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

4.1 Partnerships in LAC to undertake evaluation and diffusion of new forage alternatives

Highlights

- High carrying capacity of Mulato pastures is a positive benefit to farmers since it results in greater animal production per unit area as compared to other grasses. However, the high biomass production potential of Mulato is associated with a high demand for N particularly in acid soils of low fertility.

- The *Brachiaria* hybrid (CIAT 36087 (Mulato II) showed good adaptation to both acid-low fertility soils and well drained fertile soil.

- Adoption of *Arachis pintoi* in the llanos piedmont is affected by (a) lack of commercial seed, (b) high cost of establishment with vegetative material and (c) limited information on management of legume-based pastures.

- *Brachiaria* cultivars (Toledo and Mulato) and *Paspalum atratum* were selected on the basis of adaptation in sites in Nicaragua with soils of low fertility, whereas *Paspalum atratum* and *Panicum maximum* cv. Tanzania were selected for sites with more fertile soils.

- The drought tolerant *Canavalia brasiliensis* when used as green manure resulted in higher yield of maize as compared to the traditional maize/bean system and maize-natural fallow system in dry hillsides of Nicaragua.

- The IITA accession IT90K-284/2 was selected for seed multiplication due to superior forage and grain yields across environments and acceptance by farmers.

- Participatory evaluation of forages in Central America revealed that farmers first selected grasses followed by shrub legumes and legumes for green manure and covers. Grass-legume pastures were viewed as a complex technology, which requires a great deal of demonstration and information before adoption is to take place.

- In hillsides of Central America efforts to link farmers to markets through added value forage technologies should be mainly addressed to small farmers without full land ownership and to those who depend on outside jobs to meet foods security.

- The farmer-led seed production enterprise (PRASEFOR) in Honduras continued to make progress. In two year PRASEFOR has produced over 2 tons of grass seed with a market value of over US$15,000.

4.1.1 On-farm evaluation of new *Brachiaria* hybrids in LAC

Contributors: Marisabel Caballero and Conrado Burgos from DICTA (Honduras), Heraldo Cruz (DICTA/CIAT, Honduras), Moisés Hernández and Marco Lobo from INTA (Costa Rica), Bolívar Pinzón from IDIAP (Panamá), and Hugo Cuadrado from CORPOICA (Colombia)

Rationale

On-farm evaluation of new promising forage species complements the results reported from on-station research sites. Usually new forage options, particularly grasses, have a wide range of adaptation and may be used successfully in different production systems, but this characterization needs to be quantified with farmers under their particular circumstances of climate, soil and individual management. Under this consideration the *Brachiaria* hybrid cv. Mulato has been monitored during the last two years in cattle dual-purpose farms of Central and South American tropics. The results up to know show that this grass offers a better alternative of production compared to traditional grasses, both for the high quality and high forage production reported.

Material and Methods

Agronomic evaluations of hybrids and accessions of *Brachiaria* are underway in Gualaca (Panamá) in collaboration with IDIAP, and in Guápiles in collaboration with INTA (Costa Rica). In Panama the site is located at 100 masl and within the very humid premontane ecosystem; the soils are clay loam acid inceptisols with pH 4.8, high in Al (1.1 meq/100 ml), medium in OM (4.0 %), low in P (1 ppm), medium in K content (59 meq/100 ml) and low in Ca and Mg (1.0 and 0.20 meq/100 ml respectively). Mean temperature is 26 ºC and the site has a record of 4000 mm total rainfall from May to November. Meanwhile that Guápiles is a very humid tropical forest located at 250 masl, 4260 mm of total rainfall and a mean temperature of 24.6 ºC. The soils are sandy loams of medium fertility with pH 5.7, low in Al (0.35 meq/100 ml), and high P content (37 ppm).

For the agronomic evaluations the grasses *Hemarthria altissima* and Braquipará were planted using cuttings in Costa Rica, while other species were direct planted with seeds in both countries. Plots size of 4 m x 5m replicated 3 times were used, and depending of the site, plant cover and cutting evaluations to measure dry matter yields were carried out every 4 to 12 weeks respectively for the dry and wet season.

As resported in the IP-5 2002 Annual Report, a protocol for on-farm validation/promotion of *Brachiaria* hybrid cv. Mulato was developed and proposed to national institutions of Panamá, Guatemala, Nicaragua, Costa Rica, Honduras and Colombia. Using this protocol we have established on -farm trials with hybrids and other grasses in dual purpose and beef cattle farms the region of Yoro, Yorito, Victoria and Olancho (Honduras); León, Chinandega, Posoltega, Boaco, Chontales and San Dionisio (Nicaragua); Puriscal, Miramar, San Isidro, Nicoya, Guanacaste, San Jerónimo and Orotina (Costa Rica), Bugaba, Gualaca and Boquerón (Panamá); Nueva Conception, Coatepeque and Esquintla (Guatemala), and in the Llanos Orientales and the Caribbean Coast of Colombia.

Results and Discussion

Agronomic evaluations: Gualaca in Panamá is a site of infertile acid soils, while Guápiles in Costa Rica has soils of medium to good fertility. This difference in soil fertility accounts for the better forage yields observed in Guapiles. The *Brachiaria* hybrids have adapted well to both sites and the forage yields observed are within those recorded for other *Brachiaria* species such as *B. brizantha* cv. Toledo in Guápiles. Problems related with pests and diseases have not been reported up to now (Table 56).

Table 56. Dry matter yields of *Brachiaria* species and hybrids and other grasses evaluated under cutting in Panamá and in Costa Rica.

Species	CIAT No.	Gualaca (Panamá)	Guápiles (C. Rica)
	Yield (Kg DM /ha)		
Brachiaria hybrid	36062	1505*	2369**
Brachiaria hybrid	36087	1509	2527
Brachiaria hybrid	cv. Mulato (36061)	1603	2798
Brachiaria brizantha	26318	2241	na
B. brizantha	26124	1596	2642
B. brizantha	(Mixe)	1693	2559
B. brizantha	cv. Toledo (26110)	na	2670
Brachiaria sp.	(Braquipará)	na	2995
Other species			
Hemarthria altissima		na	3112
Paspalum atratum cv. Pojuca	26986	1505	na

* Means of 10 evaluation cuts every 4-5 weeks during the wet period
** Means of 2 evaluation cuts every 6 weeks during the wet period

On-farm monitoring: Honduras is the country where *Brachiaria* hybrid cv. Mulato has been more closely monitored in dual -purpose cattle farms. Colleagues from the national institution (DICTA) have carried out important field -work in this regard along the Atlantic coast, the northwest and the central part of the country.

In Table 57 we show that from January to June 2004 (mostly the wet period), Brachiaria hybrid cv. Mulato did not affect individual animal production in six farms monitored (P<0.05); however, there is a consistent tendency of more milk produced per cow in these pastures.On the other hand, significant increases (P<0.05) in stocking rate in all farms were observed in pastures of cv. Mulato as compared with other naturalized or improved grasses such as Jaragua, Andropogon, Toledo and Swazi grass; this in turn lead to significantly (P<0.001) more milk production per unit area, which in most farms was more than twice in cv. Mulato relative to other grasses.

Similar results have been observed in other countries with milking cows, which confirms that one of the major advantages of *Brachiaria* hybrid cv. Mulato is the high production of high quality forage that traduces in more milk per unit area.

During the first semester of 2004 additional dual-purpose and beef cattle farms were selected for the establishment and monitoring of cv. Mulato in Costa Rica (18 farms), Nicaragua (17 farms), Honduras (9 farms) and Guatemala (12 farms), for a total of 56 farms. This activity forms part of the project Enhancing Beef Productivity, Quality, Safety and Trade in Central America, which is financed by CFC (Common Fund for Commodities of the European Union) and executed by ILRI, CIAT, IICA and SIDE.

Cultivar Mulato is in the process of establishment in all selected farms in areas that range from 1 to 7 ha. The grass will be monitored in terms of animal production related to other commercial *Brachiaria* species. Additionally, a grazing trial with beef cattle that compares animal performance of cv. Mulato and *Brachiaria* hybrid CIAT 36087 is in the process of

Table 57. Stocking rate and milk production per animal and per hectare of cows grazing *Brachiaria* hybrid cv. Mulato and other grass species in dual-purpose farms of Honduras during the period January-June 2004 (Information supplied by Conrado Burgos and Heraldo Cruz of DICTA).

Farm/ Pasture	Stocking rate (cow/ha)	Mean daily milk (kg/cow)	Mean daily milk (kg/ha)
Mulato	5.1 a**	7.1 c	37.5 d
Swazi*	1.6 b	6.8 c	8.6 f
Mulato	5.6 a	5.2 c	32.1 d
Swazi	2.7 b	4.8 c	13.5 f
Mulato	9.4 a	3.8 c	36.0 d
Toledo*	3.7 b	3.8 c	14.0 f
Mulato	5.0 a	13.1 c	64.5 d
Toledo	2.7 b	12.7 c	33.3 f
Mulato	6.1 a	10.7 c	65.3 d
Andropogon*	3.4 b	10.5 c	36.7 f
Mulato	4.7 a	6.3 c	29.9 d
Jaragua *	2.1 b	5.7 c	12.3 f

* Swazi (*Digitaria swazilandensis*), Toledo (*Brachiaria brizantha*), Andropogon (*Andropogon gayanus*) and Jaragua (*Hyparrhenia rufa*).
** Within each farm means followed by different letters are statistically significant (P<0.05).

establishment at Corpoica's Research Station Taluma in east acid savannas of Colombia.

