Output 4: Superior and diverse grasses and legumes delivered to NARS partners are evaluated and released

Activity 4.1 Development of partnerships with NARS, NGO's, IARC's, ARIS and private sector in LAC, Asia and Africa to undertake evaluation and diffusion of a range of grasses and legumes for multipurpose use

Highlights

- Confirmed that *Desmodium ovalifolium* CIAT 13651 is an excellent legume cover for rubber and oil palm plantations in the Llanos.
- Observed fast establishment, excellent ground cover and high DM yields with some genotypes of *Vigna* evaluated as green manures in the llanos piedmont.
- Using farmer criteria pre-selected *B. brizantha* 26124 as a suitable alternative for pasture systems in the Llanos of Colombia.
- Selected and multiplied seed of multipurpose forages for degraded Hillsides of Haiti.
- Completed a Technical Bulletin for the release in early 2002 in Costa Rica of *Cratylia* as cv. Veraniega.
- Defined that deficient technical assistance and lack of information by farmers are the major constraints to increase adoption of *Cratylia argentea* and *Arachis pintoi* in Costa Rica.
- Made progress in the development of collaborative forage-based initiatives for Africa.

Progress towards achieving milestones

- ***Cratylia* released and available to farmers in Costa Rica**
  As part of the release process a Technical Bulletin was prepared for distribution to technicians and farmers. The official release by MAG of *Cratylia argentea* cv. Veraniega will now take place in February 2002 in a farm using the forage to supplement dairy cows in the dry season.

- **Suitable legume covers for plantations in the Llanos of Colombia defined**
  We have confirmed that *Desmodium heterocarpon* var. *ovalifolium* CIAT 13651 is a excellent option to recover degraded pastures and to use as cover in rubber and oil palm plantations in the Llanos of Colombia. The task ahead is to promote the use of this legume by graziers and plantation growers through multiplication of seed, and diffusion activities (workshops, field days and technical bulletins).

- **Selected grass and legume species for on-farm testing in Hillsides of Haiti**
  Through agronomic trials carried out in two sites in Haite we selected a range of grasses and legumes (herbaceous and shrubs) for multipurpose in diverse farming systems. To accelerate the diffusion of improved forages selected materials were multiplied and the seed sent to Haiti.

4.1.1 On-going collaboration in forage evaluation with partners

4.1.1.1 Use of Forages for recuperation of degraded areas in hillsides of Colombia

Contributors: FIDAR (NGO lead partner), UMATA, Comite Cafeteros, REVERDECER, CVC, Alcaldia de Restrepo, Universidad de Valle, Comite de Cafeteros, University of Hohenheim

Rationale

The study area located in the north of the 'Valle de Cauca' is characterized by a high natural diversity and richness of natural resources. However inappropriate land use has led to degradation of the natural resource base, threatening social, economic and environmental sustainability of the region.

The deterioration of natural resources is leading to loss of fauna and floral biodiversity, lack of vegetative cover and resulting high erosion, and reduced crop yields. Communities at the lower end of the watershed face an increased risk of natural disasters; companies utilizing water for electricity and for human consumption at the downstream of the water lines have increased costs in maintenance of plants due to increased sediments as a result of erosion, increasing electricity costs and posing at risk the availability of water of high quality. Hence there are multiple effects on well -being and environmental quality as a result of the environmental degradation.

In the past the recuperation of such fragile areas was addressed by isolated activities carried out by public and private institutions, often without incorporating the communities themselves and without long-term follow -up. Often the costs of the suggested solutions were high, reducing the possibility for wide adoption and maintenance by the community.

The present collaborative project aims to develop a concerted effort with different actors in the region including the community to reverse the degradation problem in the watershed. In the project, the Fundación para la Investigación y el Desarrollo Agrícola (FIDAR), the University of Hohenheim and CIAT try to offer sustainable alternatives based on multipurpose grasses and legumes (herbaceous, shrubs, trees), and on development of an evaluation system that incorporates the community.

The expected outputs of the project are:

- Development methods for participatory planning, monitoring and evaluation for recuperating and stabilizing fragile soils
- Stabilization of degraded zones through vegetative covers an mechanical barriers
- Economic and agronomic evaluation of different vegetative covers and mechanical options for recuperation and conservation of degraded lands, with focus on cost-effectiveness
- Farmer groups with the means and tools to continue recuperation and conservation of soils for wider application
- Develop and validate DST for the recuperation and conservation of soils, with focus on the adaptation of existing tools

Major activities

Simulation models

In 2000/2001, the calibration of the SWAT (Soil and Water Assessment Tool) was refined, to serve in the future as tool for diagnosis, planning and NRM. Maps for land use were elaborated. The community is familiarized with the tools used

Monitoring and evaluation

Changes in the administration of the municipality have led to changes in key contacts in collaborating institutions. Labor and purchased inputs are being monitored together with the identification of market opportunities with active participation of the community.

Open evaluation with farmers is strengthening the interaction with farmer groups and a process of dissemination of project results was initiated

Cover crops and mechanical erosion barriers established

On an area of 9 ha exposed to severe erosion and 14 ha exposed to moderate erosion, cover crops and mechanical barriers were established in collaboration with farmers. For materials selected by farmers seed banks were set up, one with farmers and one with students in their last year of education; the latter contributes to the environmental education. These activities are accompanied by training activities and facilitation of organization processes. A CIAL is supported with technical assistance.

4.1.1.2 Evaluation of legumes as covers for plantations in the Llanos of Colombia

Contributors: C. Plazas, M. Peters, L.H. Franco, B. Hincapie (CIAT) and Oil Palm and Rubber Growers of the Colombian Llanos

Rationale

There is a need in plantations of the Llanos of Colombia to find sustainable ways to reduce weed infestation, to maintain and improve soil fertility, to control erosion and increase soil fauna biomass. There is currently a trend to promote plantation systems in the Llanos. In the rubber plantation the target group for this promotion are small to medium size farmers who want to diversify there farming operations. In the oil palm plantations plots of up to 5 ha are rented out to landless farmers to manage the oil palms for the oil palm industry.

In 1999 a range of legume accessions of the species *Arachis pintoi*, *Desmodium heterocarpon* subsp. *ovalifolium* and *Pueraria phaseoloides* were sown under shade and no-shade conditions in the Meta department of Colombia. Based on initial results, this work was expanded to include the evaluation of different establishment procedures for the most promising cover (*Desmodium heterocarpon* subsp. *ovalifolium* CIAT 13651) in comparison with the most commonly used cover *Pueraria phaseoloides*.

Materials and Methods

In plots of 80 m^2 we established legumes covers in commercial young and old rubber and oil palm plantations in the savannas and piedemonte areas of the Llanos.

The following legumes were sown in a Randomized Block Design with three replications: *Arachis pintoi*: 17434, 18744, 18748, 22159, 22160 (seed rate 10 kg/ha); *Desmodium heterocarpon* subsp. *ovalifolium* (*D. ovalifolium)*: 350, 13105, 13110, 13651, 23762 (0.5 kg/ha); *Pueraria phaseoloides*: 8042, 9900 (3 kg/ha). Additionally a mixture of *Arachis pintoi* CIAT 18744 and *Desmodium ovalifolium* CIAT 13651 was sown. Measurements carried out include: % cover, DM yield and weeds.

Results and Discussion

In Table 99 we show the effects of different establishment procedures for *Desmodium ovalifolium*. Planting was in August 2000, and measurements were taken 6 months (dry season) and 15 months (wet season) after planting.

Table 99. Soil cover of *Desmodium heterocarpon* subsp. *ovalifolium* (*D. ovalifolium*) in rubber and oil palm (palma) plantations under different establishment procedures in two sites in the Llanos of Colombia.

Treatments	Savanna (rubber)		Piedemont (oil palm)	
	Season			
	Dry	Wet	Dry	Wet
	Cover (%)			
Soil preparation + *D. ovalifolium* CIAT 13651 (1 kg/ha)	26	85	10	2
Soil preparation + *D. ovalifolium* CIAT 13651 + Fusilade	24	84	13	3
Soil preparation + Roundup + *D. ovalifolium* CIAT 13651	24	84	4	0
Soil preparation + Kudzu. (3 kg/ha).	54	55	16	5

Establishment and development of *Desmodium* under rubber in the Altillanura has been very good as indicated by more than 80% cover in the wet season, which is better than the cover obtained with the traditional kudzu. However, during the early establishment phase (dry period) the kudzu treatment had a higher cover. In denser oil palm plantations, establishment of the legume covers was not good as a result of shading caused by the trees.

In Table 100 we present results on soil cover with different legumes in plantations two years after establishment.

Table 100. Soil cover of different forage legumes in plantations two years after sowing in two sites in the Llanos of Colombia.

Treatments	Savannas - Rubber				Piedmont-Oil Palm	
	Dry		Wet		Dry	Wet
	Old Plantation				Young Plantation	
	Shade	Open	Shade	Open		
	Cover (%)					
A.p 17434	20	15	50	47		35
A.p 18744	65	37	83	70		63
A.p 18748	32	23	75	68		47
A.p 22159	27	18	63	62		62
A.p 22160	27	23	62	63		67
D.h 350	90	93	30	83		68
D.h 13105	93	88	17	75		68
D.h 13110	92	93	12	60		77
D.h 13651	87	90	43	95		87
D.h 23762	92	92	27	82		53
P.p 8042	17	33	30	40		37
P.p 9900	25	55	30	57		37
Asoc. *Ap/Dh*	83	87	63	90		87

Under rubber in savannas *Desmodium* and the *Desmodium/Arachis* mixture maintained soil covers >80% between rubber rows (open). Cover with *A. pintoi and P. phaseoloides* (Kudzú) was much lower, oscillating between 15 and 23 % for *Arachis* and between 17 and 55% for Kudzú.

Performance of the different legume covers under palm trees in the Piedemont was not recorded in the dry season as management of palm trees includes slashing down the vegetation. In the wet season best covers were achieved with *D. ovalifolium* CIAT 13651 and the *Arachis/Desmodium* mixture.

The results from this year confirm those from last year (Annual Report 2000), but also indicate that in old rubber plantations soil cover by legumes improved substantially form one year to another. While soil covers of *D. ovalifolium* and *A. pintoi* increased in the second year, soil covers achieved with *P. phaseoloides* increased only in old rubber plantations. Under oil palm tree, *P. phaseoloides* declined from one year to another.

In this study we have identified *D. ovalifolium* CIAT 13651 as an excellent legume cover for plantations in the Colombian Llanos. The low establishment cost and superior soil cover obtained with *Desmodium* as compared to the traditionally used kudzu (*Pueraria phaseoloides*) makes it an interesting option to plantation owners. Of interest is also the association of *Arachis pintoi* CIAT 18744/*D. ovalifolium* CIAT 13651, since combining these two species led a to a more stable soil covers across seasons

Based on our results, we will now start promoting the use of *D. ovalifolium* CIAT 13651 as a legume cover in plantations in the llanos. Actions needed include seed multiplication by selected farmers, demonstration field days, technical brochures and training events for farmers and technicians.

4.1.1.3 Evaluation of green manures in the Llanos of Colombia

Contributors: C. Plazas, M. Peters, and B. Hincapie, CIAT

Rationale

One of the aims of the Forage Project is to develop green manures for rice and maize based systems in the Llanos of Colombia. It is expected that suitable legumes will reduce the need for external inputs and make thus make the crops more competitive.

Materials and Methods

Based on prior experience, several l ”best bet” legume accessions were selected to evaluate as green manures in the llanos:

1. *Mucuna pruriens* CIAT 9349,
2. *Canavalia ensiformis* CIAT 715,
3. *C. brasiliensis* CIAT 17009,
4. *Pueraria phaseoloides* CIAT 9900, 8042, 7182
5. *Stylosanthes guianensis* CIAT 11844, 184,
6. *Chamaecrista rotundifolia* CIAT 8990,
7. *Centrosema pubescens* CIAT 15160,
8. *C. rotundifolium* CIAT 5260,
9. *Arachis pintoi* CIAT 17434,18744,
10. *Desmodium heterocarpon* var. *ovalifolium* (*D. ovalifolium*) CIAT 13651, 13105,

The legumes were established in 25 m^2 plots in a Randomized Complete Block Design with three replicates at the Santa Rosa Rice station. A subset of legumes (*Vigna unguiculata* 288,716 and 733; *S. guianensis* 11844, 11833; and *Mucuna pruriens* 9394) were also established at La Libertad Station of CORPOICA and subsequently incorporated prior to planting rice.

To determine the effect of the legume green manures we compared rice yields in: a) green manure + 0 N, b) green manure + 40N c) fallow and d) fallow+ 6 increasing levels of N.

Results and Discussion

In Santa Rosa station, we found significant differences among legume species and accessions in soil cover and biomass yield at time of incorporation of the plant material (2 to 3 months after planting). The highest soil covers (> 60%)and ability to compete with weeds was observed with *S. guianensis* CIAT 11844 and 184, *Canavalia brasiliensis* CIAT 17009, *C. ensiformis* CIAT 715, *Pueraria phaseoloides* CIAT 8042. Other legumes, such as *D. ovalifolium* CIAT 13105, 13651, *Arachis pintoi* CIAT18744, 17434 and *Centrosema rotundifolia* CIAT 5260 had soil covers below 40%. On the other hand, the highest above ground DM yields were obtained with *S. guianensis* CIAT 11844 (6.7 t DM/ha), followed by *S. guianensis* CIAT 184 and *Ch. rotundifolia* CIAT 8990 with yields above the mean (2.1 T DM/ha) of treatments (Table 102).

Given that rice yields were not affected by green manure + 0 N or by green manure + 40 N, data were pooled for comparing yields after green manures with yields obtained with different levels of N fertilizer (Table 101). The incorporation of different legume species into the soil did not result in a significant increase (P>0.05) in rice yield relative to the fallow control (weeds). On the other hand, it was evident that yields of rice responded linearly to N from 0 to 120 kg/ha, but declined at higher levels (160 and 240 kg of N/ha).

Table 101. Dry matter yield of green manure and grain before soil incorporation and grain and dry matter yield of subsequent rice crops en Santa Rosa, Villavicencio, Llanos de Colombia.

Treatment	Herbage (kg/ha)	Rice (kg/ha)	
		Yield (2000)*	Yield (2001)**
S. guianensis CIAT 11844	6757	3905	3187
S. guianensis CIAT 184	4627	4171	4335
C. rotundifolia CIAT 8990	3303	2887	4297
Fallow Control	3129	3401	3933
C. pubescens CIAT 15160	2085	2512	3401
P. phaseoloides CIAT 8042	2081	3099	3914
P. phaseoloides CIAT 9900	2079	3417	3407
C. brasiliensis CIAT 17009	1967	2848	3184
P. phaseoloides CIAT 7182	1695	3609	3802
C. ensiformis CIAT 715	1543	3802	4029
D. heterocarpon subs. *ovalifolium* CIAT 13651	1501	3440	3393
D. heterocarpon subs. *ovalifolium* CIAT 13105	1411	3052	3064
M. pruriens CIAT 9349	591	3420	3614
A. pintoi CIAT 18744	585	3308	3238
A. pintoi CIAT 17434	293	3030	4312
C. rotundifolium CIAT 5260	227	2405	3465
120 N		5797	3848
80 N		4928	4435
40 N		4431	5506
240 N		4316	2550
160 N		4000	3317
0 N		3286	3159
LSD (P<0.05)	2226	1478	1115

*After incorporation of legumes
**Residual effect of legume green manures incorporated the previous year

The highest rice grain yields in the first harvest (2000) were obtained after using *S. guianensis* CIAT 184, 11844, *C. ensiformis* CIAT 715 and *P. phaseoloides* CIAT 7182 as green manures, but yields were not different from those recorded in the natural fallow. The highest rice yield obtained with a green manure (*S. guianensis* 184) was comparable to the yield obtained with 40N.

The 2nd rice yields (2001) were not significantly affected by the residual effect of legume green manures when compared with yields recorded in the natural fallow. However, it was interesting to observe that with some green manures (i.e. *Ch. rotundifolia* CIAT 8990, *A. pintoi* CIAT 17434, *C. rotundifolium* CIAT 5260 and *C. pubescens* CIAT 15160) rice yields were increased by 35% or more in the second crop as compared to the first crop, but still yields were below those recorded with 40 or 80 kg/N. In the legume green manure experiment established in 2001 in La Libertad station, the cowpea (*Vigna unguiculata)* accessions were the quickest to cover the soil when compared with S. *guianensis* accessions. Highest DM production were also achieved with cowpea, with yields above 4 t/ha DM in 80 days, confirming results obtained at other sites. (Table 102) In this experiment rice yields were not affected by green manure treatments (data not shown). In general, our results indicate that we have some excellent legume options for use as short-term green manures in annual cropping systems in the llanos.

Table 102. Dry matter yield (kg/ha) of green manure herbage before soil incorporation for subsequent rice crop at La Libertad, Villavicencio, Llanos of Colombia.

