described above have been used with success on both volcanic and calcareous soils in the Eastern Caribbean. They perform well in fertile conditions with soils ranging from moderately acid to highly alkaline, but are not suitable for acid infertile soils. In Belize, they could be expected to do well on the better soils around Central Farm (Vertisols) but should not be planted on the Lowland Pine Ridge type soils.

The operation in Antigua is of modest size and further expansion is limited by financial considerations. It has produced up to about one ton per year in total of the small seeded varieties, together with perhaps half a ton of Leucaena. This seed has been distributed to most countries of the CARICOM agreement, with any surplus being sold into Puerto Rico, Haiti or Guadeloupe. While quantities necessary for investigations and demonstrations could readily be made available to Belize, it seems unlikely that Antigua would be able to fill the commercial demand suggested by this enthusiastic audience. If quantities of more than a few hundred pounds per year are required, it would be necessary for seed multiplication to take place locally. CARDI has regional experience in this field and would be pleased to offer any technical assistance that may be required. Clearly, any scheme that may be worked out would need to supply not only a product which the consumers can afford, but also a price to the producer which offers him a fair return for his labour and capital.

LITERATURE CITED

1. Keoghan, J. M. 1980. Adaptable and productive forage legumes and grasses for more intensive small ruminant livestock systems in the Caribbean. Tropical Animal Production 5: 8-14.

2. Keoghan, J. M. 1985. A relevant approach to identifying well adapted and productive forage legumes for tropical Third World Countries. Proc. Agronomy Society of New Zealand 15: 131-135.

3. Parham, H. 1984. Interim Technical Report, Phase III IDRC/ Belize Forage Legume and Pasture Research Program, Nov. 1982 - March 1984. Ministry of Agriculture, Central Farm, Belize.

4. Tergas, L. E. 1989. The roles of legumes in livestock feeding systems in the tropics. In L. E. Tergas and E. Valencia (eds.) Utilization of legumes for Livestock production in Belize, Proc. Workshop, Belmopan, Belize, 17 November, 1989.

5. Vicente-Chandler, J., R. Caro-Costas, R. H. Pearson, F. Abruna, J. Figarella and S. Silva. 1964. The intensive management of tropical forages in Puerto Rico. University of Puerto Rico Agricultural Experiment Station, Rio Piedras. Bulletin 187. 152 p.

SUMMARY AND CONCLUSIONS

Most of the pastures utilized for cattle production in Belize are natural grasslands covering the "Pine Ridge", or natural pastures which are the result of land clearing and cultivation for a few years. The establishment of improved pastures is essential for the development of the livestock industry.

Even though native grasses are the main component of the botanical composition of natural grasslands, native legumes make a significant contribution to forage availability and quality, especially during the dry season.

The main conclusions of the workshop were to recognize the important value of legumes in livestock feeding systems in Belize and the opportunity to improve livestock production by the application of pasture and forage technology based on the utilization of native and adapted legumes.

PRESENT CONCEPT OF LEGUME UTILIZATION IN BELIZE

Despite the fact that most of the tropical forage legumes are native to Tropical America, including several species which have been collected and evaluated in Belize, their utilization by farmers in improved pastures is very limited. This workshop focused on the advantages of these plants on their ability to fix atmospheric nitrogen, their contribution to the availability of forage throughout the year, the supply of high quality feed especially during the dry season, and their contribution to soil and water conservation. Some of the disadvantages such as low palatability and toxicity problems with some species, disease and insect damages susceptibility and lack of persistance under intensive grazing, can be addressed by proper selection, pasture establishment and management. Research conducted in Belize has resulted in the proper identification of key species which can be recommended for utilization by farmers in different ecosystems.

Soybean production is relatively new to farmers in the country. However, significant progress has been achieved to develop appropiate agronomic technology to grow the crop and feeding technology for its utilization in poultry and swine production, as a substitution for imported concentrated feed.

REGIONAL EXPERIENCES AND COLLABORATION

The Caribbean Research and Development Institute (CARDI) has been involved in evaluation of forage legumes for more than 15 years. The belizean farmers can benefit from the technology developed in the region on selection of adapted and productive species, seed multiplication and production, pasture establishment and utilization, on conditions similar to this country. They are also interested in training in technology transfer.

The Tropical Pasture Program at the International Center for Tropical Agriculture (CIAT) is another institution which is also involved in research and development of pasture technology based on utilization of forage legumes. Their main contribution is probably the selection of species adapted to acid low fertile soils. Results from Costa Rica on the selection of promising accessions will assist the Forage Legume Program in Belize to find germplasm suitable to "Pine Ridge" soils. Active collaboration between these programs will be formalized through the International Network for Pasture Research and Development, which is sponsored and partially financed by CIAT.

PRIORITIES FOR RESEARCH ON TROPICAL FORAGE LEGUMES

Even though it was concluded that there was enough information on the identification of key legume species to iniciate a program on the utilization of these plants on the establishment of improved pastures in Belize, the need was recognized to conduct further research on farmer's field on the following subjects:

1. The development of economical and practical methods of pasture establishment, including "protein banks" and grass-legume mixtures.

2. Methods of weed control on forage legume pastures.

3. High quality seed multiplication and commercial production.

4. Evaluation of native and introduced legumes adapted to acid low fertile soils in the "Pine Ridge" ard to swampy areas.

The need for training of technical personnel as well as farmers was also recognized as a priority to encourage the utilization of legumes for livestock production in Belize.

LIST OF PARTICIPANTS

BELIZE LIVESTOCK PRODUCERS ASSOCIATION

NAME	TOWN	DISTRICT
Alpuche, Canuto	Corozal Town	Corozal
Bedran, Abdala	Tiger Run Farm Ltd.	Cayo
Bautista, Reynaldo	San Antonio	Orange Walk
Carr, John	Belmopan	Cayo
Carrillo, Martin	Chan Pine Ridge	Orange Walk
Chi, Ventura	San Jose Succotz	Cayo
Collins, Vera	Bullet Tree	Cayo
Farley, Wendell	Caribbean Investment	Cayo
Friesen, Joe	Spanish Lookout	Cayo
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Gallardo, Rafael	Roaring Creek	Cayo
Galvez, Ramon	Clarisa Farm	Cayo
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