Controlled grazing trial: Grazing trials to measure beef cattle animal performance were established during 2002 in Panama by IDIAP (Instituto Panameño de Investigación Agropecuaria) and in Colombia by Corpoica (Corporación Colombiana de Investigación Agropecuaria). In Panamá the site is located at 100 masl and within the very humid premontane ecosystem; the soils are clay loam acid inceptisols with pH 4.8, high in Al (1.1 meq/100 ml), medium in OM (4.0 %) and low in P (1 ppm). Mean temperature is 26 ºC and the site has a record of 4000 mm total rainfall from May to November. Meanwhile that the soils are of alluvial origin in Turipaná (Colombia) with pH 5.3, 5.9% OM, 25 ppm of P, 282 ppm of S and only Al traces.

In both sites cv. Mulato was established by direct seeding after controlling the existing vegetation with herbicides. In Panamá the 2 ha of the experiment were fertilized with 20 kg/ha of N and 10 kg/ha of P divided in 8 paddocks and established a grazing rotation of 3/21 days of grazing/rest. Meanwhile that in Colombia cv. Mulato is grazed and compared with *B. decumbens* cv. Basilisk in a rotational system of 2 days grazing, 22 rest during the wet period, and 3 days grazing, 33 rest during the dry period.

The experiments are still underway but preliminary data show a mean stocking rate of 3.2 AU/ha in Panamá and a liveweight gain of 0.630 kg/an/day during the wet season. Meanwhile in Colombia the stocking rates have been respectively 3.4 AU/ha and 2.7 AU/ha for cv. Mulato and cv. Basilisk, and similar liveweight gains of 0.530 kg/an/day for both grasses, indicating that the larger benefit of Mulato grass is to allow an increase in the number of animals under grazing per unit area. This is a result of significant more forage production of this cultivar as has been demonstrated elsewhere.

4.1.2 On-farm evaluation of new forage options for pastures rehabilitation in the llanos of Colombia

Contributors: Camilo Plazas, Daniel Vergara, J. Miles and C. Lascano (CIAT)

Rationale

Degradation of introduced pastures is one of the main constraints in livestock production systems of tropical America. This degradation results from poor pasture management and overgrazing. To address problems of pasture degradation in the llanos of Colombia in 1998- 1999 we introduced new grasses and legumes in degraded pastures in the well-drained savannas and in the piedmont. For a period of 5-6 years we have been monitoring the reclaimed pastures in commercial farms and under the management of the farmers.

Legumes

Legumes introduction in farms of the Piedmont: Results in one of the farms (La Esperanza) indicate that after 5 years of introduction of *A. pintoi* in a *B. decumbens* pasture, the legume content varied from 10% and 40%, depending on time of year. Thecrude protein (CP) of the grass on offer has varied between 9,4% and 10,2% in the legume-based pasture and between 4% and 8,7% in the grass only pasture.

In the pasture associated with Arachis LWG has been of 350 kg/ha per year, compared with 78 kg/ha per year in the unimproved pasture. Milk production is equally higher in the associated pasture than in the contro (3000 vs. 900 kg/ha per year).

In another farm (San Pedro) a pasture of *A. pintoi* - *B. humidicola* was established in an area invaded by *Homolepis aturensis*, a low

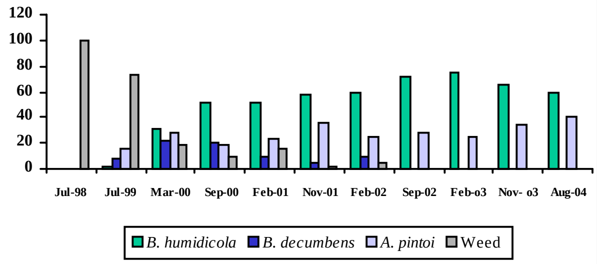

Figure 45. Legume proportion (%) in pastures of *Brachiaria humidicola* associated with *Arachis pintoi* after 6 years of establishment at the farm San Pedro in Piedmont of the Llanos of Colombia.

quality grass. After 6 years the legume has varied between 16% and 40%. The legume proportion averaged 25% during the dry period of 2003-04 and 40% in the rainy period of 2004. The weed *H. aturensis* has practically disappeared while the content of *B. humidicola* has increased (Figure 45). The carrying capacity of the pasture also increased over time. Currently between 20 and 20 steers are maintained in the pasture (10 ha) with an average weight of 280 kg under a continous grazing.

Legume introduction at farms of the well - drained savannas: The herbaceous legume *Desmodium heterocarpon* subsp. *ovalifolium* CIAT 13651 was established in 2000 a degraded *B.decumbens* pasture in a farm (Andremoni) in the well- drained savannas. The legume content increased up to 25% in the rainy season of 2001. The pasture was very productive (in fact one of the most productive in the farm). However, as a result of continous heavy grazing and no maintenance fertlizer thelegume proportion in the dry season of 2002 was reduced 5%. Its recovery in the rainy season of that year was very slow, and finally disappeared in the dry season of 2003. The alternative is to replant the seed (0.5kg/ha) and apply maintance fertilizer.

Grasses

Introduction of Toledo in the piedemmont and well-drained savannas: In 2000 at the San Pedro farm, located in llanos Piedmont, a pasture of 2,5 ha of *Brachiaria brizantha* cv. Toledo (CIAT 26110) was established in a degraded area. A group of 10 steers with average LW of 300 kg, are maintained in the pasture with occupation periods of 15 days and 30 days of rest. Forage availability in this pasture has varied between 3,5 and 5,8 t/ha of DM with a content of CP between 7,5% and 11% (Table 58). The control pastures namely *B. decumbens* cv. Basilisk in the same farm show very low contents of CP (4%, in average).

Results from the farm trial indicate that *Brachiaria brizantha* cv. Toledo is a commercial cultivar that has excellent productive potential in the Piedmont. The most important attributes of Toledo are its high carrying capacity and ability to whistand soils with poor drainage.

In 2000, at the farm El Porvenir in a well - drained savanna with acid infertile soils, a pasture of 3,5 ha was established with *B. brizantha* cv. Toledo. Results have indicated that forage availability varied between 2,6 and 6,8 t/ha of DM, with a CP content between 3,5% and 5% (Table 58). The pasture is managed with 12-15 steers of 280 kg of average LW, with 8 days of occupation and between 35 to 40 days of rest. Productivity of Toledo in the well-drained savannas has not been as good as in the piedmont. However, the grass has persisted under an intensive grazing regime and in the absence of maintenance fertilizer.

Table 58. Forage availability (t/ha of DM) and CP content (%) of *Brachiaria brizantha* CIAT 26110 cv. Toledo under grazing at farms of Piedmont and Altillanura of the Llanos of Colombia.

Season	Piedmont[a]		Altillanura[b]	
	DM (t/ha)	CP (%)	DM (t/ha)	CP (%)
March/2000	-	-	1.3	3.5
September/2000	-	-	6.8	4.2
February/01	4.8	11	5.9	4
November/01	4.4	10	3.4	5
February/02	3.5	8	2.6	2.5
September/02	3.5	7	3.9	5
February/03	5.8	8	5.5	4
November/03	4	6	4.2	4
August/04	3.5		4.9	

a. Farm San Pedro.
b. Farm El Porvenir.

On-farm evaluation of different accessions of *B. brizantha*. In 2000 at the farm El Porvenir, well drained savanna site, 5 ha of *B. brizantha* CIAT 26318 were established. In the following year, 3,5 ha of each of the accessions of *B. brizantha* CIAT 26990 and 26124 were also established in the same farm.

Forage on offer in these pastures has varied from 3,4 to 5,2 t DM/ha in *B. brizantha* CIAT 26318 and from 2,3 to 5,1 t DM/ha of DM in *B. brizantha* CIAT 26990. With *B. brizantha* CIAT 26124 production of DM has been low (between 1,98 and 0,378 t/ha of DM) due to its excellent palatability and heavy grazing system used (Table 59). The CP content of these accessions has been low in the dry season (3 to 4%) and average for a grass in the wet season (6 to 7%).

After 4 years of evaluation of the different *Brachiaria brizantha* accessions it is evident that each accession should be managed in a different form. For example, *Brachiaria brizantha* CIAT 26318 (the prefered accession of the farmer) is being used finish steers with 8 days of occupation and 35 of rest, while *B. brizantha* CIAT 26990 and 26124 are used with good results with cows with 5 days of occupation and 30 days of rest.

Grasses Evaluation at farms: *Brachiaria* Hybrid cv. Mulato (CIAT 36061). This hybrid that shows multiple attributes like its rapid establishment, excellent forage quality and drought resistance is being tested as pasture for milking cows in the piedmont and as a component in crop- pasture systems in the llanos of Colombia.