Treatment	Herbage	
	Cover (%)	kg/ha
Vigna unguiculata (IT86D-716)*	100	4917
Vigna unguiculata (IT6D-733)*	100	4132
Vigna unguiculata (IT89KD-288)*	100	4065
Vigna unguiculata cv CN	99	3971
M. pruriens CIAT 9349	100	2422
Fallow control	95	2218
S. guianensis CIAT 11844	78	2071
S. guianensis CIAT 11833	73	1680
S. guianensis CIAT 184	53	1205
S. guianensis pobl 3	74	966
LSD (P<0.05)	11.9	1275

* IITA numbers

Among the species tested, we are particularly interested in Cowpeas developed in IITA, given their fast growth and high biomass production. However, it is evident from our results that the use of short-term green manures to increase soil N in the piedemont rice production systems will not pay off. Thus, in 2002 we plan to test selected legumes as green manure in maize grown in savannas soils, since it may be more responsive to green manures than rice. It is import to indicate that maize is gaining importance as a crop in the llanos and that a legume green manure technology may be an option attractive to farmers.

4.1.1.4 On-farm evaluation of new grasses and legumes options for livestock systems in the Llanos of Colombia

Contributors: C. Plazas, J. Miles and C. Lascano, CIAT

Rationale

One major limitation for beef and milk production in Neotropical savannas is the degradation of introduced grasses, as a result of nitrogen deficiencies and overgrazing. Thus CIAT's Forage Project (IP5) has been developing improved grasses and legumes that can contribute to reclaim large areas of degraded pastures in tropical regions where livestock is a major land use system.

In collaboration with PE-5, and CORPOICA we initiated in 1998 evaluation of new grasses and legumes in representative farms of the Llanos of Colombia. A total of four farms (two in the well-drained savannas and two in the piedmont) were initially selected to evaluate new grass and legume alternatives. Selected farms were representative of the two sub-ecosystems and have large areas of degraded pastures. In addition, farmers participating in the Project indicated their willingness to cover some of the cost of the work done in their farms.

Introduction of legumes to reclaim degraded pastures

The introduction of *Arachis* to reclaim degraded *Brachiaria* pastures in the piedmont of the llanos has been successful. Results from two farms in the llanos piedmont indicate that after 2- 3 years the legume content in the pastures range from 22% when in association with *B. humidicola* (Figure) to 40% when in association with *B. decumbens* (Figure 34).

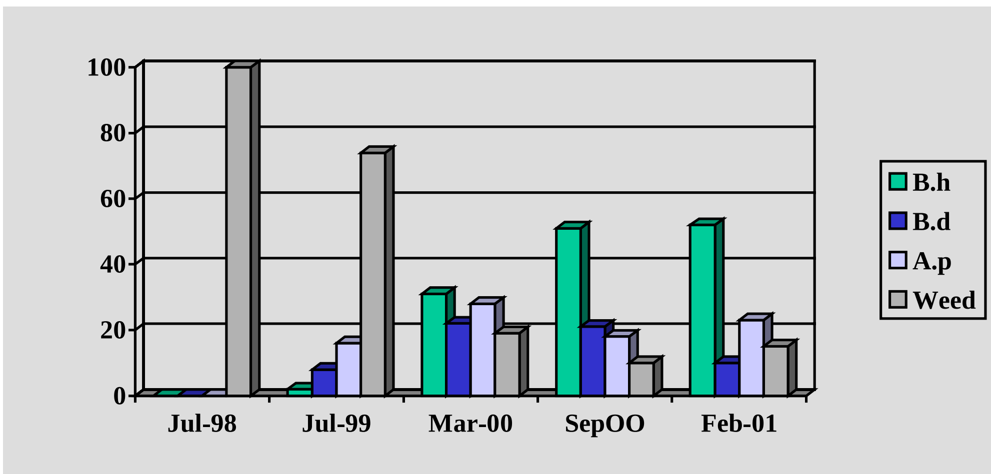

Figure 34. Botanical composition of *B. humidicola* pasture reclaimed with *Arachis pintoi* in the llanos piedmont (Farm 1)

In Farm 1, the Arachis–based pasture has been managed with high stocking rates because of heavy spittlebug attack on *B. decumbens* pastures in the property. This heavy grazing of the *Arachis*-based pasture has favored the legume and has allowed the farmer to release pressure on pastures damaged by spittlebug. The alternative was to sell animals to reduce stocking rate or to graze the spittlebug damaged pastures, with negative consequences on animal performance and on productivity of the pastures. In Farm 2, the pasture reclaimed with *Arachis* in April 1999 is now very productive and with a high legume content as shown in Figure 35.

The CP content in *Brachiaria* has increased form 5 % to 10%, which has had a significant impact on productivity of the pasture. Last year we reported that the introduction of *Arachis* in degraded pastures in well-drained savanna sites was not successful, regardless of ecotype used or planting density. Even though the establishment of the legume was adequate, soon after the initiation of grazing the proportion in the vegetation dropped significantly as results of competition with the grass.

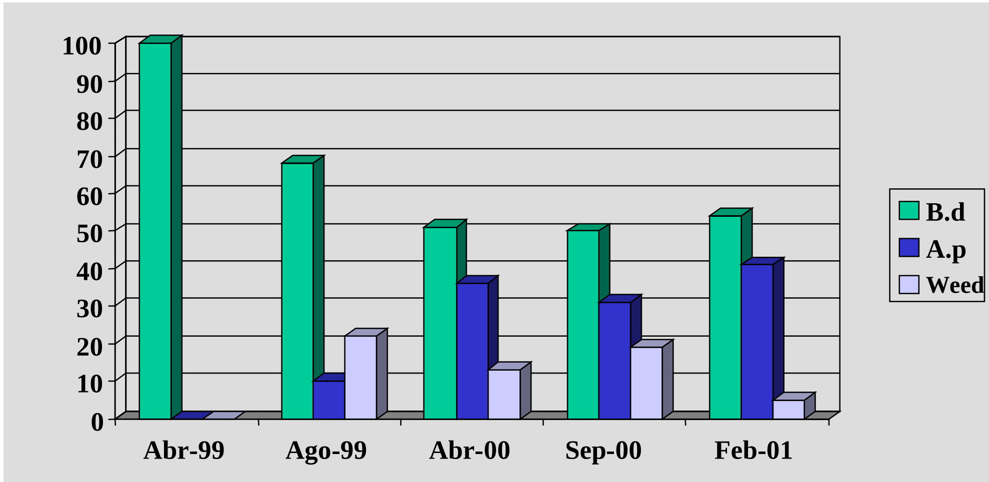

Figure 35. Botanical composition of *B. decumbens* pasture reclaimed with *Arachis pintoi* in a farm in llanos piedmont (Farm 2)

We have now established the use of *Arachis* to reclaim degraded pastures in well drained sites in the llanos will require high use of management and fertilizer inputs, but it is unlikely that farmers would be willing to pay the extra cost. The alternative is the use of *Desmodium* heterocarpon subsp. *ovalifolium* (*D. ovalifolium*) which is better adapted to acid-low fertility soils.

The value of *D. ovalifolium* CIAT 13651 to reclaim degraded pastures was evaluated in one farm located in well-drained site in the llanos. The pasture reclaimed had low availability of *B. decumbens* and high proportion of weeds. To reclaim the pasture, we plowed the land and introduced *Desmodium* (250 g of seed /ha) in May 2000. One year after the pasture has 20% legume and it is being successfully used to fatten steers (Figure 36).

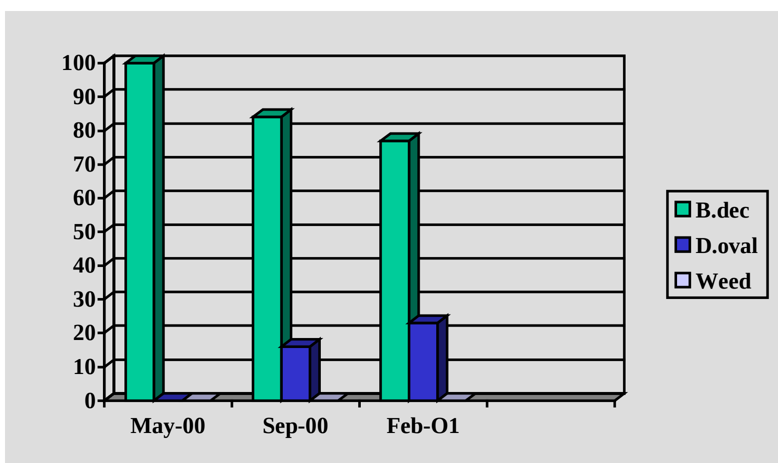

Figure 36. Botanical composition of a pasture reclaimed *with Desmodium ovalifolium* in a farm in the llanos

Given the successful introduction of *D. ovalifolium* CIAT 13651, farmers have shown interest in its use to reclaim degraded pastures. A total of 140 ha of degraded pasture in well- drained savannas have been recuperated by the initiative of farmers. Farmers in the piedmont have also reclaimed more pastures (180 ha) using *D. ovalifolium* rather than *Arachis* due to lower seed cost. We have estimated that the cost of reclaiming degraded pastures with *D. ovalifolium* CIAT 13651 is ½ of what it is with *Arachis* ($US70 vs. 152/ha) and this cost differential is a driving force in the adoption of legumes in the llanos.

Introduction of new grasses to reclaim degraded pastures

Last year we reported that in one farm located in a well-drained savanna site with acid-low fertility soils we introduced in 1999 two new *B. brizantha* accessions (CIAT 26110 and 26318). In 2000 we introduced in the same farm *B. brizantha* 26556 G and *B. brizantha* 26124. In addition, we introduced *B. brizantha* 26110 in one farm in the piedmont. Results on performance of these pastures are shown in Figure. In the dry season (February 2001), *B. brizantha* 26610 produced more biomass than the other accessions being evaluated in a well- drained savanna site. However, in the wet season (May 2001) *B. brizantha* 26556 G and 26124 have been more productive than the other grasses being tested in savannas. We have also observed that *B. brizantha* 26110 is more productive in the piedmont (P) than in a well-drained savanna (WDS) site (Figure 37).

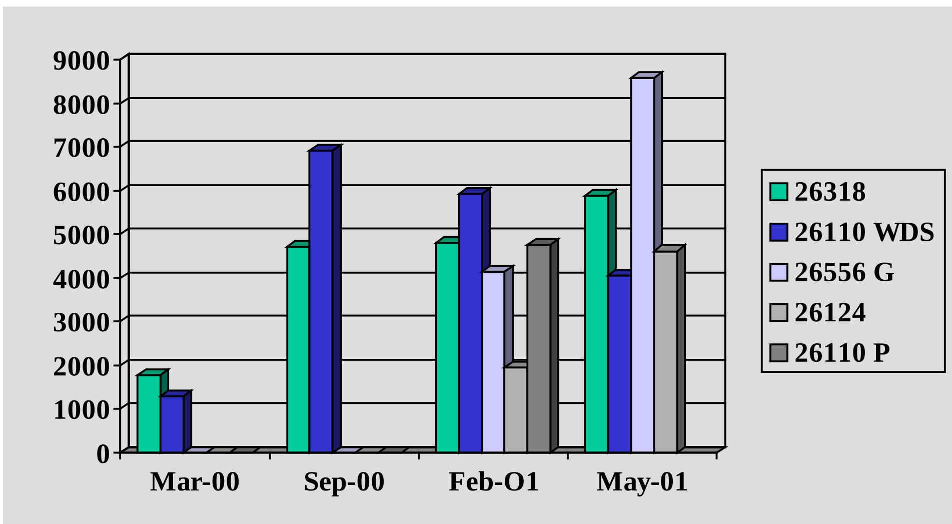

Figure 37. Forage on offer of different *Brachiaria brizantha* accessions under grazing in the llanos

The following feedback was obtained from a participatory evaluation of the new grasses being tested in the llanos:

1. *B. brizantha* 26318: It recovers fast after grazing but does not seem to be very palatable to cattle given it high stem content. Poor overall rating.
2. *B. brizantha* 26110: High forage production and this can result in forage loosing quality if not properly managed. Most farmers like CIAT 22610 but concur that it needs to be well managed (high stocking rates, short rest periods) to obtain good animal performance.
3. *B. brizantha* 26556 G: This grass was ranked No 2 by producers due to green intense color, high leaf content, large leafs and soft leaves. Unfortunately this accession was heavily attacked by spittlebug and recovery following grazing is slow. In spite of the susceptibility of this accession to spittlebug farmers expressed an interest in this genotype.
4. *B. brizantha* 26124: This accession was given the highest rating by producers given its high leaf content, large and soft leaves. One advantage farmers see with his accession is that it recovers fast after grazing and that it produces stolons that root.

Thus from the results on evaluation of new *B. brizantha* accessions, it would seem that CIAT 226110 (cv Toledo) is better adapted to the piedmont with better soils than to the more acid-low fertility soils found in well- drained savannas. In addition, it is clear that for farmers in the llanos important selection criteria for grasses include plant factors associated with quality and palatability such as leaf: stem ratio and leaf softness. Recovery of the grass after grazing is also an important selection criterion of farmers. Finally, there is an urgent need to multiply seed of selected grasses in order to expand the on-farm evaluation of the new grasses. An alternative is to make seed available to private seed companies that have interest in establishing a multilocational-testing program with new grass alternatives.

4.1.1.5 Ex-ante analysis of the utility of *Cratylia argentea* in dual-purpose production systems of the Llanos piedmont of Colombia

Contributors: F. Holmann, C. Plazas and C. Lascano (CIAT)

Rationale

About 90% of the milk produced in the Llanos comes from dual-purpose herds where pastures are the main source of feed. However, the quality of existing forages is low. On the other hand, shrub legumes have the potential to improve the feed quality of offered forages. Shrub species produce more biomass than herbaceous legumes, have a higher regrowth capacity, and produce a good quality forage in areas with prolonged dry season. Among the shrub legumes that have been evaluated and selected by CIAT is *Cratylia argentea*.

This study forms part of larger project in which we will evaluate with farmer participation the utility of *Cratylia argentea* to substitute the use of feed supplements in dual-purpose cattle production systems found in the Llanos piedmont of Colombia. The specific objective of the ex- ante economical study is to define if by using *Cratylia* farmers can reduce feed costs. Different uses of *Cratylia* are being analyzed: a) offered alone in cut-and-carry systems at milking time; (b) mixed with molasses and offered at milking time; and (c) under direct grazing by milking cows.

Materials and Methods

In order to understand the current production systems, technologies used, use of resources, and input and output prices we collected data through direct interviews of 32 farmers that operate dual-purpose production systems located in the target area. We also used data from secondary sources from the region where farms are located. To meet the objectives of the study a linear programming (LP) model was utilized as the main tool of analysis. This LP model was initially developed by the Tropical Agronomical Center for Teaching and Research (CATIE) and the International Network of Animal Production Systems of Latin America (RISPAL), which was later expanded by CIAT. The LP model was developed in an electronic spreadsheet with the objective to evaluate ex-ante the costs and benefits of the current and potential land use and their interactions between the technological components and the biological productivity.

Results and Discussion

In Table 103 we present descriptive statistics of the current dual-purpose production systems found in the Llanos piedmont. As can be observed, about 85% of total farm area is under pastures with very little area allocated to crops (1.5 ha/farm), consisting mainly of fruit trees and annual crops for self-consumption. Mean herd size is about 63 animals/farm of which 27 are mature cows.

Table 103. Means for land use, livestock inventory, stocking rate, milk production, and feed supplements for 32 farms representative of production systems in the Llanos piedmont.

Parameters	Quantity
Total farm area (ha/farm)	59.6
Area under pastures (ha/farm)	50.7
Total number of cattle (heads/farm)	63.1
Number of cows (#/farm)	26.9
Stocking rate (AU/ha)	0.92
Milk production (kg/farm/day)	112
Milking cows (#/farm)	19
Milk productivity (kg/cow/day)	5.9
Feed supplements used (kg/milking cow/day)	
* Oilpalm cake	0.43
* Feed concentrates	0.42
* Molasses	0.41
* Mineralized salt	0.12

Milk yield is about 5.9 kg/cow/day, which is significantly higher than the average for the whole of the region, which is 3.4 kg/cow/day. The amount of feed supplements offered to milking cows is low, which suggests that producers used them strategically. In Table 104 we show the forage quality parameters used in the linear programming model to do the ex-ante analysis for the scenarios considered in this study.

Table 104. Forage parameters utilized to run the linear programming model to do the ex-ante analysis in dual-purpose farms in Villavicencio.

Parameter	*Brachiaria decumbens*	*Brachiaria humidicola*	Napier Grass	*Cratylia argentea*	
				Cut and carry	Direct grazing
Crop duration (years)	10	10	10	20	3, 6, 9
High rainfall season					
* Available biomass (tm DM/ha)	4	4	8	16	4
* Crude protein (%)	6	4.5	8	15	23
* Degradability of CP (%)	60	50	60	70	70
* IVDMD (%)	55	50	55	50	60
Low rainfall season					
* Available biomass (tm DM/ha)	2	2	2	8	2
* Crude protein (%)	5	3.5	7	15	23
* Degradability of CP (%)	55	45	55	65	65
* IVDMD (%)	50	45	55	50	60
Lost forage to trampling (%)					
* High rainfall season	30	30	0	0	10
* Low rainfall season	25	25	0	0	10
Biomass transfer from high to low rainfall season (tm DM/ha)[1]	1	1	2	4	1

[1]Equivalent to 25% of biomass production during high rainfall season for grasses and Cratylia under direct grazing system and 100% for Cratylia in cut-and-carry systems.

These parameters were determined based on field data collected from several years in similar regions. It is expected that the simulation runs for the ex-ante analysis and the discussion of results will be completed by December of this year.