Piedmont of the Llanos: In a clay loam oxisol at the farm La Isla, Piedmont, in July 2001, 7,5 ha of this hybrid were established in a plot of *B. decumbens* in advanced satge of degradation.

At the beginning 3,2 steers /ha at the finishing stage were maintained in the pasture for one month. All animals received 1 kg daily of commercial concentrate as supplement and liveweight gains were in the order of 2 kg/d. In a second phase of utilization defined by the farmer, milking cows were introduced in a rotation grazing system in five plots of 0,75 ha and 3 days of occupation. With this system 12 cows milking were maintained (3,2 cows/ha) during a complete cycle of 15 days. These cows in pastures of *B. decumbens* produced on average, 5 kg of milk in morning milking, and some of them that were milked in the afternoon produced 3,8 kg more. In the new pastures of *Brachiaria* hybrid cv. Mulatto, the same cows produced daily 6,5 kg in morning milking and 4,7 kg in the afternoon milking, which meant a total increase of 23 kg of milk per day in Mulato.

At present the Mulato pasture in La Isla farm is managed under continuous grazing with 12 cows. With this management, forage offer is in the order of 2,9 t/ha of DM and milk production is of 5.0 l /cow/d. When these same cows grazing

Table 59. Forage availability (t/ha of DM) y CP content (%) of accessions of *Brachiaria brizantha* at the farm El Porvenir in the Altillanura of the Llanos of Colombia.

	DM (t DM /ha)			CP (%)		
	CIAT 26318	CIAT 26993	CIAT 26124	CIAT 26318	CIAT 26993	CIAT 26124
March /2000	1.4	-	-	2.6	-	-
September /2000	4.7	-	-	4.2	-	-
February /01	4.8	4.2	2.0	3.7	7.2	7.4
November /01	4.3	4.5	3.8	5.2	6.5	5.2
February /02	3.4	2.4	2.5	3.7	2.8	3.3
September /02	5.2	5.0	2.4	3.7	4.3	6.1
February /03	4.7	4.7	2.9	3.0	3.9	3.3
November /03	4.7	4.8	3.1	3.9	4.1	5.9
August /04	5.0	4.3	2.0			

other species of *Brachiaria* milk yield is 3.0 l/cow/day. One major problem of Mulato in La Isla farm has been plant mortalility due to poor soil drainage. The Mulato plants have been replaced by *Homolepis* sp in some areas of the pasture.

Well-drained savannas: Sowing commercial crops with grasses or crop-pasture rotations are alternatives to reduce establishment costs of pastures, to improve their productivity and quality due to high residual fertilizer and for sustainability of the crop phase over time.

With the support of Papalotla, of Mexico, and in the farm Costa Rica (located in a well drained savanna site, with a sandy loam Oxisol), in 2001 we established Mulato in association with maize in site (15 ha) with degraded *B. brizantha* cv. Marandu. Grain yield after 138 days of sowing the maize was 3,7 t/ha, while *Brachiaria* hybrid cv. Mulatto produced 4,2 t/ha with 8,7% of CP and 65% of DIVMS.

First grazing of the resulting Mulato pasture was carried with 39 old cows and heifers that were between 24 and 36 months old. These animals 36 days later weighed, in average, 506 kg, which means a daily gain of 1675 g and a total production of 2351 kg of LWG with a carrying capacity of 2,6 animal/ha. In the middle of the dry season (January 2003), after 31 days of rest, the Mulato pasture produced 3,5 t/ha of DM. In June 2004, at the beginning of the rainy seasons fertilizer was applied (67 kg/ha of N and 38 kg/ha of K) and the forage on offer increased from 2,9 to 5,1 t DM/ha. However, soon after the fertilization Mulato exhibited N deficiency (clorosis) indicating that Mulato requieres good soil fertility and frequent N fertilization (Photo 24). A small plot experiment was setup to study N fertilization management in Mulato under the llanos condition.

At present the Mulato pasture is been used with 37 heifers (2,5 animal/ha), with an average of initial living weight at wean of 250 kg, with occupation periods between 15 and 20 days and between 30 and 40 days of rests.

Other studies with Mulato and other hybrids in the Llanos are:

1. At the farm El Porvenir, Altillanura, we established 7,64 ha of *Brachiaria* hybrid cv. Mulato (CIAT 36061) in association with a rice crop, with an initial fertilization of 400 kg/ha of dolomite lime, 400 kg/ha of Calfos and 50 kg/h of smaller elements. At the same farm established 5,84 ha of *Brachiaria* hybrid cv. Mulato-2 (CIAT 36087) with the same fertilizer dose application used in Mulato.

(A) (B)

Photo 24. Mulato pasture in the Llanos of Colombia: (A): Fertilized with N (67 kg/ha) and (B) 60 days after fertilization.

2. At the experimental station Taluma of Corpoica located in the Altillanura, Mulato 2 (CIAT 36087) was established in 1,8 ha with an initial fertilization of 500 kg/ha of dolomite lime, 300 kg/ha of phosphoric rock, 75 kg/ha of potassium chloride and 30 kg/ha of sulfur flower. This pasture will be used in alternate grazing and its productivity will be compared with *Brachiaria* cv. Mulato (CIAT 36061).

3. At the research center Corpoica La Libertad, Piedmont *Brachiaria* cv. Mulato (CIAT 36061), *Brachiaria* cv. Mulato-2 (CIAT 36087), *B. brizantha* cv. Toledo and *B. decumbens* cv. Basilisk were established in associated with *Pueraria phaseoloides* and *Arachis pintoi* in plots of 2 ha each, in order to evaluate productivity, and persistence.

4.1.3 Adoption of new soil conservation technologies in the llanos of Colombia: Arable layer building technology (Capa Arable)

Contributors: L. Rivas and D. L. Molina (CIAT)

Rationale

As a result of CIAT's collaborative research activities with Corpoica, Pronatta and Unillanos, with financial support from MADR and COLCIENCIAS, a series of soil improvement and conservation practices are available. These practices focus on arable layer building technologies —part of the soil profile that can be modified through a combination of biological and physical management— in soils of the savannas of the Llanos of Colombia. These practices include use of proper crop and pasture rotations in agropastoral systems.

In August 2004, a rapid survey was conducted in order to learn about the adoption of the arable layer building technology (Capa Arable) in farms located in the area of Puerto López - Puerto Gaitán in the llanos of Colombia.

In total, 18 farmers were interviewed, including those that were using and not using the technology. The survey was done using the methodology of semi-structured interviews to groups of producers, technicians and experts of the region, to identify and understand trends and main features of the adoption process.

Results and Discussion

Results of this survey make reference to technology adoption in early phases, since the first farmers adopted it 4 years ago and the majority of them started adopting it between 1 and 2 years ago. In Table 60 we summarize the main results obtained in the survey and we discuss the major findings. In general, producers showed great interest in maintaining and improving soils quality, since this practice has a high and rapid payoff in terms of crops and pastures yield. Farmers in the past attempted to establish crops without adequate soils management and used non-adapted pasture and crop germplasm, and consequently experienced large economical failures.

Table 60. Results of the survey on the use of the arable layer building technology by producers in the Llanos of Colombia.

Variable	Level
Number of producers interviewed	18
Land Use	
Total Area of farms (ha)	
Mean	883
Range	120-5000
Area under crops (ha)	
Mean	238
Range	0-1100
Area under pastures and other uses (ha)	
Mean	645
Range	0-3900
Area under crops/Total Area (%)	27
Proportion of producers with no crops (%)	28
Most common rotation	Maize-soybean
Most common land preparation method	Vertical tillage with chisel plow

In contrast to the previous experiences, utilization of soil conservation methodologies together with the use of improved germplasm have shown significant advantages in productivity and in economic returns to the investments made.

Practices for arable layer building include a vertical corrective tillage using rigid chisels, correction of nutrient deficiencies in soil and sowing of forages and acid soil adapted crops. In some cases, lack of key inputs such as machinery, fertilizers and seeds prevents establishment of crops or timely harvest of crops, which has negative implications for building arable layer and for the economics of the system. There is great interest from the Colombian government and also from the private sector (e.g., poultry) in emphasizing grain production in the savannas of the llanos of Colombia. Some field crops are being established in the farms of poultry farmers to improve feed production in the region. Thus the expansion of field crops in the region is beeing pushed by the poultry sector.

The most frequent rotation is maize in the first semester and soybean in the second. The new rice variety, Line 30, recommended in this technology and that has not been commercially released yet is creating great expectation among farmers due to its high productive potential.

Even though there is clear conscience among producers of the fact that continuous monoculture degrades the soils and provokes greater pest and disease pressure, price variations in crops seem to drive the rotation cycles. High price expectations for soybean in 2004 induced many producers to plant this crop in both semesters.

Many of the farmers that have introduced crops in their farms traditionally have been and continue to be livestock producers. The majority of these farmers interviewed said that they are working with crops to improve soils and to subsequently sow high productivity pastures. Thus it seems that there will be a high demand for new forage cultivars that are being developed by CIAT Tropical Forages Project, as is the case of the new Brachiaria hybrids such as Mulato already in the market.

Productivity gains constitute the principal benefit perceived by those who apply soil conservation practices in the well -drained savannas of the llanos. In general, yields in the first sowing are low, but increase subsequently as a result of soil improvement. With soybean, initial yields are between 1,5 and 1,9 t/ha, and in rare cases reaches 3t/ha. With maize, yields are between 4 to 5 t/ha. It is foreseen that over time crop yields will begin to decline and when this occurs it will be the time to introduce pastures in the rotation.

Since the introduction of crops is new in the Llanos, most farmers interviewed do not have enough clarity on the duration of the crop phase and pasture phase of the rotation. Several of the farmers interviewed consider that between 4 and 5 years of crop rotations is needed before reconverting the land to pastures; other farmers estimate that changing crops to pastures will occur when productivity of the crop starts to decline as a result of soil fertility loss.

Constraints for adopting the arable layer building technology are economic in nature and lack of infrastructure.

Some of the economical constraints have to do with:

1. Low availability of capital associated with inappropriate credit plans.
2. Market price fluctuations of products that generate large income variations.
3. Eventual oversupply of products such as rice, and
4. High cost of inputs and agricultural machinery.

In terms of infrastucture the following limitations were mentioned:

a) Poor roads that increase cost of transportation, and
b) Low quality of seeds sold in the market that results in poor yields and reduced income.

Those farmers who have not introduced crops in their farms mentioned various reasons for not having done so:

a) Land shortage, which is something critical in small properties that do not have sufficient areas to establish crops.
b) Lack of capital and machinery to start agricultural activities.
c) Lack of experience in agriculture.
d) Time shortage or little desire to invest additional time to crops, and
e) Farm topography that does not permit crop establishment.

In summary, our survey indicates that the most immediate impact area for the arable layer building technology developed by CIAT is the Puerto López – Puerto Gaitán region, approximately 180 thousand hectares. It is considered that for its rapid adoption, investment by the Colombian government in improving road infrastructure is critical. In addition, in the more remote areas of the llanos there are a number of other critical factors (i.e. lack of machinery, inputs, technical assistance, qualified hand labor and roads and communications) that prevent the introduction of crops to establish rotations with pastures in sustainable agropastoral systems.

4.1.4 Adoption of *Arachis pintoi* in in the Llanos of Colombia

Contributors: Camilo Plazas and D. Vergara (CIAT)

The adoption of *Arachis pintoi* cv. Mani Forrajero in the Piedmont of the Llanos of Colombia has been a slow process. In order to learn about the causes of this low adoption of this legume, a survey was conducted among 77 farmers located in Villavicencio, Restrepo and Guamal.

Results of the survey indicated the following:

1. 83% of farmers interviewed knew the legume and of these the majority learned about it in a field day, in a neighbor's farm and as an ornamental plant. However, it was interesting to see that only half of the people surveyed had received information on the legume, and that a very low number (11%) had received information on establishment and grazing management of pastures with Arachis.

2. Of the total farmers surveyed, thirty six (47%) farmers had sown Arachis and of these, only eight had had problems with establishment due to an inadequate time of sowing. Only one farmer mentioned problems with seed germination. On the other hand, only 28 of farmers (36%) had between one and two plots established with this legume in their farms. Of those, 12 had less than 1 ha, 11 between 1 and 3 ha and five more than 3 ha. Of those using Arachis, 21 had used vegetative material for establishment.

3. Concerning utilization of Arachis, 32% of farmers that have Arachis use it to graze cows, 7% with fattening animals and the rest with different kinds of animals. Out of 41 farmers that use the legume, 19% had it in pastures associated with grasses, generally *Brachiaria* species and 49% had it as an ornamental legume. Other small uses of Arachis were as protein bank (15%), as cover (2%) and for rehabilitation of degraded pastures. On the other hand, only one farmer multiplied seed of Arachis for expanding the area the farm.

4. Concerning satisfaction with Arachis, the survey showed that out of 26 farmers that had used the legume in pastures, 23% were convinced that *A. pintoi* increased milk production, 15% that it increased LWG in animals and 11% that it improved soils characteristics.

5. By areas in the piedmont, in Villavicencio 89% of farmers surveyed knew *Arachis* for more than 10 years and 78% had received information on its establishment and management. In Restrepo, even though most farmers recognize the advantages of Arachis its adoption has been slow because of lack of information. In the Ariari, 88% of farmers in the survey knew the legume and 65% had information on how to utilize it as feed resource. In this zone the greatest use of Arachis was in protein banks and in association with grasses.

In summary, results indicate that 93% of farmers using Arachis were satisfied, among other reasons because of increased forage production, soil and moisture conservation, persistence, tolerance to pest and disease, good palatability for animals and because it is easy to propogate with vegetative material. Reasons of those not using Arachis for not having established the legume varied from not knowing it (38% of farmers surveyed), not knowing how to use it (16% of farmers surveyed) and to high cost of sexual seed (3% of farmers surveyed).

Results of this survey showed some features of the diffusion and adoption process of *A. pintoi* in the Llanos of Colombia:

(1) Lack of commercial seed at an accessible price for farmers in current cattle-raising situation in the region is, maybe, the main constraint for diffusion of *Arachis*.

(2) High costs of establishment with vegetative material.

(3) Limited information to farmers on establishment and management of Arachis based pastures

As a follow-up of the survey, between July and August 2004, a series of workshops were held with farmers on, establishment, fertilization establishment and maintenance and uses of Arachis. These workshops were held in San Martín (35 participants), Guamal (33), Villavicencio (60) and Restrepo (50) with cooperation of Comité de Ganaderos del Meta, the Farmers Training School of Restrepo, the Comité de Ganaderos of San Martín and the Asociación de Ganaderos of the Ariari (Aganar).

4.1.5 On-farm evaluation of forage options in hillsides in Colombia

Contributors: C.V. Duran (Universidad Nacional de Palmira), Luz Mary Ocampo (Secretaría de Agricultura del Valle), M. Valderrama (Instituto Técnico de Roldadillo, INTEP) and farmers from the Grupo de Productores de la Ondina, J.I. Roa (IPRA), L.H. Franco and M. Peters (CIAT)

Rationale

The Norte del Valle of Colombia is an important livestock area. However forage options available to livestock holders are limited and hence restrict productivity of livestock operations. Through a participatory approach it is aimed to define and adapt forage technologies hence improve livelihoods of farmers.

Material and Methods

Work was initiated in 2002 with a participatory diagnosis and several farmer visits to farms and research stations employing improved forage technologies. This was followed by planning meetings with farmers to establish a trial including several forage options, planted in contour lines at the ‘finca La Ondina’ in Roldanillo (800 mm annual rainfall, high temperatures), located in the piedmont of the Western Cordillera, in the Northern Valle. Farmers and researchers observe the adaptation of the various options through qualitative measurements (see Photo 25). Farmers then select and adapt forage technologies to their particular conditions, with the innovation process supported by close interaction with technicians and researchers.

Photo 25. Farmers at Roldanillo, Valle (trial at "Finca La Ondina"), 2004.

The following forages were established:
Brachiaria híbrido cv. Mulato
Brachiaria brizantha cv. Toledo
Panicum maximum cv. Mombasa
Brachiaria dictyoneura cv. Llanero
Cratylia argentea cv. Veranera
Leucaena leucocephala local.

Results and Discussion

Farmers defined the following criteria as important for selection of forages:

- Palatability
- Color
- Forage on offer
- Adaptation to low fertility soils
- Adaptation to drought
- Tolerance to ants
- Organic Matter production
- Cover (aggressiveness)
- Rooting capacity
- Persistence under grazing
- Adaptation to fertility gradients

The criteria selected are very similar to those selected in evaluations with farmers in Central America, confirming the validity of the participatory approach used. To support the farmer innovation process, parallel training events were organized on subjects such as forage utilization, pasture assessment (BOTANAL), pasture establishment, pasture management, ant control and silage and hay making. After two years, farmers are starting to adopt *Brachiaria* hybrid cv. Mulato, *B. brizantha* cv. Toledo, *Cratylia argentea* and *Leucaena leucocephala*. Farmers expressed the need to evaluate forage materials at different altitudes and rainfall regimes. Thus new trials were established at altitudes of 1200 to 1500m and 1500 to 1800 masl.

4.1.6 Participatory introduction of improved forages in smallholder dairy systems in hillsides of Nicaragua

Collaborators: A. Schmidt, C. Davies, E. López, M. Peters, L.H. Franco, and P. Argel (CIAT)

Rationale

It is recognized that many relevant agriculture technologies are not achieving their full potential impact due to low levels of adoption, which has led to more emphasis on the use of participatory research methods to enhance adoption of improved technologies. The BMZ funded forages project 'Farmer Participatory Research in Action: Selection and Strategic Use of Multipurpose Forage Germplasm by Smallholders in Production Systems in Hillsides of Central America' achieved the development of a technology package made up of different components: a) methods for participatory diagnosis and stakeholder analysis, b) characterized forage germplasm acceptable to farmers, c) demonstrated benefits of improved forages in animal production results including economic analysis, d) complementary training modules (participatory evaluation and selection, forage utilization/management, participatory monitoring and evaluation), and e) seed systems (informal and formal public, and private).