4.1.1.6 Analysis of intensification of milk production systems in Colombia

Contributors: Juan Carulla (U. Nacional, Bogotá), Silvio Guzmán (Fundación San Martín, Barranquilla), Manuel Martínez (U. de los Llanos, Villavicencio), Luis A. Giraldo (U. Nacional, Medellin), B. Rivera (U. de Caldas, Manizales), F. Holmann y Andrew Farrow (CIAT)

Rationale

From 1992 to 1999, milk production in Colombia grew at an annual rate of 4.3% and dairy imports during the same period represented 2.6% of domestic production. Thus, Colombia is practically self-sufficient in milk production. On the other hand, Colombia has always been a net exporter of beef, but with a clear loss in relative importance throughout this decade. In 1991 Colombia exported about 5% of its domestic production. Since then, the reduction in exports has been noticeable, dropping to less than 1% in 1999.

Nonetheless, Colombia has a significant potential to increase livestock production given the high proportion of land under pastures and abundant feed resources, good public infrastructure, genetic potential of its livestock inventory, human resources, and availability of technologies and livestock services. However, internal discusion exists within Colombia as to whether its farmers will be able to survive and compete in a scenario of free trade without tariff barriers.

The objectives of this study were to (1) identify the technologies that have a positive effect in the productivity and profitability of milk in five contrasting regions of Colombia; (2) quantify the effect of these technologies on the productivity and profitability of milk; (3) quantify the investment needed to adopt these technologies at the farm level; (4) geo-reference farms in Colombia to identify patterns of adoption with regards to level of infrastructure, human population, and market access; and (5) analyze the comparative advantages in each region to increase the future supply of milk.

This study is a collaborative project between CIAT and five institutions in Colombia: Universidad Nacional (Bogota and Medellin sites), Universidad de Caldas, Universidad de los Llanos, and Fundacion San Martin. In addition, this study is an integral part of a transregional analysis led by ILRI.

Materials and Methods

Data for this study came from direct surveys to 545 producers done between February and November of 2000 in five contrasting regions of Colombia distributed as follows: (1) 145 farms in the Eastern plains (Arauca, Casanare, and Meta); (2) 116 farms in the Caribbean region (Atlantico, Guajira, Magdalena, Cesar, Bolivar, and Cordoba); (3) 105 farms in the coffee region (Quindio, Valle, Caldas, and Risaralda); (4) 97 farms in Antioquia; and (5) 82 farms in the highlands of Cundinamarca and Boyaca.

The survey information was then developed into a database using Access and completed in April of 2001. The statistical analysis of the database started in May of 2001 and it is expected to be finished in May of 2002. For the geo-reference analysis new software developed at CIAT (i.e., accessibility wizard) will be used to identify patterns of intensification in order to complement farm-level data and to better understand the drivers of adoption of technologies.

Expected Outputs

The final product of this study will be a publication which includes (a) an analysis of the milk production systems found in each of the five regions studied (i.e., 5 chapters); (b) an additional chapter which integrates the five regions as a country; (c) a chapter using GIS which analyzes market access and identify patterns of intensification; and (d) a final chapter analyzing the comparative advantages and disadvantages of different milk production systems to meet the future supply of milk.

4.1.1.7 Participatory evaluation of forages for multipurpose use in Haiti

Contributors: Levael Eugene (CIAT), Ellisssaint Magloire (ORE), Joseph Andrefoine (ORE), P. Argel, C. Lascano, M. Peters, Luis A. Hernández, CIAT

Rationale

This year we completed a collaborative project in Haiti through the HGRP (Hurricane George Recovery Program), which financed by USAID and administrated by the Pan American Development Foundation (PDF), an ONG based in USA, and which in turn subcontracted with other ONG's based in Haiti, such as ORE (Organization for Rehabilitation of the Environment) and with CIAT for the recovery of the country after the devastation caused by hurricane George in 1998.

The short-term objective of CIAT's work on forages in Haiti through the HGRP was to select grasses and legumes well adapted to soils and climate of target hillsides and to determine seed production potential of selected species.

Thus the expected outputs from the forage work in Haiti were to:

1. Select grasses (prostrate for cover and erect for cut and carry) and legumes (herbaceous for cover and green manure and shrubs for cut and carry) based on initial assessment of environmental adaptation, seed production potential and farmer preference.
2. Train Professionals on Forage Agronomy and Seed Multiplication.
3. Define a strategy for scaling-up forage work in Haiti (i.e. choice of species for local seed multiplication, on-farm trials and diffusion mechanisms).

Activities

To accomplish these outputs we carried out the following activities:

1. Reviewed available rainfall and soils data in target areas and previous experiences with introduction of grasses and legumes.
2. Reviewed CIAT Forage database and selected grass and legume species that could be adapted to target areas.
3. Delivered small quantities of forage seed to Haiti through ORE to establish selected grasses and legumes species in small plots in replicated trials in two sites (Camp Perrin, and Deron) to assess seed multiplication potential.
4. Prepared research protocols to ORE's staff for the evaluation of forage germplasm for multipurpose use (feed resource and covers**).**
5. Evaluated a range of forage species and selected best bet options for seed multiplication.
6. Provided short-term training to a staff from ORE on Forage Agronomy in CIAT- Palmira and Costa Rica.

7. Provided training in forage agronomy and in participatory evaluation methods to professionals of different organizations in Haiti.

Two contrasting sites were chosen for the evaluation activity: Camp Perrin and Derón (south of the country). In Camp Perrin (flat areas) the rainfall is bimodal with a total of 2114 mm (mean of the last 6 years); soils are of calcareous origin and the predominant crops are maize, sorghum, tobacco and vegetables. The other two sites are located in hillsides with different slopes.

The experiment located in Camp Perrin was established in August 2000 with the participation of Agronomist from ORE and CIAT. ORE personnel established the trial in Debron in September of the same year. Due to excessive rainfall following planting, the germination of small seed grasses was poor in some case and additional seed was sent for replanting this year and to complete the quantity necessary to establish the third trial in Marigot.

Camp Perrin is located close to sea level, while Deron is placed at mid altitude (around 600 masl)). At both sites the soils are of calcareous origin; however at Deron the soils give the appearance of being acid soils because of the intense red color they have, but this occurs because most of the soil basis are washed away with the rains except the iron compounds that produce the reddish color observed, however the pH is over 6. Both soils have low contents of organic matter (around 2.0%) and phosphorus (around 1.4 ppm), meanwhile the calcium content is high (over 2.5%) as well as the exchange capacity (over 31 meq/100 g).

Results and Discussion

At both sites the forage germplasm planted consisted of shrub legumes, herbaceous grasses and legumes, and legumes as green manure/cover crops. Plant emergence was limited by heavy rains following planting, particularly of small seeded legumes such us *Desmodium ovalifolium* and *Stylosanthes guianensis.*

At Camp Perrin the plots had a uniform cut during April and a first evaluation of dry matter yields was carried out in August. At Deron the plots were cut two weeks before the evaluation in June of this year. A visual rating of adaptation of the species allowed us to rank species based on adaptation and production potential in the two sites (Table 105).

In Camp Perrin and Deron, the shrub legumes *Leucaena leucocephala* subsp. *glabrata* (OFI 34/92) and *L. leucocephala* CIAT 17263 were outstanding given the calcareous nature of the soils in the two sites. However, it was interesting to note that *L. collinsi* OFI 52/ 88 and *L. macrophylla* subsp. *nelsonii* OFI 57/85 performed well in Camp Perin but failed in Deron, which could be related to differences in rainfall distribution in the two sites. Other shrub legume species such as *Cratylia argentea* were slow to establish but it is expected to produce good biomass once established, particularly in the dry season.

In terms of grasses it was evident that several accessions of *Panicum maximum* and *Brachiaria* sp performed well in both sites. Of the herbaceous legumes tested, *Centrosema macrocarpum* and *C. pusbescens* performed well in both sites and could be excellent supplement to animals on low quality feed such as crop residues used in Haiti to feed cattle. *Arachis pintoi* established well in both sites, but growth was retarded possibly as a result of micronutrients. Other legumes such as *Mucuna* sp and Cana*valia ensiformis* are very well adapted in the two sites and are obvious choices for green manures.

Based on these initial results we selected a number of grasses and legumes for seed multiplication and subsequent delivery to Haiti. A total of 340 kg of seed of grasses and legumes were sent to Haiti this year as part of HGRP. This seed was stored in ORE and will be used for regional and on-farm testing in the new HAP project in which CIAT will participate.

Table 105. Evaluation of multipurpose forage established in Deron and Cam Perrin during 2000 in Haiti.

Species	Sites	
	Camp Perrin	Deron
Shrub legumes		
L. leucocephala subsp. *Glabrata* OFI 34/92	Excellent	Excellent
L. leucocephala CIAT 17263	Excellent	Excellent
L. collinsii OFI 52/88	Excellent	Failed
L. macrophylla subsp. *Nelsonii* OFI 47/85	Excellent	Failed
C. callothyrsus CIAT 22310	Regular	Good
C. callothyrsus CIAT 22316	Good	Good
F. macrophylla CIAT 17403	Good	Failed
C. argentea CIAT 18515/668	Good	Poor
Herbaceous Grasses and Legumes		
P. maximum CIAT 16051	Good	Excellent
P. maximum CIAT 16028	Good	Excellent
P. maximum CIAT 16031 (cv. Tanzania)	Good	Good
B. brizantha CIAT 26110 (cv. Toledo)	Good	Excellent
B. decumbens CIAT 606 (cv. Basilisk)	Good	Excellent
B. dictyoneura CIAT 6133 (cv. Llanero)	Regular	Poor
B. humidicola CIAT 679 (cv. Humidicola)	Regular	Poor
B. humidicola CIAT 26427	Regular	Poor
S. guianensis CIAT 1844	Failed	Good
N. wightii CIAT 204	Poor	Failed
C. ternatea cv. Tejuana	Poor	Poor
A. pintoi CIAT 18744 (cv. Porvenir)	Regular	Regular
A. pintoi CIAT 22160	Regular	Regular
C. macrocarpum CIAT 25522 (cv. Ucayali)	Good	Good
C. pubescens CIAT 15160	Good	Regular
D. ovalifolium CIAT 33058	Failed	Failed
Green manure/cover Legumes		
Mucuna sp.	Excellent	Regular
Canavalia ensiformis CIAT 715	Excellent	Good
Pueraria phaseoloides CIAT 7182 (Kudzú)	Good	Regular

4.1.2 Releases and adoption by farmers of new forage species

4.1.2.1 Release of *Cratylia argentea* as cv. Veraniega by MAG in Costa Rica

Contributors: P. J. Argel (CIAT), Carlos Hidalgo, Marco Lobo, Vidal Acuña (MAG), Jesús Gonzalez (ECAG) and Carlos Jiménez (UCR)

Rationale

The shrub legume *Cratylia argentea* was introduced in 1988 for evaluation in Costa Rica at the experimental station Los Diamantes (Guápiles), within the cooperation agreement between MAG-CATIE-ECAG and the Tropical Forage Program of CIAT. The legume is a shrub that reaches between 1.5 and 3.0 m high, and adapts well to a wide range of sites in Costa Rica located between 0 and 900 m.a.s.l., above this altitude plant growth slows down. The plant grows well in well-drained Ultisol soils and in Inceptisols of good to moderate fertility located in subhumid ecosystems with 5 to 6 months dry. The plant does not grow well in calcareous soils or in heavy soils with tendency to high moisture saturation.

The cultivar Veraniega is a physical blend of the accessions *C. argentea* CIAT 18516 and *C. argentea* CIAT 18668, both collected in Brazil respectively at the localities of Sao Domingos (Goiás) and Cuibá (Mato Grosso). These accessions have identical growth habit, similar adaptation to climate and soil and similar contents of minerals, crude protein (around 20% in 3 months old plants), and in vitro dry matter digestibility (around 54%). Cultivar Veraniega flowers and sets good quality seeds in humid and subhumid tropical conditions; the seed has low physical and physiological dormancy.

Fodder banks of cv. Veraniega can be established by direct seeding following a conventional disking soil preparation or after minimum soil tillage. Forage yields depend upon re-growth age, cutting height and planting distance. For instance, dry matter yields per cut have been reported of 2.6 t/ha and 5.1 t/ha, and 1.9 t/ha and 5.3 t/ha, after increasing respectively the cutting height from 30 to 90 cm and the cutting frequency from 60 to 90 days, in a one year old forage banks planted at 1.0 m x 1.0 m between plants and rows. The plant tolerates prolonged dry seasons and up to 30% of the DM yield has been reported during this period of the year.

In dairy farms of cv Veraniega can substitute concentrate or chicken manure when offered fresh or as silage to milking cows during the dry season, together with high energy sources such as sugar cane or king grass. Because the good adaptation and productivity of this shrub in Costa Rica and elsewhere, the Ministry of Agriculture and Livestock (MAG) of this country decided to release it as cv. Veraniega, in a joint activity with the University of Costa Rica, the ECAG and CATIE, all of them members of the Tropileche Consortium.

Actions for the release of Cratylia

A Technical Bulletin entitled “Cultivar Veraniega (*Cratylia argentea* (Desv) O. Kuntze). Una Leguminosa Arbustiva para la Ganadería de América Latina Tropical”, is presently under printing. Four thousand units will be published, which contain information related to the species origin, botanical description, soil and climate adaptation, establishment, pest and disease tolerance, seed quality and production, nutritive value, utilization and management, and response of milking cows to feeds based on Cratylia.

The Technical Bulletin will back up the official release of the cultivar programmed in a field day in February 2002 in one dual purpose cattle farm that has been utilizing successfully *C. argentea* cv. Veraniega for the last 4 years.

The main use of cv. Veraniega in Costa Rica is as protein supplement for lactating dual purpose cows during the dry period (5 to 6 months dry), offered either fresh or as silage. Lately the legume is being used in partially confined cattle feeding systems, as a substitute of highly costly concentrates. These systems are being promoted in Costa Rica in pronounced hilly country where small and medium size farmers fat between 5 to 20 bulls per year; thus the confined or partially confined fattening system is a practice that reduces the animal pressure on steep highly eroding soils.

4.1.2.2 Opportunities and constraints to adoption of *Cratylia argentea* in Costa Rica

Contributors: Ewout van den Ouwelant (U. of Wageningen, Holland), P. J. Argel and F. Holmann (CIAT)

Rationale

Although many factors influence animal production, the availability of feed is undoubtedly one of the most important. Scientists and farmers are jointly seeking alternative sources of animal feed for the dry season. The legume *Cratylia argentea* was introduced to Costa Rica as an alternative source of feed for cattle during the 6-month dry season. Since 1995, an increasing number of farmers are now using this legume, but the process of incorporating this new feeding alternative into production systems and changing farmers' attitudes will take some time. Since then, information about this legume has spread and its use has become more common. This study was carried out to learn more on the knowledge, experience, and benefits that early users in Costa Rica have of Cratylia.

Materials and Methods

Data was obtained by direct interviews with farmers located at three sites in Central-Pacific Costa Rica during March-April 2001. Two groups of farmers were interviewed; one group consisted of 39 Cratylia users and the other, of 25 non-users. Users were asked about their experiences in the initial years of establishment and non-users provided information on potential uses of this legume.

Results and Discussion

More than 50% of farmers who had planted Cratylia were still not using it as feed because of its recent establishment. Of the farmers surveyed, 80% indicated that the most important reason for planting Cratylia was its availability as feed during the dry season and 65% indicated that it was mostly offered fresh, mixed with other feed sources.

Cratylia was well accepted by cattle and mostly fed to the most productive animals, according to 80% of the participants. Leaf retention, regrowth after cutting, and seed production were considered, attributes of Cratylia as good by 70% of the respondents; whereas 60% thought Cratylia helped prevent soil erosion.

Although no major problems were reported, some disadvantages of planting Cratylia were indicated. The legume's slow initial growth and sometimes difficult establishment are seen as negative aspects, as well as the high labor costs involved in cutting the forage and in initial land preparation. Cratylia's biggest advantages are its excellent resistance to drought and its potential to reduce production costs.

With proper management, Cratylia can completely replace chicken manure, thereby substantially reducing feeding costs during the dry season. Figure 38 shows the different opinions about Cratylia by early adopters.

Over the last five years, the average area sown to Cratylia per farm has been maintained because of the failed attempts of several producers who lacked know-how and technical assistance to plant more area. Perspectives for the future are, however, optimistic.

Of the farmers currently using Cratylia, 85% are planning to increase the area planted over the next five years, with an average of 0.7 ha/farm. Most of the farmers (88%) not using Cratylia have no objections about changing their farming practices and adopting the legume.

The lack of information and deficient technical assistance are the major constraints to increasing the rate of adoption of *Cratylia* in Costa Rica. The communication between producers and researchers is mainly through the offices of the Ministry of Agriculture (MAG). The future of *Cratylia* could prove promising with improved services and communications toward farmers.

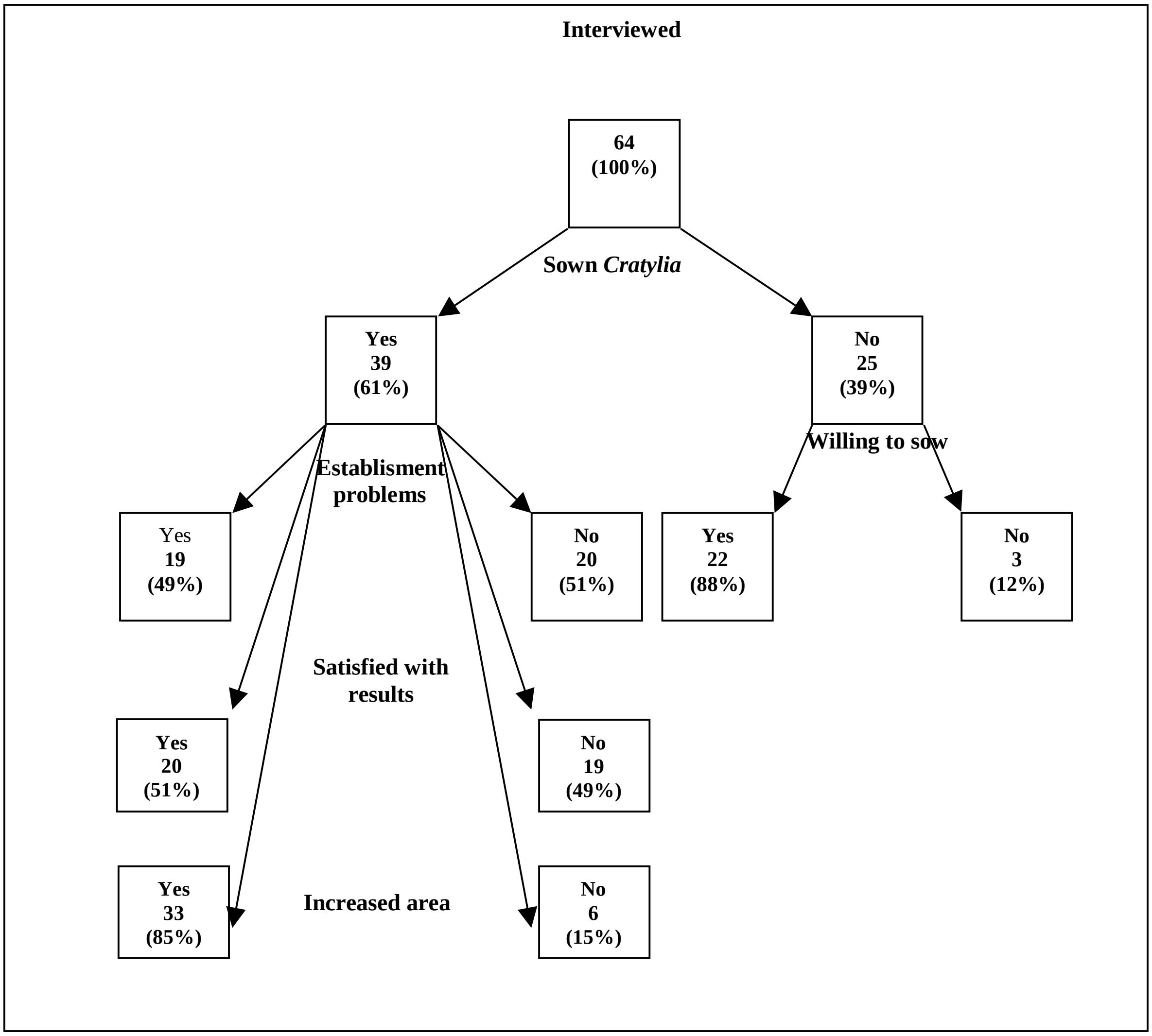

Figure 38. Overview of number of farmers with different adoption characteristics of *Cratylia argentea* In Costa Rica

4.1.2.3 Adoption of *Arachis pintoi* in Costa Rica

Contributors: Tobías Wuenscher (U. of Hohenheim, Germany), R. Schultze-Kraft (U. Hohenheim), P. J. Argel, L. Rivas y F. Holmann, M. Peters (CIAT)

Rationale

Degradation of pure grass pastures is a frequent problem in the tropics. The legume *Arachis pintoi* was found to show a number of characteristics, which can contribute to the development of sustainable and productive pastures in the tropics. The legume was introduced in Costa Rica in 1987 and is used as a pasture plant, as a cover crop in plantations, as a ground cover on roadsides and steep slopes, and as an ornamental plant. It can be grown pure to form protein banks or it can be grown in association with grass species. *A. pintoi* can be fed to various animals including horses, donkeys, sheep, goats, pigs and chicken. The forage has a high protein content and good digestibility. With relatively little area of pure *A. pintoi* good extra weight gains can be achieved and grass/ legume pasture associations are more profitable than improved, grass-alone pasture system.

The objective of this study was to learn about the adoption process by livestock farmers at an early stage in order to accelerate the diffusion process using as a case study the region of Huetar Norte of Costa Rica.

Materials and Methods

The zone known as Huetar Norte was chosen to be the study region because both milk and beef production are predominant farming activities. It was decided to gain relevant information by means of thoroughly structured interviews. The farmers were visited on their properties to be directly and personally interviewed.

The target population was livestock holders and owners of pastures. The frame population was a list of 7131 livestock holders. A simple random sampling was applied to the frame population. 115 interviews were conducted within the simple random sample. We also interviewed 34 farmers in a directed sample. Two questionnaires were used in the interviews: a) short version for the random sample, and b) long version to be used with farmers, which had already worked with *A. pintoi*. MAG extension workers (21) and the author of this study conducted interviews. All interviews were conducted between January and March 2000.

Results and Discussion

The average farm size in the random sample was 69.8 ha. The average farm was made up of 52.5 ha of pasture, 3.3 ha of perennial plantations, 1.9 ha of annual crops and 12.1 ha of land with other uses like trees for wood. The average herd size was 86.4 head of cattle per farmer. The most frequent pasture species was Ratana (*Ischaemum indicum*). The most frequent improved pasture species was Estrella (*cynodon nlemfuensis*). A total of 104 farmers (90.4%) had already heard about *A. pintoi* and 29 farmers (25.2%) had already sown the legume on their land, mostly for ornamental purposes. Only 8 farmers said to have sown it to improve livestock nutrition.

Comparison of adopters and non-adopters: Adopters seek technical information about new forage-based technologies more intensely than non-adopters. For example, 66.6% of adopters but only 34.3% of non-adopters had attended at least one workshop or field day in 1999. In addition, adopters have an average farm area of 128.2 ha and an average herd size of 196 animals compared non-adopters with an average farm area of 69.9 ha and an average herd size of 86 animals. Adopters have herds with an average of 49.8% being dairy cattle, whereas non-adopters have herds with only 19.8% of dairy cattle. Of the adopters, 42.4% belong to the highest gross income category whereas only 15.0% of non- adopters belong to this category. Similarly, only 9.1% of adopters but 17.8% of non-adopters belong to the lowest income category. Thus, adopters of *A. pintoi* tend to be larger producers obtaining higher incomes with more emphasis on milk production and who are more interested in obtaining new information about forage technologies.

Adopters and their experiences with *A. pintoi* as a forage legume: The majority of adopters received information about *A. pintoi* through the extension service of MAG (40.6%) and the ITCR (15.6%) and a 59.4% of the adopters acquired the planting material from one of the three "*Arachis pintoi* centers". The majority of plots were sown with stolons (82.2%).

The main reason for planting *A. pintoi* was to improve pasture (50 % of the answers) quality. Of all adopters 51.5% planted *A. pintoi* in association with grasses and 48.5% planted it in pure stands. The majority of farmers feed it to all types of cattle, some only to milk cows, calves or sick cattle. Within the group of all interviewed adopters (33 farmers) the total area planted with the legume was 73.87 ha.

Of all adopters 87.9% (29 farmers) said to be satisfied with the results they have so far obtained with the use of the legume. However, 3 farmers (9.1%) said to be more or less satisfied and 1 farmer (3.0%) said to be not satisfied.

Advantages of the legume were described as; a) good quality feed (36.6%), b) increases cattle production (15.9%), c) persistence and d) ability to improve soil fertility. Most frequent disadvantages mentioned by adopters were that it a) attracts slugs (12.8%) and b) difficulty to control broad leaf weeds.

The majority of the adopters found that the establishment of *A. pintoi* was slow and 73.1% said that their cattle did not need time to get used to the legume. Whereas 37.5% o said *A. pintoi* could disappear when mixed with improved grasses. Nearly a third of the adopters found it performed better than other improved grass species in the dry season and 81.8% of adopters wanted to increase the area planted with *A. pintoi* in the next five years.

Establishment and maintenance costs differed substantially within the group of adopters. The establishment costs ranged from US$ 57.60 to US$ 348.67 per ha. The maintenance costs ranged from US$ 6.40 US$ to US$ 91.39 per year. The maintenance costs for other pastures ranged from US$ 34.67 to US$ 156.67 per year. Thus in the opinion of farmers the maintenance of *A. pintoi* – based pastures was less than the maintenance of another pasture. Not a single farmer who had planted A. pintoi had taken credit to pay for the investment.

Non-adopters and their perceptions of *A. pintoi*: Of 109 interviewed non-adopters, 98 (89.9%) had already heard about *A. pintoi* and of these 22 said to have already sown it on their farm, mostly for ornamental purposes. The majority of non-adopters (51.6%) has obtained information about the legume from colleagues, neighbours or friends.

Of the non-adopters, 62.4% knew that *A. pintoi* could be used as a feed for cattle and 55 (58.5%) of the farmers though that the legume could serve a useful role on their farm. The majority of these farmers would use it in association with grasses for grazing (51.7%). Most frequent reasons for not using A. pintoi was a) lack of information (27.9%) and b) seed not readily available (13.4%).

In summary our results show that the estimated adoption rate of *Arachis pintoi* as a forage legume is very low in “Huetar Norte” region of Costa Rica. An estimated 3.5%, or 248 farmers had planted an estimated 0.0006% (252 ha) of Arachis-based pastures. Thus the diffusion process is at a very early stage.

The most negative experiences with *A. pintoi* are related to establishment of the legume and to persistence under grazing when in association with a grass. The establishment was seen by a large number of the farmers interviewed as a very time consuming, and costly matter. Persistence was often seen to be a problem, particularly when the legume was in association with a grass. However, after having the legume well established farmers generally had less expenditure in maintenance of the pasture as compared to other pastures and thus experienced an economical benefit from the legume.

In order to accelerate the adoption process it is recommended to develop technologies that ensure a relatively low cost of establishment (i.e. reduced price of seed) as well as management practices that ensure its persistence under grazing. Moreover, it is recommended that training courses be given to extension workers and to ensure the on-farm establishment of Arachis-based pastures for demonstration purposes.

4.1.3 Development of new collaborative research proposals with NARS, NGO's IARC and ARIS

4.1.3.1 New initiatives for the evaluation and promotion of multipurpose forages, with focus in Africa

Contributors: Michael Peters, R. Kirkby, and Thomas Oberthuer, Douglas White, Arturo Franco

In line with the advances made by CIAT's Bean Program in Central, Eastern and Southern Africa, CIAT is expanding its efforts with work on multipurpose forages. Such work is intended to have impact not only on feed improvement for livestock but also on Natural Resource Management (NRM).

Currently, there are three initiatives under way, which include Africa. Common to all initiatives is the collaboration with partners in and outside the region, farmers, NGOs, NARS, ARIS and other International Research Centers.

Improvement of smallholder dairy systems in Southern and Eastern Africa: This initiative with more regional focus is in collaboration with the International Livestock Research Institute (ILRI) and cuts across many of the on-going work of ILRI and CIAT in Southern and Eastern Africa. CIAT and ILRI have done a reconnaissance survey and consulted with partners in the region. Based on this survey and experiences we aim to concentrate on the dairy sector in the region. Criteria for site selection would be based on: a) complementing existing activities, b) representatives, c) systems that are evolving and driven by market forces, and d) potential impact. Tanzania, Uganda and Malawi are currently seen as the most likely countries for reference sites.

The focus is on dairy production, as dairy is seen to both increase food security and income**.** The dairy systems in Eastern and Southern Africa are also particular appealing given that in current intensive farming systems, NRM and poverty alleviation needs are strongly related. In many cases NRM and Poverty alleviation have linked entry points, i.e. the use soil conservation strips as potentials for growing improved feed or, vice versa, growing improved feed to promote soil conservation.

To implement the work ILRI/CIAT will use a participatory approach but will attempt to compare the efficiency of Participatory and Non-Participatory approaches at different points in the Research Development continuum. In addition, CIAT/ILRI will define strategic research issues based on demand and perceived problems and opportunities.

Some basic problems in the target periurban areas are land tenure, land scarcity and HIV/AIDS. In dairy, production often responsibilities for particular processes are shared between women and men. However, in view of the HIV/AIDS problem – i.e. the insecurity who in the household would be there in a decade - we believe that we need to involve both genders and all age groups in the technology development process and concentrate on labor conserving technologies. As forage seed systems are less well developed than in other Regions and the development of the milk-marketing sector is highly variable, Agroenterprise Development will be an important part of the Research and Development Process.The two other initiatives relating to forages incorporate Africa as part of a global or transregional initiatives.

Linking forage databases to Expert Systems to define entry points of forages: This initiative, which involves CSIRO, Australia, ILRI and CIAT, seeks to develop a Forage Database linked to an Expert System, which will aim to define potential entry points for forages in systems. This effort should result in enhanced adoption of improved forages and in a more efficient use of past and future Research and Development experiences. This activity will also complement and strengthen existing database and targeting efforts based on spatial analysis carried out by CIAT and its partners contributing to the project proposal.

Development of DST for targeting forages: This initiative developed by ILRI, IITA, CIAT and Universities, intends to include local knowledge and demand into a decision making tool. Though a great number of research results could be relevant across regions, the final decision on uptake of multipurpose forages will depend on the clients, the small and medium sized farmers. Their decisions will depend on a number of economic, cultural and environmental considerations. Therefore the idea is to define at the community level the most important criteria for decision-making and incorporate this as an interactive component in a Forage Targeting Tool, which links to existing or evolving databases. Intended users of such a tool would be primarily NGOs, Development projects and NARS.

Activity 4.2 Evaluation with farmer participation of multipurpose forages in crop and livestock systems

Highlights

- Adapted participatory methods for the evaluation of forages and identified farmer criteria for selecting forages for hillsides of Honduras.
- Advanced farmer led-testing of forages in Honduras and observed higher preference to evaluate grasses followed by shrub legumes.
- Established experiments in 8 communities of San Dionisio, Nicaragua to evaluate the effect of legume green manures in crop production
- Found significant increases in daily milk production of dual purpose cows grazing a Brachiaria-Leucaena paddock as compared to only paddock.
- Found significant increases of liveweight gains of young female calves during the dry period that had access to a protein bank of *Leucaena leucocephala* for 3 hours daily in contrast with those that had no access to the protein bank.

Progress towards achieving milestones

- **Model for participatory selection of forages developed**
  We have made progress in the development of a glossary of local terminology used by livestock farmers in hillsides of Central America to facilitate communication with technicians. In addition we have defined criteria used by farmer to select forages and have determined preference ranking of forages by farmers. Finally, we have initiated activities at the Honduras bench mark site to design and carry out forage-based experiments with crop and livestock farmers.

- **Known value of different legume green manures for crop production in hillsides of Central America**
  We established experiments in eight communities of San Dionisio, Nicaragua to evaluate with farmers the effect of three legumes on maize yield. Production economical and acceptability data will be analyzed to determine adoption potential of green manure technology by farmers in hillsides of Central America.

- **Known value of *Leucaena* to supplement milking cows and pre-weaved**
  We demonstrated that with small areas of *Leucaena leucocephala* CIAT 17263 farmers can produce 20% more milk and improve by 67% the liveweight gain of calves during the dry season in dual-purpose cattle farms.

4.2.1 Development of Participatory Methods to enhance adoption of forages as feed resources and for INRM

Contributors: R.Van der Hoek (University of Hohenheim**),** M. Peters, V. Hoffmann (University of Hohenheim)**,** J. Ashby, M. Ayarza

Rationale

Many regions in developing countries, including the hillsides of Central America, are characterized by deteriorating biophysical conditions such as erosion, loss of soil fertility and deforestation, resulting into diminishing resources, like depletion of nutrients, and in lower crop and livestock production. In addition, the growing population in these countries demands a higher food production. Maintaining and improving soil fertility and soil conservation are crucial. For this, a broad range of inputs are available, such as organic materials like animal manure, green manure and composted crop residues.

It is well recognized that forage-based technologies can play an important role in improving the environmental and socio-economic sustainability of smallholder production systems in the tropics, especially in situations with a fragile balance between the availability of natural and economic resources and their utilization. Forages can serve multiple objectives, such as provision of animal feed, enhancing soil conservation and maintaining and improving soil fertility.

Most of this research is being carried out in CIAT's reference site in hillsides of Honduras with the financial support of BMZ, Germany.

Expected outputs include a manual on participatory methods for forage-based technologies, scientific publications and a Ph.D. thesis (Hohenheim University).

The main activities being carried out are:

1. Systematization of farmers' perception on their own land use and the influence of new technologies
2. Development and adaptation of participatory approaches for the identification, testing, evaluating of forage-based technologies in complex systems.

During the last 10-20 years, many participatory methods and tools have already been developed. Some of these existing methods will be selected during this research process and their suitability will be tested in the process of identifying, testing and evaluating of forage based technologies as well as systematizing of farmers' perceptions on their own land use and the influence of new technologies. Consequently, existing methods will be adapted, aggregated in new combinations, or new methods will be developed if necessary.

Results and Discussion

Up to present, a detailed research proposal has been elaborated and a first analysis of the farming systems in the research area has been carried out.