The package developed by the CIAT-led project attracted the attention of the ASDI-funded bilateral development project FONDEAGRO (Fondo de Desarrollo Agropecuario) based in Matagalpa as a key input to enhance milk production in the projects' target region Matiguás and Rio Blanco in Nicaragua. The target group consists of approx. 1,300 livestock holders in three zones. After adapting the technology package to the specific needs of FONDEAGRO, CIAT was asked to implement the package within their project.

Material and Methods

CIAT was contracted (1) to select and implement three forage nursery trials in different sites offering a wide basket of germplasm options to farmers, (2) implement on-farm animal production experiments to demonstrate pasture management and increased milk production based on improved grasses and grass-legume associations, (3) implement dry season feed opportunities based on the shrub legume *Cratylia argentea* in combination with cut&carry grasses, (4) conduct training modules on forage agronomy and pasture management, participatory methods for evaluation and extension, seed production and participatory monitoring and evaluation, and (5) develop a seed production system within the project in order to secure long term sustainability and adoption of the selected forage options. The project ended March 2004 after 18 months.

Results and Discussion

Adaptation of grasses

Despite the short project duration we could successfully introduce new germplasm into the project area. As shown in Table 61, the wide basket of forage germplasm options included grasses, and herbaceous and shrub legumes. Pasture establishment resulted difficult due to unusual high precipitation at the beginning of the project. Furthermore, increased sowing rates were required because of the high weed pressure in this region. A total of 367 plots were established at three sites and evaluated during the periods of maximum and minimum precipitation. Agronomic data was recorded as well as farmers' preferences in collaboration with project farmer groups. At the Ubú Norte site a fertilizer treatment was applied in order to demonstrate possible effects on yield of grass species.

Results from the agronomic evaluation of 18 grasses at Ubú Norte are presented in Table 62 No fertilizer effect could be observed throughout the experiment; however, it remains to be seen if pasture yields will decline in the area over time demanding at least regular maintenance fertilization. The objective of demonstrating to farmers the benefits of fertilizer application, who traditionally do not apply any fertilization to pastures, could not be achieved basically due to the short project duration.

At Ubú Norte *Panicum maximum* accession CIAT 16031 cv. Tanzania followed by *Paspalum plicatulum* accession CIAT 26989 produced the highest dry matter yields in combination with good soil cover indicating ease of establishment even under very high rainfall conditions.

Although the *Brachiaria* hybrid's cv. Mulato full potential is expressed under drier conditions, yields did not differ significantly between the periods of minimum and maximum precipitation. The robust *B. brizantha* accessions CIAT 26110 cv. Toledo and "Mixe" can also be considered promising and productive grasses for Ubú Norte. Plant diseases and pests were no limiting factor, except for one Rhizoctonia foliar blight attack on *B.* hybrid cv. Mulato.

The yield of grasses recorded at La Patriota site (Table 63) were lower than those observed at Ubú Norte. Again *Paspalum* accessions and

Table 61. Forage options established within the FONDEAGRO project.

Grasses	Herbaceous legumes	Shrub legumes
B. brizantha CIAT 6780	*A. pintoi* CIAT 18744	*C. argentea* CIAT 18668
B. brizantha CIAT 26110	*A. pintoi* Ciat 22160	*C. argentea* CIAT 18516
B. brizantha CIAT 16322	*D. ovalifolium* CIAT 33058	*C. calothyrsus* CIAT 22310
B. brizantha CIAT 26646	*C. pubescens* CIAT 15160	*C. calothyrsus* CIAT 22316
B. brizantha CIAT 26124	*C. brasiliensis* CIAT 17009	*L. leucocephala* CIAT 17263
B. brizantha CIAT 26318	*C. pascorum* cv. Cavalcade	*D. velutinum* CIAT 13953
B. brizantha CIAT 26990	*C. plumieri* DICTA	*Cha. rot. grandifolia* CIAT 18252
B. brizantha "Mixe"	*P. phaseloides* CIAT 7182	*Cajanus cajan* (local)
B. decumbens CIAT 606	*S. guianensis* CIAT 11844	*Gliricidia sepium* (local)
B. humidicola CIAT 679	*Lablab purpureus* (local)	
B. dictyoneura CIAT 6133	*Mucuna pruriens* (local)	
B. ruziziensis CIAT 654	*Vigna umbellata* (local)	
B. hybrid CIAT 36061		
B. hybrid CIAT 36062		
P. maximum CIAT 16051		
P. maximum CIAT 16031		
Pas. plicatulum CIAT 26989		
Pas atratum CIAT26868		

Table 62. Plant height, soil cover and DM yields of 18 grass accessions in the period of maximum and minimum precipitation in Ubú Norte, Nicaragua.

	Plant height (cm)		Soil cover (%)		DM yield (g/m^2)	
	Min	Max	Min	Max	Min	Max
Fert. Level						
- High	55	76	73	75	283	338
- Low	56	71	69	67	311	302
CIAT No.						
606	56	73	73	82	244	329
654	39	55	52	37	239	188
679	-	-	-	-	-	-
6133	37	55	46	65	234	347
6780	40	65	78	91	171	244
16322	72	94	84	88	252	348
26110	72	76	70	64	375	363
26124	64	75	67	66	264	320
26318	62	61	47	17	359	342
26646	65	76	70	76	305	275
26990	64	73	53	48	357	277
36061	52	69	74	81	305	308
36062	52	54	76	49	322	253
"Mixe"	56	77	81	86	331	355
16031	67	105	81	83	260	432
16051	51	82	68	83	256	332
26868	48	78	87	91	443	325
26989	42	71	95	97	328	400
Mean Acc.	55	73	71	71	297	320
LSD (0.05)	13.3	21.3	24.9	30.3	193.6	271.5

Panicum maximum cv. Tanzania were the most productive grasses. local check, *B. brizantha* cv. Marandú, resulted at all site less productive than the new grasses introduced by the project. *Brachiaria* cultivars Mulato and Toledo adapted well at the La Patriota site.

At the third project site Paiwítas, the *Paspalum* accessions performed well throughout the evaluation period, while *P. maximum* accessions were well below average, probably due to the lower pH and organic matter content of the soil at Paiwítas (Table 64). Soil conditions might also be the reason that grasses at this site showed the lowest dry matter production, height and soil cover of all three experimental sites. *Paspalum*, accessions *B. decumbens*, *B. brizantha* "Mixe", and *B. brizantha* cv. Toledo were the best forage options for Paiwítas.

Table 63. Plant height, soil cover and DM yields of 13 grass accessions in the period of maximum and minimum precipitation in La Patriota, Nicaragua.

CIAT No.	Plant height (cm)		Soil cover (%)		DM yield (g/m^2)	
	Min	Max	Min	Max	Min	Max
606	50	84	72	88	233	298
6133	51	62	68	65	311	154
6780	33	107	90	94	117	205
16322	55	90	87	93	164	239
26110	53	104	90	92	181	270
26646	53	96	70	90	167	269
36061	47	86	82	67	183	270
36062	53	73	80	67	215	212
"Mixe"	55	82	62	77	267	341
16031	76	108	93	73	425	192
16051	50	94	82	87	227	347
26868	57	94	95	93	453	259
26989	53	97	100	98	454	372
Mean Acc.	53	91	82	83	261	264
LSD (0.05)	24.8	22.6	33.2	39.6	333.6	320.6

Table 64. Plant height, soil cover and DM yields of 13 grass accessions in the period of maximum and minimum precipitation in Paiwítas, Nicaragua.

CIAT No.	Plant height (cm)		Soil cover (%)		DM yield (g/m^2)	
	Min	Max	Min	Max	Min	Max
606	57	81	90	92	256	233
6133	39	50	50	47	208	154
6780	48	69	60	67	141	111
16322	54	84	70	63	195	305
26110	67	93	67	72	287	191
26646	52	77	63	70	249	227
36061	45	71	70	73	220	120
36062	36	65	55	63	155	191
"Mixe"	52	63	68	72	224	276
16031	60	91	60	70	167	202
16051	42	67	83	87	159	126
26868	50	80	80	75	351	410
26989	52	84	88	93	316	636
Mean Acc.	50	75	70	73	225	245
LSD (0.05)	15.9	28.9	43.4	43.6	212.6	315.8

Adaptation of legumes

The accessions *Stylosanthes guianensis* CIAT 11844, *Arachis pintoi* CIAT 18744, *Desmodium ovalifolium* CIAT 33058 and *Canavalia brasiliensis* CIAT 17009 were the most promising herbaceous legume materials in the three sites (data not presented). *Pueraria phaseoloides* had establishment problems, which seemed to associated with low seed quality. The annual legume options *Lablab purpureus* and *Vigna umbellata* showed quick establishment and high dry matter production at all sites. The shrub legumes did not establish well at the three experimental sites. Due to its slow initial growth, *Cratylia argentea* only showed promising results at the end of the project period. *Cajanus cajan* and *Calliandra calothyrsus* seemed to be well adapted to the Ubú Norte and Paiwítas sites. At La Patriota site, however, high water table conditions throughout the year apparently affected the shrub legumes evaluated.