Some results and conclusions are:

Farmer Categories. From approximately 40 interviews conducted with farmers in different zones in CIAT's site in Honduras we now have categorized farmers and their current production systems as follows:

a) Farmers in the lower lying areas (<500 m) have around 15 ha of arable land, whereas farmers in the medium (500-1000 m) and higher (>1000 m) zones have access to 5 and 3 ha, respectively.
b) Maize is the main crop at lower altitudes, beans are mostly grown at the medium and higher altitudes, whereas coffee is mostly found at the higher altitudes. Many farmers from the lower regions have bean and coffee fields at medium and higher altitudes.
c) Livestock (and more specifically cattle) ownership shows the same tendency. Many farmers in the lower areas posses more than 10 heads, whereas in the medium altitude zones farmers have 5 animals or less. In the higher areas almost all farmers have no cattle at all. Other types of livestock, such as pigs and poultry, are found in all zones. In some higher situated villages considerable amounts of sheep and goats are found.

Current activities with participatory methods in the region. In the region many Research and Development organizations are active with farmer groups. With respect to the use of participatory methods CIAT and IPCA (Investigación Participativa en Centro America) should be mentioned. The latter organization works with groups of farmers that conduct research in their communities. SERTEDESO is another important organization that offers a wide range of technologies focused on product diversification and soil fertility and conservation. All organizations offer important entry points with regard to the research theme.

Local experiences with forage-based technologies. Most cattle owners have experiences with local forages and CIAT and SERTEDESO are carrying out research activities to introduce new species. However, up to present, the activities have been focused mainly on cattle owners who represent only a small part (15%) of all farmers.

Future research activities. The next steps in the research process will address the following topics:

- Identification of research priorities and definition of objectives of experiments with forage based-technologies and development of forage ideotypes for different uses within the system. Participatory methods on priority setting, formulation of objectives and development of ideotypes will be used and adapted

- Design of experiments and protocols to test with farmer participation forage ideotypes. Extensive use will be made of participatory methods on formulation and design of experiments.

- Execution of several types of experiments with forage-based technologies (i.e. testing of forage germplasm, experiments on management and utilization of forages and crop residues, use of manure, compost). During and after the experiments monitoring and technical (e.g. treatment effects), economical (e.g. assessments of profitability and risks) and social (e.g. taking into account gender aspects, age, consumption patterns) evaluations will take place. The application and testing of participatory monitoring and evaluation tools will be a key element in this work.

The objective of this research is to work not only with the “conventional” users of forage- based technologies, (i.e. cattle keepers). Given the diverse production systems in the region there would seem to be ample scope (enough entry points) for the development of participatory methodologies for the utilization of forage -based technologies for farmers with cropping systems on steep slopes (forage crops for soil conservation and fertility) or farmers keeping small animals (forages for poultry, pigs, sheep, goats).

4.2.2 Evaluation of forages for multipurpose use with farmer participation in Hillsides of Central America

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CIAT Projects: SN-3, PE-2, PE-3

Costa Rica: The project in collaboration with the Ministerio de Agricultura y Ganadería (MAG) works in two sites: Bajo de Jorco in Acosta and Bocana in Puriscal. Both sites are located in the Central/Southern Regions of the San Jose Province.

In the first site, we are evaluating pasture grasses and herbaceous and shrub legumes, as well as live barriers of *Cratylia argentea* in degraded hillside areas. In the second site the work so far has been restricted to the use of *C. argentea* as live barriers.

In Acosta, MAG is managing a project called 'Reconversión Productiva', in which about 30 livestock producers (all men between 16 and 60 years) participate. Though women occupy a very important space in the production system through their work, but up to now there is no direct participation of women.

Capitalizing on this interest and existing linkages with MAG the project identified initially 17 farmers for the Participatory Evaluation of Forages, which was later reduced to 10. To maintain group motivated, objectives were clarified and the importance of active participation of all involved for the project was stressed.

In Puriscal, the project via MAG is working with a producers association, some of which are involved in livestock production. Currently the group is composed of 25 farmers between 19 and 65 years, with both women and men involved.

All farmers concur that the scarcity of forage in the dry season is their main problem, followed by steep slopes and low soil fertility. These problems limit the intensification of production, which is one of their main goals. A glossary of terms utilized by farmers with technical translations was elaborated to integrate terminology used by farmers and technicians.

Honduras: Participatory diagnoses with 59 farmers of which 45% were women (age 18-75 years) was carried out in three hillside sites (Victoria, Sulaco, Yorito) of Honduras. Scarcity of feed for the dry season and lack of seed availability were identified as the major limitations to raise livestock in these sites.

Based on the participatory diagnoses carried out initially, forage nurseries were established with farmers participating in land preparation, planting and in selection of forage options. Each group is composed of 15 to 20 farmers, and participation in individual events is from 65 to 75%, which is an indication that farmers have maintained interest in the evaluations of new forage options. However, only 10-15% of farmers participating regularly are women, particularly in Jicaro. Age groups are much better represented, varying between 25 and 76 years.

Particular strengths of these groups are high interest, unconditional participation and high stability. Initial weaknesses include lack of knowledge on forage germplasm, fear to communicate their assessment on forage options, lack of knowledge of what constitutes participatory evaluations and low level of organization.

To maintain the groups interested, the project facilitates activities that will result in stronger organizations such as initiatives for artesanal seed production and technical information on dairy products such as cheese. As a result of this process farmers now have less fear in communication and have obtained a better understanding of the utility of different forage materials.

Nicaragua: The project is working in three sites in the municipality of San Dionisio: Wibuse, El Corozo y Piedras Largas.

In 2000, the institutions involved (PRODESSA, INTA and CIAT) in the Project identified farmer leaders, who then invited small to medium crop-livestock owners for a meeting to select interest groups, present the project and establish farmer committees. A total of 56 farmers (15, 18 and 23, in El Corozo, Piedras Largas and Wibuse, respectively) got involved (only 3% women).

During the same meeting information was obtained on feeding strategies employed by farmers throughout the year. Inmost cases, during the wet season cattle are maintained on native pastures, on Jaragua (*Hyparrhenia rufa*.) and Estrella (*Cynodon* spp.). In the dry season crop residues (maize, bean and sorghum stover) becomes an important feed alternative. However, most producers stress the problem of quantity and quality of available feed resources during the dry season and several indicated the need to buy supplements (i.e. rice bran) at very high prices. Poorer livestock owners that cannot purchase supplements in the dry season face a reduction in production, lower reproduction and even death of their animals.

During 2000 and 2001, a Rapid Participatory Diagnosis on livestock production was carried out in the El Corozo and Wibuse sites to further characterize farmer groups. About 90-95% of the farmers indicated the low productivity of jaragua, estrella and native pastures as the principal problem for raising livestock. Hence farmers suggested the introduction of a variety of forages to be compared to existing grasses. Of the 56 farmers initially participating in the 3 committees, 60% maintain active participation, while the participation of the other 40% is more irregular or have been replaced by new-interested farmers.

Farmers are now conscious about the need to look for new forage alternatives to improve production and conserve Natural Resources and as a result, there is an increasing demand for seeds of selected grasses and legumes. However, we should indicate that there is still a lack of understanding of the participatory process by some farmers and their role in it. Further progress has also been limited by conservative attitudes of some livestock owners and lack of trust in religious and political processes sometimes has limited participation in collective activities. Moreover some producers had high expectation to obtain benefits from the project without any participation.

To maintain the interest of the groups the projects continuously clarifies concepts and relies on farmers with leadership to motivate other farmers. Also there is an active process of feed- back to local organizations, with the aim that farmers and local organization obtain ownership of the project. The project also participates in local events showing results and facilitates an active interaction between the different sites of the project. Events are scheduled to correspond to times of lower activity of farmers.

Adaptation of Participatory Methods for forage evaluation

One outcome of working with farmers in CA has been the adaptation of participatory procedures for forage germplasm development and deployment. The procedure is based on open evaluations using preference-ranking techniques. The first product obtained through open evaluations has been a glossary of local terminology, which is developed with farmers in response to the technology farmers are exposed to, in this case forages. Based on this, local terminology has been developed to facilitate communication between farmers and technicians/researchers. At the same time an interactive process of communication and verification has been initiated. A second product has been the identification of criteria for selecting forage species from a farmers perspective. An example is shown in Table 106 for herbaceous legumes evaluated in Wibuse, Nicaragua.

The first column corresponds to technical criteria, which then are described according to farmers reasons in the second column. In this case, yield is related to the quantity and development of leaves, to drought tolerance and retention of leaves to green color, cover is important for soil conservation and adaptation is a positive response of the forage to biophysical conditions. Frequency indicates the number of responses for each criteria, indicating its relative importance. For better interpretation is important to record the number of farmers participating and their composition according to age and gender. The last column shows the qualitative scale used by farmers for each criteria. As for other technologies, farmers in Latin America seem to use expressions like good, regular and bad.

Table 106. Criteria and reasons for farmers selecting legumes in Wibuse, San Dioniosio Nicaragua.

Criteria	Reason given by farmers	Frequency of responses	Farmer's Qualitative Scoring
1. Yield	Quantity of leaves	10	Good
2. Drought tolerance/Leaf retention	Green Color in the dry season	5	Good
3. Soil conservation	Cover	4	Good
4. Adaptation	Adapted to climate and resistant to pest and disease	1	Regular

The third product is Preference Ranking of Forage Technologies, using regression procedures. In Figure 43 we show an example for cover legumes in one of the sites in Nicaragua. It is clear that Caballero (a local *Lablab purpureus*) has high acceptance while mungo (*Vigna mungo*) is the least accepted by the farmers.

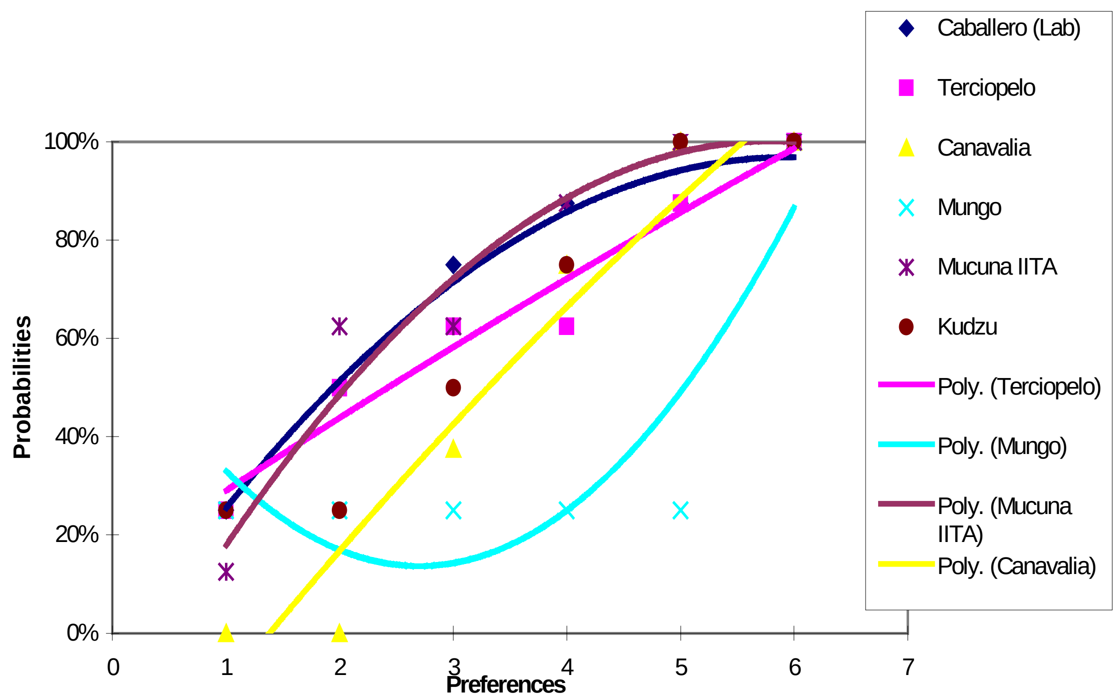

Figure 39. Preference ranking of six cover legumes, Piedras Largas, Nicaragua

These results then are related to the criteria obtained in the same evaluation, giving indication for potentially successful technologies. The participatory methods being developed are disseminated through training courses, workshops and field practices. At the end two main achievements are expected:

1. That people participating in the training become trainees themselves and
2. Development of a Training Module to guide technicians through the process.

Agronomic Evaluation of Forages in Hillsides of Central America

In the following section agronomic results from Honduras are shown as an example of the data being recorded in the three hillside sites of Central America.

Green manures: Soil cover 7 months after establishment was good with most species tested, the exception being Pueraria phaseoloides CIAT 7182 in Las Cañas (Table 107). Significant (P<0.05) differences among accessions were observed in yields in the two sites. However, in both sites Mucuna deerengianum and Lablab exhibited high yields.

Table 107. Soil cover and Dry Matter yield of herbaceous legumes in two sites of Yoro, Honduras.

Species	Sites			
	Las Cañas		Luquigue	
	Cover (%)	Yield (kg/ha)	Cover (%)	Yield (Kg/ha)
Mucuna pruriens Negra	95	8355	-	-
Mucuna pruriens IITA BENIN	95	8315	90	11193
Lablab purpureus DICTA	43	6980	93	12017
Mucuna deerengianum	95	6471	95	12321
Canavalia brasiliensis CIAT 17009	77	3859	80	8681
Pueraria phaseoloides CIAT 7182	3	450	52	2313
LSD (P<0.05)		3466		7236

Productivity of grasses in the dry season is shown in Table 108. Yields were slightly higher in Luquique than in Las Cañas. However, due to severe drought, yields were relatively low in both sites. However, it was interesting to observe that in spite the prolonged dry season the cut and carry grass 'Camerún' performed well in the two sites.

Table 108. Dry Matter yield (kg/ha) of 8-week regrowth of shrub legumes in the dry season, in two sites in Yoro, Honduras.

Species	Site			
	Las Cañas		Luquigue	
	Cover (%)	Yield kg/ha	Cover (%)	Yield kg/a
Pennisetum purpureum cv Camerun	37	1430	25	1022
Panicum maximum CIAT 16031	25	624	18	413
Brachiaria brizantha CIAT 26646	42	521	30	936
Andropogon gayanus CIAT 621	26	510	30	638
Brachiaria brizantha CIAT 26110	25	464	23	668
Brachiaria brizantha CIAT 16322	33	439	20	1088
Brachiaria hybrid CIAT 36061	25	385	17	640
Brachiaria humidicola CIAT 6133	60	133	28	137
LSD (P<0.05)		525		462

With shrub legumes we only found differences in DM yield among accession in Luquigue (Table 109). The highest yields were recorded for *L. leucocephala* CIAT 17263 in Las Cañas and for *C. calothyrsus* CIAT 22310 in Luquigue. *Cratylia argentea* had low yields in the two sites due to its slow establishment. The distribution of forage materials to farmers around the Yorito reference site are shown in (Table 111).

Table 109. Dry matter yield (g/plant) of 9-week regrowth of shrub legumes in the wet season, in two sites in Yoro, Honduras.

Treatment	Sites			
	Las Cañas		Luquigue	
	Leaf and fine stem	Total Dry Matter	Leaf and fine stem	Total Dry Matter
		(gDM/plant		
Leucaena leucocephala CIAT 17263	219	293	210	256
Calliandra calothyrsus CIAT 22316	183	230	230	312
Leucaena macrophylla 47/85	155	208	0	0
Calliandra calothyrsus CIAT 22310	135	154	437	607
Cratylia argentea CIAT 18668	48	50	95	107
Local control	0	0	0	0
LSD (P<0.05)	NS	NS	258	354

Table 110. Distribution of forage materials in the Yorito Reference Site, Honduras (2001).

Material	Area	Quantity			Farmers	Institution	CIAL/ Farmer Association
		Seed	Vegetative Material				
			Stacks	Bags (50 kg approx)			
	(m^2)	(g)	(No.)	(No.)	(No.)	(No.)	(No.)
A. gayanus 621	2400	2400			5	1	
B. dictyoneura 6133	1200	4800		4	8	4	
B. brizantha 26110	5600	4875			17	6	1
P. maximum 16031	6400	3400			11	4	2
P. purpureum cv. Camerún	6400		3200		16		
A.pintoi 22160	400			1	1		
C. argentea 18668	5000	5080			12	2	1
C. pubescens 15160	400	100			2		
L. leucocephala 17263	5500	495			9	2	
L. purpureus	1000	1000			1		
S. guianensis 184	1200	900			5	1	
M. pruriens IITA BENIN	1000	1000			5	1	
Total	36500	24050	3200	5	88	20	4

Most of the forage species that have been distributed in the Yorito area has been through sexual seed, the exception being *P. purpureum* that does not produce seed. In addition more area has been planted with grasses (60%) than with legumes and farmers have preferred to evaluate shrub legumes rather than herbaceous legumes. An interesting development is that farmers harvested 188 kg of pure seed of *Brachiaria brizantha* 26110 for further testing in 2002.

Small fund scheme

The project is carrying out a competitive funding scheme to facilitate the diffusion of results and methods being developed. The main problem for approving proposals has been lack of knowledge on participatory methods, which need to be part of the work. Most proposals therefore were assigned to partners already involved in the project.