Participatory selection of grasses and legumes

Farmers' preference ranking (Photo 26) from all three project sites is presented in Table 65. While some of the expressed preferences by the farmers groups are coherent with recorded agronomic data, the high ranking of *B. brizantha* cv. Toledo and *B.* hybrid cv. Mulato seems to be triggered also by other factors such as seed availability and especially the promotion activities of other entities contracted by FONDEAGRO. Large quantities of seed of both cultivars were distributed among farmers clearly influencing their preferences. It has to be mentioned as well that a high percentage of the group members had not been exposed to forage germplasm before. Therefore, results should be regarded as highly biased and indicating limitations of participatory methods, which have to be taken into account in future projects.

Photo 26. Participatory evaluation of grasses in Paiwítas, Nicaragua.

Table 65. Farmer's dry and wet season preference ranking of grass and legume germplasm at three sites in Nicaragua.

Species	Ubú Norte		Paiwítas		La Patriota	
	Min	Max	Min	Max	Min	Max
Grasses	26110	26110	36061	26868	16031	26110
	6780	36061	26110	36061	26110	36061
	16031	6780	6780	26110	36061	6780
	36061	16031	36062	6780	16051	16031
	26989	26989	16051	36062	26989	26868
Herb. legumes	17009	17009	17009	11844	17009	18744
	7182	15160	15160	15160	Lablab	Mucuna
	15160	*V. umbellata*	18744	*C. plumieri*	11844	11844
	Lablab	71820	Lablab	Lablab	33058	33058
Shrub legumes	Cratylia	Cratylia	Cratylia	Cratylia	22310	Cratylia
	Cajanus	Cajanus	22310	Gliricidia	Cajanus	Cajanus
	17263	17263	Cajanus	Cajanus	Cratylia	17263
	22310	22310	22316	18252	17263	22316

Staff from CIAT facilitated the establishment of a series of plots with a smaller selection of materials in different locations across the target zones. These plots are managed directly by farmer groups under the supervision of Technoserve, which is an extension company (45 technicians) contracted by FONDEAGRO. The acquisition and import of 530 kg of grass and legume seed mainly from Honduras and Costa Rica was facilitated by CIAT. CIAT's Seed Unit in Atenas, Costa Rica, played a vital role in this effort.

Grazing experiments with milking cows

In order to demonstrate milk production potentials of the new forage options on offer, large grazing plots (1-2 ha) were established in each zone of the FONDEAGRO Project. The grass *B. brizantha* cv. Toledo (CIAT 26110) was chosen for this effort. Parts of the plots were established in association with *Arachis pintoi* CIAT 18744. On demand of FONDEAGRO, these plots are managed intensively with electric fences (Photo 27). Milk production is being recorded in comparison to the traditional pastures available in the area. First results indicate a milk increase of approximately 25% on the improved pastures over the control. This has to be confirmed through further grazing cycles in the future.

Photo 27. Intensive pasture rotations with electric fences in Ubú Norte, Nicaragua.

Forages for Cut and Carry

The establishment of *Cratylia argentea* and cut and carry grasses for dry season feeding resulted very difficult due to high rainfall and the inherent slow initial growth of the shrub legumes. While plots of *Pennisetum* spp. established well at all sites, *Cratylia argentea* only reached production stage at the Ubú Norte site (Photo 28). Further research is necessary on plant establishment of *Cratylia* in order to speed up initial growth and reduce the risk of failure under different environmental conditions. Nevertheless, farmers at Ubú Norte, convinced of the benefits of the shrub legume for the dry season, harvested the first *Cratylia* seed and doubled the area of *Cratylia* at this experimental site in 2004. Remaining seed was sold to other project areas.

Photo 28. *Cratylia argentea* for dry season feed in Ubú Norte, Nicaragua.

Training

Training of project technicians (45), and a small group of key farmers, was a major accomplishment of the project. Training courses were held on forage germplasm characteristics (Sept 2002/May, 2003), participatory monitoring and evaluation (Feb., 2003), forage seed production (Mar., 2003) and pasture management (Apr., 2003). Dry season feed strategies for all three project zones, taking into account available germplasm at the sites, were developed during a workshop in November, 2003 (Photo 29). Field days to observe seed harvest were conducted in

December, 2003.

In March 2004 a last training course was held on intensive pasture rotation utilizing electric fences in order to prepare technicians for the establishment and management of additional grazing plots in the target areas.

Photo 29. Grass silage for smallholders – training course for field technicians of FONDEAGRO, Nicaragua.

Development of Forage Seed Systems

The development of a forage seed production system within the project in order to secure long term sustainability and adoption of the selected forage options could only be initiated due to the short duration of the project. Efforts were made to organize farmers interested in seed production and initiate seed multiplication of *B. brizantha* cv. Toledo, *Arachis pintoi* and *Pueraria phaseoloides*. Since formal seed markets in Nicaragua are only beginning to evolve (only grass seed of few selected species available) with prices often beyond the economic ability of farmers, such a multiplication system is key for the FONDEAGRO project's success. CIAT facilitated the first steps of this process, but it remains to be seen if activities will continue after CIAT's project involvement ended.

Summary

During the project we successfully introduced new promising forage germplasm options in a region where natural pastures are the main source of feed for livestock and where farmers had only restricted access to information and seed of improved forage cultivars. Training technicians and key farmers allowed for the development of local capacities to ensure that the introduced forage germplasm will be managed and multiplied adequately. Benefits were shown and farmers, who formerly spent little time and effort on improving feed resources for their animals, establish now their own plots and buy seed on their own account. One important lesson learned in this project is the need to develop forage germplasm for water-logged areas.

Assisting development projects with forage germplasm options, methodologies and training is an effective way of scaling research results. However, more up-to-date training and information materials have to be developed for this purpose.

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

Collaborators: A. Schmidt, P.P. Orozco (CIAT), Campos Verdes (San Dionisio, Nicaragua), M. Peters, L.H. Franco, G. Ramirez (CIAT), and E. Barrios (TSBF-Soils)

Rationale

Farmers are increasingly concerned by the high price of inputs used for agriculture production such as fertilizers. At the same time soil fertility on farmer fields is decreasing and weeds are becoming a larger problem. In order to overcome these limitations, the local farmer organization "Campos Verdes" initiated (backed up by CIAT) activities to introduce, evaluate and promote the use of cover crops and green manures (CCGM) in the communities of San Dionisio in 2001.

Drawing from former experiences, Campos Verdes hypothesized that CCGM legumes significantly contribute to soil fertility enhancement, water and soil conservation and weed suppression. Some of these green manure legumes may be even used as forage or for human consumption. It was also taken into account that growing CCGMs may result in a smaller amount of applied agrochemicals, which are already contaminating the scarce water resources of the people in San Dionisio. Further objectives were participatory learning about CCGM, and their management within the local community.

This initiative was a logical extension of our germplasm work with multipurpose legumes and scaling efforts within the Calico watershed in collaboration with TSBF. We therefore supported CCGM experiments at watershed level with traditionally known legumes (e.g. *Mucuna pruriens*, *Canavalia ensiformis*) and exposed farmers to newly introduced legume accessions of *Vigna unguiculata* and *Lablab purpureus*. Results (see AR 2003; p. 145) indicated the possibility to replace traditional nitrogen fertilizer application to following maize crops through the establishment of a CCGM crop in the outgoing preceding rainy season.

Since farmer-led experiments are always more susceptible to data loss, we established also a long-term crop rotation experiment at our Sol Wibuse site in order to monitor the effects of CCGM crops in relation to the traditional production system in San Dionisio. This experiment established in 2001 served as a mother-trial for an on-farm validation project funded by FUNICA (Fundación para el Desarrollo Tecnológico Agropecuario y Forestal de Nicaragua) in 2003. Within this project different legume options for soil fertility enhancement are currently being tested at 28 farms in the watershed. In this report we present the first results of these activities.

Materials and Methods

At the SOL Wibuse site in San Dionisio (Lat. N12°46’49.5"; Long. W 85°49’35.2", 560 masl, annual prec.1366 mm; 26°C) four crop rotation treatments (Table 66) were established on 5m x 5m plots with three replicates. In the first planting season each year, maize was established in the traditional way including basic, low level fertilization. For the maize + cowpea / *Canavalia brasiliensis* rotation, cowpea seed was sown in two lines between two maize rows; 15 days after maize establishment. Cowpea plants were cut 30 days later and left on the plot surface as mulch. In the second planting season, plots were either sown with beans, *Canavalia brasiliensis* or kept in fallow until the following year. *C. brasiliensis* was identified in a previous CCGM germplasm experiment as highly drought resistant, staying green during the entire dry season at the SOL site. Maize and other plant residues were left on the plots. Maize yields were recorded.