The following projects were approved and will start in the 2nd half of 2001

- Asociación de Campos Verdes (a farmer grassroot organization), San Dionisio, Nicaragua: Improving our soils with green manures – a participative project of communities of San Dionisio
- Instituto de Tecnología Agropecuaria, INTA, Nicaragua: Participatory evaluation on the use of *Cratylia argentea* as feed supplement to milking animals in San Dionisio
- Ministerio de Agricultura y Ganadería de Costa Rica, MAG: Participatory evaluation of *Cratylia argentea* cv. Veraniega as live barrier and feed resource in degraded areas of Puriscal hillsides
- Fundación Ecotrópica, Puriscal, Costa Rica: Participatory evaluation of establishment methods for *Brachiaria brizantha* 26110 (Toledo) in association with *Desmodium ovalifolium* 33058 and *Arachis pintoi* 18744 in the Puriscal hillsides
- Servicios Técnicos para el Desarrollo Sostenible, SERTEDESO, Yorito, Honduras: Artesanal seed production of multipurpose forage grasses in Yorito, Sulaco and Victoria

4.2.3 On-farm evaluation of selected forages as feed resources in dual cattle systems of Central America through the Tropileche Consortium

4.2.3.1 Grazing of *Leucaena leucocephala* by lactating cows and young calves in a dual purpose cattle system located in a sub-humid area of Costa Rica

Contributors: Beatriz Sandoval, Marco Lobo, Carlos Hidalgo and Vidal Acuña (MAG), P. J. Argel (CIAT)

Rationale

The low animal production figures associated with cattle farms in the Latin American tropics are mainly related to poor quality and availability of the pastures used, which consist mainly of introduced African grasses. It is also well known that tropical legumes, particularly shrubs and trees, can improve the quality of the diet offered to the animals due to high levels of protein and mineral contents. This is particularly true during the dry period, when grasses become mature and loose quality. Tropileche is a project aimed at the improvement of animal feed supplies with emphasis on forage legumes with farmer participation, and one alternative promoted has been the use of the tree legume *L. leucocephala* to feed lactating cows and young calves in dual purpose cattle systems.

Materials and Methods

Two paddocks were planted with *L. leucocephala* subsp. *leucocephala* CIAT 17263 in one farm located in the district of Miramar (Costa Rica). The soils are moderately acid sandy loams (pH 4.8 to 5.2), with low aluminum and phosphorus content. A mean temperature of 27°C and an annual rainfall of 2040 mm, distributed from May to November, had been recorded. One paddock consisted of 4.0 ha of Leucaena planted on strips and associated with the grass *Brachiaria decumbens* cv. Basilisk to be grazed by lactating cows (see IP-5 Annual Report 2000). The other paddock consisted of a Leucaena protein bank of 0.8 ha planted by direct seeding at a distance of 1.0 m between rows and 0.75 m between plants (13,300 plants/ha), to be grazed by young (around three months old) female calves.

Forage availability in Leucaena was measured using the forage reference pattern method known as "Adelaida technique", while forage availability of the grass was measured by the well known rank dry weight method. Milk production was monitored in the associated Brachiaria – Leucaena pastures, and in a pure Brachiaria stand with dual purpose lactating cows using a simple cross over design. Twenty cows were assigned randomly to each treatment (paddock), and the cycles consisted of 10 days grazing (7 days adaptation and 3 days of measurements).

Animal liveweight of 3-4 months old female cebu x swiss brown calves was monitored in the protein bank of Leucaena. Following the milking of the cows, 20 female calves were allowed to graze Leucaena for 3 hours daily, and later moved to a *Brachiaria* spp. pasture, for a period of 31 days. A similar group of young female calves was maintained only in the Brachiara pastures, and the liveweight of both groups was measured at the end of the observation period. A t test was used to compare liveweight means of both groups.

Results and Discussion

Milk production of cows which had access to the Brachiaria – Leucaena pastures produced significantly ($p<0.05$) more milk (6.4 kg milk/cow/day) in contrast with cows grazing only Brachiaria (5.6 kg milk/cow/day), as a response to improvements of quality in associated pastures. In addition, DM availability was higher (1.6 t more DM) in the associated grass-legume pasture shown in Table 111. This is consistent with results observed elsewhere in pastures that have a legume component, which gives the opportunity to increase the stocking rate or to prolong the days of ocupation of the paddocks.

Table 111. Dry matter availability and protein content of *B. decumbens* cv. Basilisk in monoculture and associated with *L. leucocephala* CIAT 17263 after 45 days of rest in a farm located in Miramar, Costa Rica.

	Pastures		
	B. decumbens (Monoculture)	*B. decumbens* + *L. leucocephala*	
DM availability (t/ha)	2.5	3.4	0.7
Crude protein (%)	8.8	10.0	23.4

Liveweight gains of young female calves with access or not to the Leucaena protein bank is shown in Table 112. It is clear that the larger effect of the legume on weight gain was experienced during the dry period, that last for about five months in this site. During the wet period there was no effect of the legume or gain when the animals had access to grasses like *B. brizantha* cv. Marandú and La Libertad. These grasses maintain acceptable levels of crude protein and digestibility during the wet period and thus the effect of the legume is less noticeable.

Table 112. Liveweight gains of young female calves with or without access to a protein bank of *L. leucocephala* CIAT 17263 of 45 days of re-growth in a cattle dual purpose farm located in Miramar, Costa Rica.

	Liveweight gain (g/day)	
Calves group	Dry	Wet
With access to Leucaena	400 a*	525 a
Without access to Leucaena	240 b	520 a

* t test ($p<0.04$)

4.2.4 Alternative strategies for on-farm forage seed production

Contributors: M. Peters, A Schmidt, SERTEDESO, Guillermo Giraldo

CIAT projects: PE-2, PE-3

Rationale

Lack of seed often limits adoption of forage- based technologies as in most cases commercial seed production is not well developed, with notable exceptions of the seed sector for tropical grasses in LAC. Even where a commercial seed sector exists, it may be limited to a few forage options and quantities of seed demanded by small farmers may at least initially not be an attractive market for profit oriented private companies. Hence any forage germplasm development program directed towards farmers needs to address this problem. At the same time forage seed production may be an opportunity for farmers to increase income.

Key in the success of functional seed systems directed towards smallholders is the matching of demand and supply of seed and planting materials and cost. As smallholders are living often in marginal or remote areas, this is particular important as these groups often have limited access to information market, and cash to purchase seed.

Activities

Both in Honduras – through a small fund scheme – and in Nicaragua activities are underway to enhance forage seed production by smallholders. Approaches are different according to sites. In Honduras farmers have started seed production but need help in organization, while in Nicaragua there is a need to start from scratch. Beyond facilitating and learning from these seed production efforts in Central America, a strategy for forage seed production is being elaborated.

4.2.5 On-farm evaluation of green manures in hillsides of Nicaragua

Contributors: Campos Verdes (San Dionisio, Nicaragua), Axel Schmidt, Michael Peters, Edmundo Barrios, Luis Alfredo *Hernández*

CIAT projects: PE-2, PE-3, SN-3

Rationale

Farmers are increasingly concerned about the lower prices they ar getting for their harvest products and increasing input prices on the market. At the same time soil fertility on farmer fields is decreasing. Weeds become a larger problem over time. In order to overcome these limitations and backed up by CIAT, the local farmer organization “Campos Verdes” initiated a project to introduce, evaluate and promote the use of cover crops and green manures in the communities of San Dionisio.

Cover crop and green manure legumes may significantly contribute to enhanced soil fertility, water and soil conservation and weed suppression. Some of these green manure crops show high drought tolerance and can be used as forage or even for human consumption. It was also taken into account that growing green manures may result in a smaller amount of applied agrochemicals, which are already contaminating the scarce water resources of the people in San Dionisio.

While plant adaptation/management and technical feasibility are important factors, economic viability is considered decisive for adoption of cover crops and green manures. Therefore, cost-benefit analyses are one of the main objectives of the project in order to compare the current management including N-fertilizer and agrochemical application with the use of cover crops and green manures. Other objective are objectives are the demonstration are selection of legumes for green manure that have drought tolerance, management of cover crops and green manures with active participation of the local community and identification of key indicators of soil organic matter status.

Materials and Methods

A workshop was held in San Dionisio in April 2001 to which all members of Campos Verdes had been invited. A total of 27 farmers attended the event and the proposed project was presented and discussed.

Sites with different soil and climate conditions throughout San Dionisio were identified and legume cover and green manure options were discussed. Farmers chose *Mucuna pruriens*, *Canavalia ensiformis* and *Lablab purpureus* as legumes for the experiment. At the end of September 2001 the experiments were established on 8 farms in different communities of San Dioniso (Table 113).

The experiments consist of seven treatments, which were arranged in a randomized block design with 3 replicates at each site. The treatments are summarized in Table 114.

Table 113. Location and site description of on-farm cover crop/green manure experiments in San Dionisio, Nicaragua.

Farmer	Community	Latitude	Longitude	Altitude	Observations
D. Salgado	Piedra Colorada	12° 49’ 47.2 N	85° 51’ 51.1” W	504	River valley
A. Castro	Susuli central	12° 48’ 29.2” N	85° 50’ 24.5” W	564	Slope
J. Hernández	Susuli arriba	12° 47’ 48.0” N	85° 50’ 05.2” W	565	Steep slope
V. Cebilla	Corozo	12° 47’ 02.2” N	85° 52’ 17.6” W	484	Slope
J. Orozco	Carizal	12° 47’ 08.2” N	85° 54’ 15.0” W	715	Moderate slope
J. Jarquín	Piedras Largas	12° 43’ 32.6” N	85° 49’ 43.1” W	474	Slope
J. Hernández	Jícaro	12° 46’ 19.2” N	85° 50’ 15.6” W	530	Very steep slope
E. Ochoa	Ocote arriba	12° 45’ 23.2” N	85° 53’ 17.3” W	735	Slope

Table 114. Treatments included in on-farm cover crop/green manure experiments in San Dionisio, Nicaragua.

Treatment	Year 200*	Year 2002
1	Maize	Maize without N-fertilizer (Control)
2	Maize	Maize with low N-fertilizer level
3	Maize	Maize with high N-fertilizer level
4	Maize	Maize with very high N-fertilizer level
5	Maize with *Mucuna*	Maize without N-fertilizer
6	Maize with *Canavalia*	Maize without N-fertilizer
7	Maize with *Lablab*	Maize without N-fertilizer

*Cover crops/green manures were sown into existing maize plots in September when the maize was entering its mature stage.

Legumes were sown in maize plots (4 x 4 m) at the traditional bean sowing distance (0.4 x 0.4 m). Legume evaluation will be carried out on a monthly basis recording field emergence, plant height, ground cover, incidents of pests and diseases, weed presence, biomass production, drought tolerance, flowering patterns and seed production.

Soil samples will also be taken prior to the establishment of the experiments, prior to the maize planting and at the end of the experiments and analyzed. The cover crops and green manures will be kept in the maize plots throughout the dry season and maize will be planted in the wet season. Fertilizer treatments will be applied and maize yields recorded. Pest, disease and weed incidents will be evaluated throughout the project. Cost-benefit analyses will be conducted and presented in a final workshop in November 2002. Field days will be held at strategic points of the project (legume establishment, legume drought tolerance, mulching and maize planting, maize harvest) in order to demonstrate and discuss practical management issues with the communities. By discussing soil fertility issues key informants for local soil organic matter management techniques and indicators will be identified.

Expected outputs

Local on-farm evaluation data and economic analyses will be available for further promotion and dissemination of legumes species for use as cover crops and green manure. It is expected that a growing number of farmers in San Dionisio will adopt green manure technologies for growing maize in the future and will show further interest in other legume species. Local indicators for soil organic matter will be identified and the local knowledge on the management of soil organic matter documented.

Activity 4.3 Forage seeds: reproductive biology, quality, multiplication and delivery of experimental and basic seed

Highlights

- Continued to multiply and deliver to partners in the region, experimental and basic seed of a wide range of promising forage species.
- Found that main seed dormancy mechanism in *B. brizantha* cv. Toledo is related to physical factors in the seeds

Progress towards achieving milestones

- **Seed of selected forages delivered to partners and seed companies**
  Seed multiplication and delivery from our two seed units continue to be an important mechanism to promote adoption of new forages. This year we delivered basic seed of different forage species to Haiti for on-farm testing and of a new *Brachiaria* hybrid to a seed company for regional testing.

4.3.1 Multiplication and delivery of selected grasses and legumes in the Seed Units of Atenas and Palmira

4.3.1.1 Seed Unit of Atenas

Contributors: P. J. Argel and Guillermo Pérez (CIAT)

Seed multiplication activities continued in the Atenas Seed Unit (Costa Rica) in collaboration with the Escuela Centroamericana de Ganadería (ECAG). The seed produced is destined to support advanced evaluations of promising forage germplasm both by CIAT's projects and regional research/development institutions.

From August 2000 through August 2001 a total of 262.48 kg of experimental and basic seed was either produced at Atenas or procured from collaborator farmers. The bulk of the seed was formed by *Cratylia argentea* (125.04 kg), *Brachiaria* spp. (99.73 kg), *Arachis pintoi* (9.50 kg), *Leucaena* spp. (3.57 kg), *Centrosema* spp. (6.49 kg), *Desmodium heterocarpum* spp. *ovalifolium* (3.80 kg) and *Paspalum* spp.(4.92 kg). In addition, small quantities of experimental seed of *Panimum maximum, Desmodium velutinum, Chamaechrista rotundifolia* spp. *grandiflora, Clitoria ternatea, Calliandra* spp. and *Stylosanthes guianensis* was multiplied.

During the period August 2000-August 2001 a total of 614.01 kg of experimental and basic seed were delivered by the Seed Unit of Atenas (Costa Rica). Table 115 shows that eighty eight seed requests were received from 10 countries, where more than half of the requests came from Costa Rica, the host country of the forage project. However, a significant amount of seed was delivery to Haiti (282.59 kg), a country recently involved in forage projects with the assistance of CIAT. *C. argentea* has been the species with more demand regionally, which indicates the strong expectation that this shrub legume has generated both among researchers and cattle farmers.

Table 115. Countries, number of requests and amount of experimental/basic forage seed delivered by the Seed Unit of Atenas (Costa Rica) during the period August 2000-August 2001.

	No. of	Forage species (kg)			
Country	Requests	*Brachiaria* sp.	*A. pintoi*	*C. argentea*	Other species
Belize	1		25.0		29.0
Brazil	2		0.52		1.6
Colombia	6	6.47	0.5	22.0	2.0
Costa Rica	62	52.0	21.0	107.3	30.5
Philippines	1				0.3
Guatemala	1			2.0	
Haiti	3	61.22	1.9	1.7	217.77
Honduras	1			3.0	
Mexico	3	5.0	7.0		
Nicaragua	8	2.9	0.8	0.2	7.3
Total	88	127.57	63.72	136.2	286.52

4.3.1.2 Seed Unit of Palmira

Contributors: A. Ortega, A. Betancourt, B. Hincapie y J. W. Miles (CIAT)

The Project operates a small seed multiplication unit which is intended mainly to service the seed requirements of the Project. Where possible, seed produced in excess of Project needs is donated (small quantities) or sold (larger volumes) to bona fide researchers or private producers. In May 2001, this Unit suffered the irreplaceable loss of the technician who handled with exceptional competence all field and laboratory operations -- Mr. Alcibiades Ortega -- who was seriously injured in a highway accident returning from the CIAT-Popayán multiplication site. We are still adjusting to this terrible tragedy.

A total of nearly 2 t of seed was harvested during the previous 12 mo (July 2000 to June 2001). Half of this total is represented by seed of three accessions of *A. pintoi*. Twenty-one *Brachiaria* accessions were multiplied, mostly for on-farm evaluation under grazing, including promising new hybrid selections. Thirty-four accessions of *Cratylia caliandra* were multiplied. Several additional legume genera [*Calliandra* (4 accessions), *Centrosema* (3 accessions), *Clitoria* (1 accession), *Desmodium* (5 accessions), *Leucaena* (4 accessions), *Mucuna* (5 accessions), *Rhynchosia* (1 accession), *Stylosanthes* (7 accessions), and *Vigna* (16 accessions)] complete the list.

During the first 6 mo of 2001, 134 individual samples of seed of 16 forage genera were dispatched from the Seed Multiplication Unit, accounting for a total of nearly 400 kg of seed (Table 117). This seed was distributed to recipients in 14 different countries, as detailed in Table 116.

Table 116. Genus distributed, weight (kg) and number of sample send during the first semester of 2001.

Genus	Kilograms	Number of Sample
Aeschynomene	0.010	1
Andropogon	10.000	1
Arachis	308.45	20
Brachiaria	6.426	20
Calopogonium	0.070	2
Canavalia	0.150	1
Centrosema	8.260	7
Cratylia	18.155	15
Desmodium	28.403	30
Flemingia	0.040	1
Leucaena	2.250	4
Mucuna	1.000	1
Panicum	0.120	1
Pueraria	3.105	24
Stylosanthes	0.195	5
Zornia	0.010	1

This sample were send to 14 countries: Germany (15); Brazil (2); Costa Rica (11); Haiti (13); Honduras (37); Japan (1); Mexico (1); Nicaragua (52); Senegal (2); Tanzania (4); Uganda (1); Uruguay (6); USA (2), and Colombia (320) distributed: CIAT (190), CORPOICA (18), Particular (36), Universities (11), Others-GNO (65).

4.3.1.3 The effect of storage conditions on viability and germination of acid-scarified and non-scarified seeds of *Brachiaria brizantha* cv. Toledo (CIAT 26110)

Contributors: P. J. Argel and Guillermo Pérez (CIAT)

Rationale

Commercial cultivars of several species of the genus *Bachiaria* grass are widely used in the Latin American tropics. However, given the variability of the livestock ecosystems in terms of soils and climate, as well as management, new Brachiaria cultivars are developed by research institutions aiming at more productive plants with good agronomic attributes and of high forage quality. Planting by seed is the common practice to establish Brachiaria fields, and the seed industry has grown considerable during the last 20 years to cope with an increasing demand for Brachiaria cultivars. Seed yield and quality are variable among the Brachiaria species, and one of the key components in the development of new cultivars deals with seed yield, viability and dormancy. Highly dormant seeds require seed storage and treatment to breakdown this conditions and that may limit a wide and opportune use of the cultivar. Thus the studies carried out to understand the degree of dormancy and methods to break it down are justified, particularly with new cultivars such as *B. brizantha* cv. Toledo (CIAT 26110).

Materials and Methods

Seeds of cv. Toledo were hand-harvested in November 1999 in Atenas. The seed was cleaned, processed and stored at ordinary ambient conditions, namely mean temperature of 24°C and Relative Humidity (RH) of 60-80%. Three months after harvesting (15 February 2000) half of the seed was scarified with concentrated sulfuric acid for 12 minutes and washed with abundant water. Then two lots of scarified and non-scarified seed were formed; half of the seed was stored at the ambient conditions described, and the other part was stored in a cool room kept a constant 20° C of temperature and 50% RH. Thus 4 different lots of seeds (treatments) were formed: 1) Cool room non-scarified seeds (CNS); 2) Cool room scarified seeds (CS); 3) Ambient non-scarified seeds (ANS), and ambient scarified seeds (AS).

One month latter (namely 4 months after harvest) a germination test was carried out on plastic trays filled with a mixture of 60% sand and 40% soil. Four replicates each of 100 seeds per tray were evaluated. Watering of the trays was done daily with sterile water and count on germinated seeds was recorded 3, 7, 10, 14 and 21 days after planting. These tests were repeated every two months for a total of 8 tests during approximately two years. Germination percentages were determined and statistically compared as well as the Rates of Speed Germination (RSG). The latter measures how quick the seeds germinate once they are put in adequate germination conditions; a higher value of RSG indicates that a high proportion of the seed germinated during the first days of the test. This has practical implications since a rapid germination may conduce to quicker pasture establishment and better competence with weeds.

Results and Discussion

It is very common to find high levels of seed dormancy in forage grass in process of domestication; the nature of the dormancy can be physical (e.g., glume and lemma tightly closed) or physiological (e.g., immature embryo), or the combination of both. This is a natural event of ecological importance that secures the survival of the species, but may have negative practical implications in commercial plantings, and on the reliability of germination tests. Figure 40 shows that four months after harvest scarified seed of *B. brizantha* cv. Toledo had high levels of germination independent of seed storage (85.5% and 78.0% germination respectively for scarified seed stored at ambient conditions and in the cool room).

Non-scarified seed germinated less indicating that the dominant dormancy factor present in Toledo seed is caused by physical factors. The controlled cool environment seems to increase the expression of this type of dormancy since germination was only 28.2% for the CNS treatment in contrast with 69.0% for the ANS. This could be associated with less seed moisture content that the seed may have reached in the cool room (50% RH), non-measured in this experiment, compared to the seed moisture content reached at ambient humidity (60-80% RH), since it is well known that as seed loses moisture, the physical dormancy increases.

Six months after harvest all the seed lots had high levels of germination, although again the sulfuric acid scarification improved the germination of the seeds. Germination tests carried out afterwards and for the following 18 months, have shown high levels of seed germination (close to 90%) independent of seed treatment, which indicates the high viability that the cv. Toledo seed has. The data also indicates that 6 months after harvest no scarification of the seed is needed to obtain high germination percentages, independent of seed storage conditions.

Under appropriated temperature and humidity conditions, the speed of seed germination varies according to the level of dormancy. Hard seeds for instance may take longer to become imbibed with water, thus delaying the initiation of the germination process. In this particular experiment, seed germination was monitored for 21 days and the rates of speed germination (RSG), a measure that indicates how fast the seeds germinate, varied among treatments as illustrated in Figure 41.

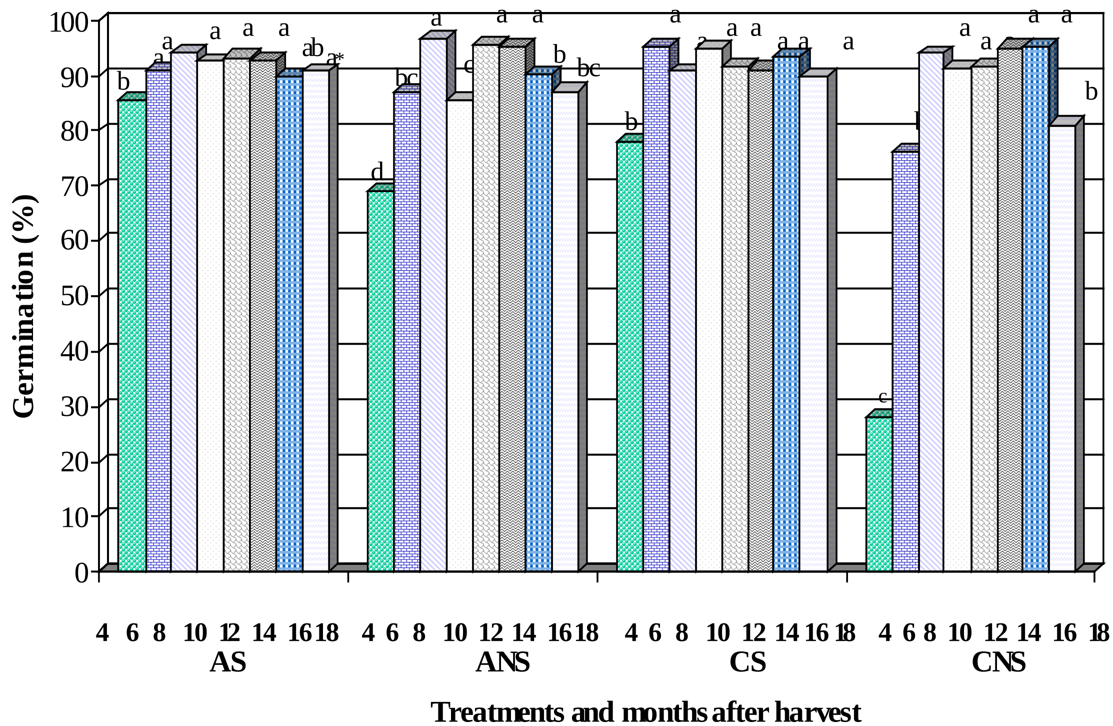

Figure 40. Germination percentages of *B. brizantha* cv. Toledo (CIAT 26110) seeds scarified and non-scarified with sulfuric acid and stored in ambient and controlled conditions (AS, ambient scarified seeds; ANS, ambien non-scarified; CS, controlled scarified and CNS, controlled non-scarified) (P<0.05).

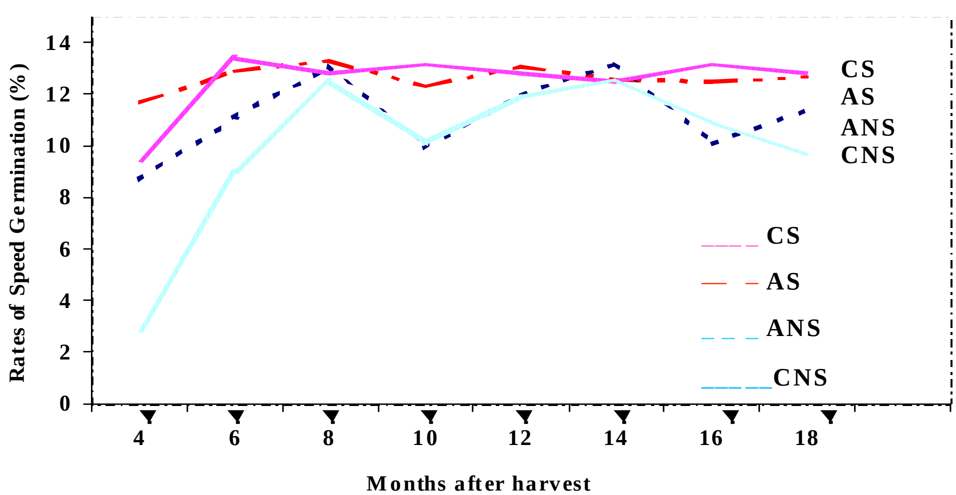

Figure 41. Rates of speed germination (RSG) of sulfuric scarified and non-scarified *B. brizantha* cv. Toledo (CIAT 26110) seeds stored at ambient and in controlled conditions for 18 months (CS=controlled scarified seeds; CNS=controlled non-scarified; AS=ambient scarified; ANS=ambient non-scarified).

For the first 8 months after harvest, the non-scarified seeds had lower RSG, particularly the seeds stored in controlled conditions, in contrast with the acid scarified seeds. This again indicates that dormancy was mainly imposed by physical factors, which in turn had larger expression in cool storage conditions. Also, 4 months after harvest AS and ANS seeds had higher RSG in contrast with CS and CNS seeds. This may suggest a certain degree of physiological dormancy, which was short lived since the differences in RSG had practically disappeared 6 to 8 months after harvest for all the storage conditions. It is also clear that RSG are higher and more reliable for acid scarified seeds than for non-scarified seeds independent of the storage conditions.

Activity 4.4 Expert systems for forage biodiversity linking geographical information with biological data

Highlights

- CIAT's forage database, with a graphical interphase is now ready and will soon be able for distribution in a CD-ROM and in the Internet.
- Developed a conceptual model to target forages to different biophysical and socio-economic conditions.

Progress towards achieving milestones

- **Forage database published in a CD-ROM and distributed**
  The development of CIAT's forage database with a graphical interphase was completed and can now be accessed in Intranet. By the end of the year we expect to have the database in a CD-ROM and in CIAT's new Web page.

- **Developed a conceptual framework for a Decision Support System (DSS)**
  Progress was made in developing a conceptual model to target forages to differente environments and socio-economic niches. In addition, potential users and stakeholders of the DS Tool were identified, and an inventory of data, models and algorithms available was completed.

4.4.1 Development of a forage database with graphical interface

Contributors: A. Franco, F. Barco, B. Hincapié, L.H. Franco, G. Ramírez, C. Lascano and M. Peters (CIAT)

Rationale

The Tropical Forage Program in CIAT has generated a great deal of information on the evaluation of germplasm, right from collection or exchange to the release of cultivars by national institutions. A great part of this information had been entered into an ORACLE database, which at present is available for CIAT scientists.

To access the forage data base an information system based on the fourth generation language ORACLE FORMS 3 was developed; this system is available via a CIAT's Server. However, in view of the technological advances, the requirements of users in CIAT and the importance of sharing research results with partners through the Internet or via magnetic means, it is important to convert this information system to a graphical, user-friendly and attractive platform.

Materials and Methods

The programs in ORACLE FORMS 3 were converted to a tool based on Microsoft Access for utilization via CD-ROM and based on Microsoft Visual InterDev for the Internet Version, to ensure wide access of information. Target groups for the database are mainly NARS and NGO's, with initial emphasis on Latin America. In the future an English version of the database is planned.

Results and Discussion

The information incorporated into the database includes information on characterization and adaptation of different forage accessions collected over the past 20 years in CIAT's main research reference sites and through networks (RIEPT). The database contains information on agronomic characterization of 5374 accessions carried in Santander de Quilichao and Carimagua, Colombia and 2209 accession evaluated in 8 evaluation sites in the savannas, forest margins and hillsides. In addition the database includes data from over 230 sites from the RIEPT, RABAOC and *Centrosema* networks as well as data from Genotype x Environment trials of *Arachis pintoi* and *Desmodium ovalifolium.*

In 2001 new data was added, the layout improved and a help manual elaborated. Once the help manual is edited, the database will launch and CD-ROM version will be available to collaborators. Currently the database is available on the CIAT Intranet, and will be available on the Internet when the new CIAT web site is launched (Photo 19)

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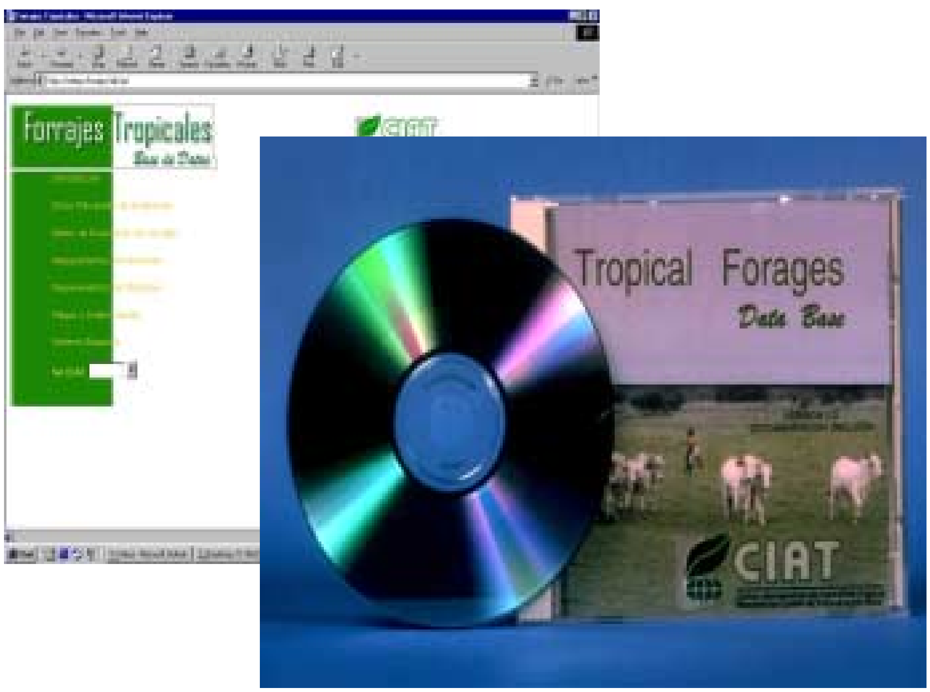

Photo 19. Tropical forages database-Internet and CD-ROM

4.4.2 Incorporating Socio-Economic Data and Expert Knowledge in representations of Complex Spatial Decision-Making

Contributors: R. O'Brien, R. Corner (both Curtin University), S. Cook, M. Peters, Th. Oberthür, G.G Hyman, L.H. Franco, A. Franco, B. Hincapie

CIAT projects: PE-4, SN-3

Rationale

The overall approach which intends to integrate agro-ecological, economic and social information, is based on the following two main assumptions:

1. A wealth of information on the agro-ecological adaptation of forage germplasm is available in CIAT's-held forage databases. However, the access and hence utilization of this information needs to be improved.

2. In previous evaluations of forage germplasm adaptation, to environmental conditions, the agro-ecological information is separated from socio-economic factors influencing forage germplasm adoption.

Based on these assumptions, the targeting of forage germplasm intends to enhance the utility of existing information and, in future, to integrate environmental and socio-economic adaptation of forage germplasm for multiple uses. It is anticipated, that this approach will allow a more accurate and client-oriented prediction of possible entry points for forage germplasm.

One product of this research will be a fully functional web-based or CD-ROM tool, primarily designed for targeting forage germplasm in Central America. The primary target users are, NGO's, development agencies, national research institutes and decision makers in government. In conjunction with farmers, these users will be able to more effectively target suitable locations for new forages, with the aid of the tool. This will result in more informed choices being made, thus allowing more effective use of public funds dedicated to agricultural development and natural resources conservation.

Tools to better target forages will also help improve the wellbeing of smallholders by assisting them to more effectively utilize their resources in sustainable ways. The addition of carefully selected forages to a farming system has a plethora of benefits both for the farmers and for the environment as well as the wider community. These benefits derive both from the direct influence of forage planting, and the indirect increase in cattle production and cropping system improvements, and include for example improved sustainable intensification, reduced erosion and alleviation of protein and micronutrient deficiencies in the community.

Materials and Methods

Literature and model review: Review of literature and of existing similar models and software will be ongoing. An effort will be made to identify current and as yet unpublished work on the topic, by contacting relevant university departments and research organizations, and by attending and presenting at conferences where possible. This will help identify possible approaches to representing spatial decision-making with particular emphasis on incorporating socio-economic data and expert knowledge. Existing tools will be evaluated to determine their effectiveness in representing expert spatial decision-making processes and in particular in targeting forage germplasm. Initial research suggests that that regression tree and Bayesian techniques will likely prove the most useful methods, as these techniques could cope with data uncertainties like gaps and errors in the data. A possible approach will be to use regression trees to determine rough climatic envelopes, followed by Bayesian modeling to estimate likelihood of adoption success within these envelopes.

Case study – design and develop a tool: As a case study, a decision support tool to target forage germplasm will be designed and developed, using geographical information system (GIS) technology.

This targeting consists of identifying which forages would be suitable or successful in a particular location, given data and/or knowledge about the forages and about the location in question.

The forages data will be in the form of spatial coordinates for a number of locations at which accessions have performed successfully. Success will be defined from data available in the CIAT forages database, other data sources and input from experts. It is recognized that definition of success may vary from species to species, and may also depend on the unique characteristics of the farmer. In particular, a risk-averse farmer may require a high level of certainty that the selected forage will be successful according to his or her criteria, whereas in other situations a lower level of certainty but a higher rating of success may be desirable.