Results and Discussion

In Figure 46 Maize yields from four different crop rotation treatments are presented. The recorded yields did not differ in 2001 and 2002 as expected. Only in 2003 after two years of rotation significant differences between rotations were recorded. The maize-natural fallow rotation showed the lowest maize yields. The traditional

Table 66. Treatments of long-term CCGM crop rotation experiment at Sol Wibuse site, Nicaragua, 2001-2003.

Crop rotation/treatment	2001		2002		2003	
	Prim	Post	Prim	Post	Prim	Post
Trad. Maize / bean	M	B	M	B	M	B
Trad. Maize / natural fallow	M	NF	M	NF	M	NF
Maize / *C. brasiiensis*	M	CB	M	CB	M	CB
Maize+cowpea / *C. brasiliensis*	M+C	CB	M+C	CB	M+C	CB

Prim = “Primera” (first planting season); Post = “Postrera” (second planting season)

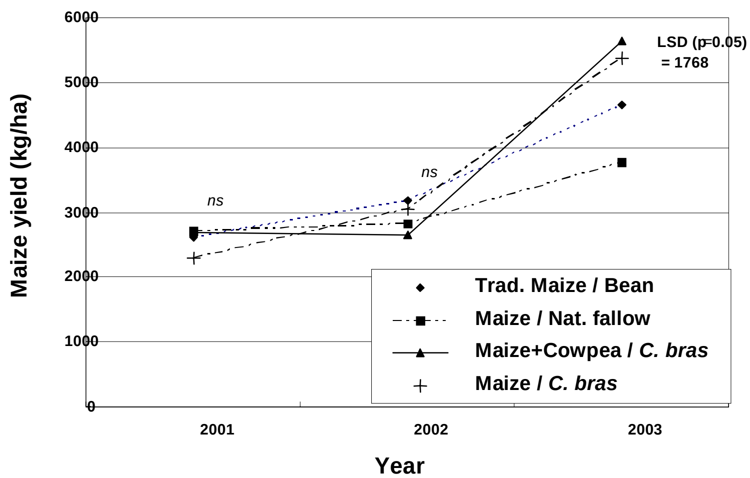

Figure 46. Maize yield of for different crop rotation systems at Sol Wibuse site, San Dionisio, Nicaragua, 2001-2003.

maize-bean rotation produced 4652 kg/ha of maize, which is above the average production level in San Dionisio. Highest yields were observed in the maize + cowpea/*C. brasiliensis* and the maize/*C. brasiliensis* rotation plots. Statistical analysis showed no significant differences between the two later ones.

Since the benefits of CCGM crops are related to soil organic matter accumulation at the topsoil we explain the observed differences between rotations with the amount of organic matter produced in each treatment. Plant species found in natural fallow plots showed only low biomass production (data not presented) and thus low organic matter accumulation in the topsoil. The relative high level of production in the traditional maize / bean rotation can be attributed to plant residue management applied, which differed from farmer fields. Both maize and bean residues were left on the plots and not burned as usually done by farmers, which leaves the rotation with a negative nutrient balance as shown by E. Sindhoj (TSBF, AR 2003).

The high yields observed in the maize + cowpea / *C. brasiliensis* and the maize/*C. brasiliensis* rotation are probably due to the massive biomass production of *C. brasiliensis* and the constant soil cover the plant specie provides during the entire dry season (Photos 30, 31).

Photo 30. *Canavalia brasiliensis* in the dry season in San Dionisio, Nicaragua

Photo 31. *Canavalia brasiliensis* sown in maize residues in the outgoing rainy season in San Dionisio, Nicaragua

The effect of cowpea on the maize yields is presumably low given the short time period of 30 days for establishment and biomass production as compared to *C. brasiliensis*. More data recorded including biomass data of cowpea, *C. brasiliensis*, and fallow species along with soil analysis and economic parameters will be recorded at the end of 2004 when the experiment ends. However, with the data presented we can conclude that legumes which drought resistance and produce enough biomass are able to enhance farmer production systems in the dry hillsides of Nicaragua and reverse the current tendency of these soils to degrade leaving farmers with higher yields and lower production costs.

The results presented were shown to farmers during participatory evaluations and field visits at the SOL site. In the FUNICA project similar crop rotations were established on 28 farms in 20m x 20 production plots under farmer management. First results indicate farmer preference for cowpea over *Mucuna pruriens* which was included as a rotation element on farmer's demand (Photo 32). Data analysis will be performed early 2005 and results will be presented in our next annual report. Further research on the mechanism behind the observed effects on maize yield in the hillside soils in Nicaragua is necessary and will be sought through our collaboration with TSBF/ Soils.

Photo 32. *Vigna unguiculata* as a cover-green manure crop prior to maize

4.1.8 Cafeteria type experiment with new grasses under dry hillsides conditions of Nicaragua

Collaborators: A. Schmidt, C. Davies, and E. López (CIAT)

Rationale

The importance of involving grazing animals at early stages of the germplasm selection process is widely recognized. Cafeteria type experiments are considered useful, efficient and rapid instruments to assist in the evaluation and selection of forage germplasm. However, we recognize that results from Cafeteria experiments only give relative indications of the acceptability of a given grass or legume accession. Therefore, we established an experiment to determine the relative acceptability of different accessions of *Brachiaria brizantha* and of *Brachiaria* hybrids developed by CIAT.

Materials and Methods

At the SOL Wibuse site in San Dionisio, Matagalpa, Nicaragua (Lat. N12°46'49.5"; Long. W 85°49'35.2", 560 masl, annual prec.1366 mm; 26°C; 6 months dry season from November to May) plots (5m x 5m) of *Brachiaria brizantha* cv. Toledo (CIAT 26110), *Brachiaria brizantha* accession CIAT 16322, *Brachiaria* hybrid cv. Mulato (CIAT 36061), and *Brachiaria* hybrid Mulato 2 (CIAT 36087) were established in three replicates on a pronounced slope in October 2003 (Photo 33). Plots were fertilized on establishment. First grazing (cycle 1, dry season) took place in March 2004, followed during the wet season by cycle 2 and 3 in June and July 2004, respectively.

Two fasted heifers were introduced to each block (replicate) (Photo 34) and during four days, the following animal activities were recorded at five-minute intervals for a total of nine hours (7 a.m. - 4 p.m.): grazing activity on each of the four grasses on offer, standing, walking, ruminating, or

Photo 33. Established plots of new grasses for the cafeteria type experiment at the SOL Wibuse site, San Dionisio, Nicaragua.

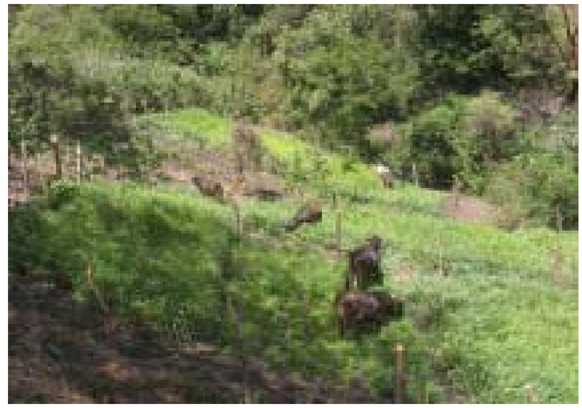

Photo 34. Heifers grazing a new grass cafeteria at the SOL Wibuse site, San Dionisio, Nicaragua.

dinking water. Based on the number of observations, animal activity profiles per site and relative acceptability indices for each grass (no. of observations of a given grass being grazed/ total no. of grazing observations expected in the respective block, if all grasses were of equal acceptability) were calculated. Accessions with low relative acceptability score indices less than 1 while those with higher acceptability had indices greater than 1. Plant height (cm), soil cover (%) and DM availability (g/m^2) were recorded before and after each grazing cycle.

Results and Discussion

In Table 67 relative acceptability indices of the four grasses are presented. In the dry season cycle no statistically significant differences were detected in relative acceptability among grasses since animals showed no preference towards one specific grass accession or hybrid. Similar results were recorded in the first wet season cycle. However in cycle 3, *B.* hybrid Mulato 2 (CIAT 36087) was less accepted by animals as compared with the other grasses of the experiment. Data on DM availability for the hybrid (not presented) confirm these findings.

It remains to be seen if the described differences continue to be observed in future cycles allowing for a better characterization of *B.* hybrid Mulato 2 (CIAT 36087) with regard to acceptability and persistence under intensive grazing. Grazing will be carried out every 4-6 weeks according to rainfall conditions. The experiment will conclude in December 2005.

Table 67. Relative acceptability indices (AI) of four Brachiaria accessions/hybrids in San Dionisio, Nicaragua.

Species	AI-Dry season	AI-Wet season	
	Cycle 1	Cycle 2	Cycle 3
B. brizantha CIAT 16322	0.98	0.89	1.14
B. brizantha CIAT 26110 (cv. Toledo)	1.15	1.12	1.13
B. hybrid CIAT 36061 (cv. Mulato)	0.94	1.08	0.98
B. hybrid CIAT 36087 (Mulato 2)	0.93	0.91	0.75*
	ns	ns	

* Species significantly different at $p<0.05$ (Ryan-Elliot-Gabriel-Welsh Range Test), ns = not significant.