The scope of the final tool will be decided in conjunction with end users. The majority of the research will be carried out at CIAT in Cali, Colombia. CIAT holds an extensive forage germplasm database, as well as various climate and other biophysical GIS databases. CIAT also will provide expertise on forage adoption and GIS technology. Data will be collected for one or more study areas in Central America, and the model will be developed to reflect the needs of the users in this area. The tool will then be provided to users in other areas for further testing and verification.

The aim is to produce a tool that can be adapted by the user to fit a particular purpose, using available data in their location, so portability is an important test. Some basic data may be built in to the tool, such as climate data, soil data and population density. Other data will be specifically collected to test the tool for targeting forage germplasm.

Consultation: Prior to and during the development of the tool, there will be consultation with potential users. These potential users will be representatives from CIAT, and development agencies, NGOs, national research institutions and ministries of agriculture and natural resources in Central America, with focus on Honduras, Nicaragua and Costa Rica.

Testing and validation: Once case study data has been collected, these will be applied to a number of algorithms including existing software packages. The appropriateness and accuracy of these methods will be evaluated using standard validation procedures, such as bootstrapping and jack-knifing, as well as expert opinion. From these trials, methods will be selected for development into a software tool for the case study. These methods will be verified and validated throughout the development period in collaboration with potential users.

The cooperation of targeted end users may be problematic, and this will be addressed by closely collaborating with selected users in the initial stages of the project, and by asking them to contribute to the testing and validation of the model.

Implementation: The tool will be implemented using existing GIS software and programming software, such as MapObjects with Delphi, or ArcView and Avenue. Ideally the final product will require no special GIS licenses and will run completely stand-alone to promote accessibility for poorer users in tropical developing countries.

Results and Discussion

Potential users and stakeholders: A large number of potential users and stakeholders in development agencies, NGOs, national research institutes and ministries of agriculture and natural resources, mainly in Central America, have been contacted via email with brief details on the project and a request for feedback. In addition a presentation on the project was given to Central American ministry of agriculture representatives during the 5th Global Spatial Data Infrastructure conference in Cartagena, Colombia, in

May 2001. Feedback so far has been limited, but positive. Next steps are to strengthen these linkages and ideally work alongside a potential user during the development of the model. Potential users will also be involved in the testing of early versions of the model.

Data: A review has been conducted of data available through CIAT as well as other readily available data for Central America (eg. FAO, USGS). Also data has been identified which has been used in similar projects, but may not currently be available for the region, as well as data which would be desirable in the model, according to forage and agriculture experts at CIAT. Next steps are to access available data in useful formats, and to identify methods for obtaining other data identified.

Models and algorithms: Literature on similar models and algorithms has been reviewed, as well as existing software packages. A number of these have been identified as potentially relevant and useful. In particular the Bayesian methods used in the Expector software have been applied to limited forages data, as a proof of concept. Next steps are to test this and other algorithms on a wider dataset, and start developing the actual tool.

Conceptual model: A conceptual model has been developed, taking into account the research into algorithms and data, and discussions with supervisors at CIAT. Several key concepts have been identified which will be addressed in the model. Next steps are to disseminate this research further for more input and feedback, and refine the conceptual model as research on data and algorithms continues.

Activity 4.5 Facilitate communication through Newsletters, Journals, Workshops and Internet

Highlights

- New information on the bioecology and management of spittlebugs shared in a 5-day workshop for sugar cane entomologists in Guatemala.
- Reference collection of 675 papers on the spittlebugs and the superfamily Cercopoidea strenghtened for conversion to an on-line bibliographic database.
- Advanced in the development of a Forage Page that is compatible with CIAT's format.

Progress towards achieving milestones

- Research information produced by CIAT's Forage team made available to partners.
- During 2001 we carried out workshops and training courses in Guatemala, Haiti and Colombia on bioecology of spittlebug, principles of forage evaluation and progress made in forage development in the Llanos, respectively.

4.5.1 Development of a Forage Web Page

Contributors: B. Hincapie, S. Staiger, and IP-5 staff

CIAT projects: Communication Unit

Rationale

It is becoming more and more important to quickly exchange information with partners and the community interested in research. CIAT is in the process of updating its Web Page and a as a result we initiated the development of a web page for the Tropical Grasses and Legumes Project in collaboration with CIAT’s Communication Unit (Photo 20).

Progress

During 2001 a graphic platform was developed. We are now in the process to compile information which should allow the user to obtain information on the 'What, How, and Who' of Project IP5. The layout is using the accepted CIAT format and templates.

Currently the following processes are underway

1) Development of a general framework established containing History, Personnel, Highlights and Products of the project. This part is near completion

2) Definition and discussion with all members of the project on the content and design of the page. Each member is than expected to provide the scientific and organizational input of the respective research area. Other areas for the web page include Annual reports, newsletters and publications in PDF format, a list of publications, indication of donors and collaborators and a list of released cultivars. This process is initiated and should be completed during 2001.

3) Establishing links to the newly developed Forage Database and linkages to sites of collaborators. Also to establish links to published information respective to the outputs of the project. This process is well advanced and contribution of all staff will amplify the number of linkages.

Completing these 3 steps is anticipated to yield a comprehensive web page which the will need to be regularly updated.

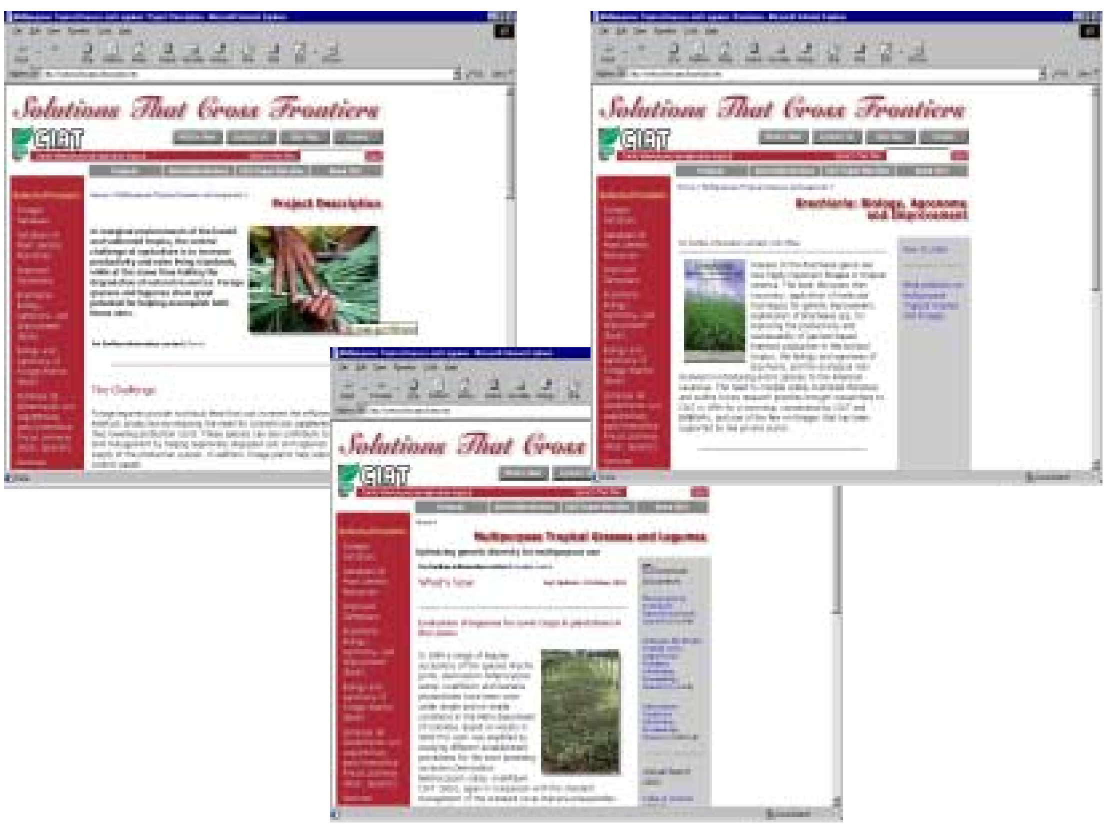

Photo 20. Screens showing of the Web Page of Forages

4.5.2 Information and technology transfer for spittlebug management in graminoids

4.5.2.1 Workshop in Guatemala on the Bioecology and Management of Spittlebugs in Graminoid Crops

Contributors: Daniel Peck

Despite the impact of spittlebugs in forage grasses, sugar cane and other graminoid crops in the New World, there is little expertise on their biology and management outside of CIAT and EMBRAPA. Access to information is also extremely limited because there is no text that summarizes our knowledge of the family Cercopidae and existing guides to grassland spittlebugs are outdated, imprecise and ignore family level bioecology (see section 4.6.2). To partially fill this gap, five workshops on the Bioecology and Management of Grassland Spittlebugs have been carried out from 1997 to 2001, three in CIAT, one in Ecuador and one in Guatemala.

The fifth workshop took place 13-17 August, 2001 at CENGICAÑA (Centro Guatemalteco de Investigación y Capacitación de la Caña de Azúcar), Santa Lucía Cotzumalguapa, Guatemala, sponsored by ATAGUA (Asociación de Técnicos Azucareros de Guatemala) and CAÑAMIP (Comité de Manejo Integrado de Plagas de la Caña de Azúcar). Unlike past events, the main interest of this group was information regarding spittlebugs pests in sugar cane. In Guatemala, spittlebugs are considered the most damaging pest in this crop. There are proposed IPM programs that achieve relatively good control largely through cultural techniques and biological control based in fungal entomopathogens.

The event was attended by 20 agronomists and entomologists representing the major sugar cane farms in southern Guatemala, the Ministry of Agriculture and Ranching, and CENICAÑA. The workshop was five days of intensive lectures, labs and discussions to provide a theoretical and practical foundation on spittlebugs as insects so that they can be better interpreted as pests. A 150-page manual with supporting information and notes was prepared for each participant as well as a compilation of 34 relevant articles.

4.5.2.2 Reference collection and on-line bibliography of the Cercopoidea

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Rationale

A major limitation to advances in the management of spittlebugs in forage grasses and sugar cane is difficult access to information. First, there are no published reviews of the insect family Cercopidae or the superfamily Cercopoidea despite their economic significance in cultivated graminoids such as forage grasses and sugar cane. Such material exists for other groups of economically important Homoptera such as the leafhoppers, planthoppers, aphids, scales and whiteflies, but students of the spittlebugs and froghoppers must turn to articles and gray literature to acquire an understanding of this group of insects.

Second, reviews of the biology and management of spittlebugs are inadequate. The few that exist are not widely disseminated, are outdated, and contain overgeneralizations and erroneous information, particularly regarding taxonomy. Third, much of the available information is in gray literature sources that are difficult to access. The quality of research from small and isolated universities or research teams is challenged by not being able to acquire the information necessary to support studies on this pest group.

Materials and Methods

To start to overcome some of the limitations in information dissemination, we are strengthening our reference collection on the Cercopoidea. References have been gathered over the last 10 years. In 2001 we began working with CIAT Information Services to make this information source available on-line.

Results

At present, we have physical copies of 675 references related to the superfamily Cercopoidea. Of these, 468 are directly related to spittlebugs in graminoids, 320 related to forage grasses, 145 related to sugar cane and 23 related to other graminoids such as rice and turfgrass. At present, all references are housed alphabetically in filing cabinets of the Spittlebug Bioecology and IPM Research Group. All citations are entered into an electronic database (EndNote). This bibliography has been printed and deposited in the CIAT library. Key words were assigned to each citation to facilitate searching from within the program software (Table 117).

Table 117. Key words assigned to references in the Cercopoidea bibliography for key-word search in EndNote.

Region	Crop	Management	Habitat	Biology	Classification
Africa	Alfalfa	Ants	Biogeography	Aggregations	Aphrophoridae
Asia	Arachis	Biocontrol	Cover crops	Aposematism	Cercopidae
Australia	Beans	Burning	Dispersion	Bioacoustic behavior	Cercopoidea
India	Cacao	Cultural control	Distribution	Color polymorphism	Clastopteridae
Indonesia	Cassava	Cutting	Endophytes	Comparative phenology	Machaerotidae
New Zealand	Centrosema	Disease transmission	Habitat selection	Copulation	Pipunculidae
Canada	Citrus	Disturbance	Host plant selection	Defense	Procercopidae
Caribbean	Coffee	Economic impact	Host plants	Diapause	Taxonomy
Central America	Conifers	Economic threshold	Litter arthropods	Egg development	
Costa Rica	Cowpea	Entomopathogens	Original habitat	Fecundity	
Panama	Fruit trees	Fertilization	Pasture management	Feeding strategies	
Europe	Grasslands	Grazing	Plant architecture	Life table	
Mexico	Maize	Herbivore competition	Plant quality	Lights	
South America	Marijuana	IPM	Rainfall	Longevity	
Brazil	Millet	Marking	Vegetational diversity	Morphology	
Colombia	Oil palm	Mites		Movement	
Ecuador	Pecans	Natural enemies		Nymph development	
Peru	Rice	Nematodes		Oogenesis-flight syndrome	
Venezuela	Sorghum	Pasture assessment		Oviposition	
U.K.	Strawberry	Pasture pests		Preference-performance	
U.S.	Stylosanthes	Pesticides		Pheromones	
	Sugar cane	Phytotoxemia		Population dynamics	
	Turfgrass	Plant impact		Protandry	
		Plant resistance		Reflex bleeding	
		Rearing		Reproduction	
		Salpingogaster		Spittle mass	
		Sampling		Stadia	
		Spiders		Tenerals	
		Trampling			

Categorical labels were also assigned to facilitate subgrouping of references in the initial on-line database (Table 118).

For the on-line interface, references were converted from EndNote to ProCite. The initial version is a rigid (non-searchable) database divisible into categories with relevant references listed alphabetically. This version will probably be available on the CIAT web page by the end of the year.

Discussion: The reference collection and on-line bibliography will be further improved in the following steps: (1) continual acquisition of new references with a focus on neotropical spittlebugs in graminoids, (2) continual updating of the electronic database, (3) housing physical references in the CIAT library, (4) adding information to the on-line site on how to order copies of references from the CIAT library, and (5) making the on-line database completely searchable by author, category and key words.

Table 118. Codes assigned to references in the Cercopoidea bibliography for subdivision of references in rigid (non-searchable) on-line database.
A01 - Cercopids in graminoids
A02 - Other Cercopoidea
B00 - Bioecology
B01 - Behavior
B02 - Biology
B03 - Diapause
B04 - Ecology
B05 - Population dynamics
B06 - Taxonomy & Systematics
C00 - Management
C01 - Biological control & Natural enemies
C02 - Chemical control
C03 - Cultural control
C04 - Host plant resistance
C05 - Impact
C06 - Integrated pest management
C07 - Rearing
C08 - Sampling & Monitoring
C08 - Sampling & Monitoring
D00 - Host plants
D01 - Forage grasses
D02 - Other grasses
D03 - Sugar cane
D04 - Non-graminoid host

4.5.3 Training course activities

This year a training course on forages was organized as part of the activities of HGRP in Haiti. Technicians (30) from ORE, PADF, the Ministry of Agriculture and NGO's attended the training course. CIAT staff (Luis Horacio Franco, Luis Alfredo Hernández and P. Argel) presented topics related to the utility of tropical forages in mix-cropping systems, forage seed multiplication, methodologies for the evaluation of tropical forages, alternatives of grasses and legumes for Haiti and the use of participant methods for the evaluation of forages. A field visit was also organized to see the status of the forage plots established in Camp Perrin.

The topics presented were well received and generated a good deal of questions among the participants. It is obvious that the theme of tropical forages has not been a priority in Haiti, perhaps because the predominant production systems emphasize on grains and cash crops given the high population pressure on the land and the need to produce staple foods.

At the end of the presentations the participants group was divided in three sub-groups to discuss future needs and ways to promote the use of tropical forges in Haiti. The group also outlined the potential uses in agricultural systems of different forages species (Table 119).

Statements were also made of the possibility of using *B. brizantha* for direct grazing and of *Leucaena leucocephala* and *L. diversifolia* as firewood. But it is interesting to note that pastures for direct grazing are not considered a priority in Haiti and this is something to take into account when planning future pasture evaluation activities in the country.

Table 119. Potential uses of tropical forages in Haiti.

Species	Living fences	Cut and carry	Erosion control	Green manure	Contours
B. brizantha		XX*			X
P. maximum	X*	XX	X		X
P. purpureum	XX	XX	XX		X
T. laxum	X	XX	X		X
Mucuna			XX	XX	
L. diversifolia	X	XX			
G. sepium	X	XX			
Canavalia sp.			X	XX	

*Appropriate
**Highly appropriate

In general, there is consensus among technicians in Haiti that improved forages can have multiple uses in current agriculture systems such as:

- Barriers to reduce and control erosion
- Living fences with the option to cut and carry
- Green manure to recover or improve soil fertility
- Protein/energy banks established along fences or between crop borders
- Improve feeding quality of crop residues such as maize and sorghum

Therefore, in the selection of forage options for Haiti we need to keep in mind this possible utilization practices. We have already selected forage species for Camp Perrin and Deron, but more options need to be tested in other parts of the country. It is also important to initiate on-farm evaluation of the best choices and to advance on seed multiplication of the promising germplasm.