4.1.9 Evaluation of milk production potential of different grass-legume associations in the hillsides of Nicaragua

Collaborators: A. Schmidt, C. Davies, E. López, M. Peters, L.H. Franco, and G. Ramirez (CIAT)

Rationale

Livestock farmers in Central America face severe forage shortages during the dry season preventing them from producing and earning an income in time periods with favourable market prices. But even in the wet season milk production levels are low due to insufficient protein intake and inadequate pasture management. Furthermore, improved animal breeds with genetic potential to produce milk are needed, but such improvements have to be based on equally improved feeding practices. As part of the BMZ/GTZ-funded project "Farmer Participatory Research in Action", where farmers evaluated and selected new forage technologies for the hillsides of Central America, the production potential of different forage technologies on offer under the environmental conditions prevailing in the area was assessed. Since farmer group members were particularly interested in grass-legume associations, our objectives were two-fold: a) to determine the milk production potential of selected grass-legume associations in both, the wet and the dry season, and b) to demonstrate how to manage grass-legume pastures.

Materials and Methods

At a farm close to the SOL Wibuse site in San Dionisio, Matagalpa, Nicaragua (Lat. N12°46'49.5"; Long. W 85°49'35.2", 560 masl, annual prec.1366 mm; 26°C; 6 months dry season from November to May) four different grass-legume associations were established. During the wet season 2001, the grasses *Brachiaria brizantha* cv. Toledo (CIAT 26110), *Brachiaria brizantha* cv. Marandú (CIAT 6780), *Brachiaria decumbens* (CIAT 606), and *Brachiaria humidicola (dictyoneura)* cv. LLanero (CIAT 6133) were associated with *Arachis pintoi* accessions CIAT 18744 and CIAT 22160 on 2 ha, respectively (Photos 35, 36). The associations were fertilized at establishment with 50 kg/ha N, P, K, respectively, and 20 ka/ha Mg. After two years a maintenance fertilization of 18 kg/ha N and 46 kg/ha P was applied. Standardization cuts were carried out at the end of each dry season.

Photo 35. Grass-legume association *B. brizantha* cv. Toledo (CIAT 26110) – *Arachis pintoi* CIAT 18744/22160 at Wibuse, San Dionisio, Nicaragua.

Photo 36. Grass-legume association *B. brizantha* cv. Marandú (CIAT 6780) – *Arachis pintoi* CIAT 18744/22160 on a steep slope at Wibuse, San Dionisio, Nicaragua.

A total of 16 cows of similar breed, age and stage of lactation grazed the four grass-legume association were arranged in a completely balanced crossover design during 5 cycles from the beginning of the wet season 2002 through the dry season 2003-2004 (Table 68).

Table 68. Completely balanced cross-over experimental design for milk production assessment of four grass-legume associations in San Dionisio, Matagalpa, Nicaragua, 2002-2004.

Animal No.	Group	Rotation period: Days 1-14	Days 15-28	Days 29-42	Days 43-56
1-4	1	D Bb26110	B Bd606	A Bhd6133	C Bb6780
5-8	2	B Bd606	C Bb6780	D Bb26110	A Bhd6133
9-12	3	A Bhd6133	D Bb26110	C Bb6780	B Bd606
13-16	4	C Bb6780	A Bhd6133	B Bd606	D Bb26110

Milk production of each cow was recorded throughout the experiment. The 14 days of each rotation were split in a 7-days adjustment period, in order to avoid residual effects, and a 7-days recording period. Animals were milked once a day leaving one quarter to the calf.

Results and Discussion

Average milk production/cycle for the grass-legume associations are presented in Table 69. Although the *B. brizantha* cv. Toledo (CIAT 26110) – *Arachis pintoi* CIAT 18744/22160 association showed the highest milk production, no significant differences could be established for the first cycle upon the onset of the wet season 2002. The cycle conducted in late 2002 resulted in increased production in the association with *B. brizantha* cv. Marandú, but again no significant differences between the four associations were recorded.

For the dry season cycle of 2003 a decline in production was observed in all pastires. However, in the wet season cycle in 2003 production levels were generally increased (up to 100%) probably due to the standardization cut and application of the maintenance fertilization. Associations with the grasses *Brachiaria brizantha* cv. Toledo (CIAT 26110), *Brachiaria brizantha* cv. Marandú (CIAT 6780), and *Brachiaria decumbens* (CIAT 606) outperformed significantly the association with *B. humidicola* (*dictyoneura*) which showed the lowest milk yields throughout all cycles. In the dry season cycle 2003/2004 increasing signs of weed infestation and thus degradation could be observed in the *B. humidicola* (*dictyoneura*) association.

Average daily milk production/animal (Table 70) followed the same general patterns as described in Table 68. Milk production with the locally available breeds can reach up to 6.17 L/day, which represents nearly 100% increase over what is obtained with local pastures. Although production of the legume-based pastures decreases in the dry season cycles, the production level still exceeds 3 L/animal and day, when a large number of small livestock holder do not produce any milk at all. Dry matter yields of the different grass and legume components in the 5 grazing cycles are presented in Table 71.

Table 69. Average milk production (L) per grazing cycle in four different grass-legume associations at Wibuse, San Dionisio, Nicaragua, 2002-2004.

Association with *Arachis pintoi*	Average milk production (L) per grazing cycle: Max 2002	Max/Min 2002/2003	Min 2003	Max 2003	Min 2003/2004
B. brizantha cv. Toledo	259	224	193	530	367
B. Brizantha cv. Marandú	195	289	184	557	358
B. decumbens	209	239	198	419	353
B. humidicola (dictyoneura)	158	151	156	395	212*

(*species significantly different at p<0.05; Ryan-Elliot-Gabriel-Welsh Multiple Range Test)

Table 70. Average milk production (L) per animal and day of four different grass-legume associations at Wibuse, San Dionisio, Nicaragua, 2002-2004

	Average milk production (L) per animal and day				
Association with *Arachis pintoi*	Max 2002	Max/Min 2002/2003	Min 2003	Max 2003	Min 2003/2004
B. brizantha cv. Toledo	6.17	4.12	3.78	5.41	4.36
B. Brizantha cv. Marandú	5.56	4.44	3.29	5.69	4.26
B. decumbens	5.10	4.43	3.60	5.83	4.20
B. humidicola (*dictyoneura*)	5.62	3.51	3.28	5.44	4.05
Legume-grass association (average)	5.61	4.13	3.49	5.60	4.22
Local pastures (average Wibuse)*	3.0 -3.5	2.0-3.0	0-1.5	3.0 -3.5	0-1.5

(* Results of survey at micro watershed level)

While DM yields observed in *B. brizantha* cv. Toledo (CIAT 26110) were low in the first grazing cycle, the grass showed its full potential and good adaptation throughout the experiment with high dry matter yields, especially in the dry season as compared to *B. brizantha* cv. Marandú (CIAT 6780) and *B. decumbens* (CIAT 606). *B. humidicola* (*dictyoneura*) produced the lowest dry matter yields of all grasses.

The dry matter yields of *Arachis pintoi* differed considerably between the dry and wet season. The legume associates well with *B. brizantha* cv. Toledo, probably due to the higher water availability in this grazing area (see Photo 35). *Arachis pintoi* yields in the association with *B. brizantha* cv. Marandú (CIAT 6780) declined over time to the extent of only representing 2% of the total dry matter on offer. The legume percentage of all other associations levelled out at 10%.

The experiment demonstrated the high production potential of the grass –legume associations evaluated in both seasons. The grass-legume associations evaluated seem to be well adapted to the harsh conditions of the Central American hillsides with the exception of the low yielding *B. humidicola (dictyoneura),* which showed signs of degradation after 3 years of grazing. During field days farmers were especially interested in results with *Brachiaria brizantha* cv. Toledo (CIAT 26110) given that the grass showed rapid regrowth at the beginning of the

Table 71. DM yields (kg/ha) of four different grass-legume associations at Wibuse, San Dionisio, Nicaragua, 2002-2004.

	DM yield (kg/ha)				
Grass-legume associations	Max 2002	Max/Min 2002/2003	Min 2003	Max 2003	Min 2003/2004
Grass component					
B. brizantha cv. Toledo	1028	14962	8827	22416	19919
B. Brizantha cv. Marandú	3446	16608	8506	25478	16170
B. decumbens	4992	14305	8712	16479	14726
B. humidicola (dictyoneura)	2471	11331	6971	10550	12155
LSD (0.05)	2923	ns	ns	10544	ns
Legume component					
B. brizantha cv. Toledo	1112	3709	1028	2307	1817
B. Brizantha cv. Marandú	492	1400	545	619	393
B. decumbens	462	1646	518	1018	1634
B. humidicola (dictyoneura)	848	2157	727	1491	1526
LSD (0.05)	480	1692	ns	1670	ns

rainy seasons, produced high dry matter yields, and associated well with *Arachis pintoi* (Photo 37).

Since new forage materials are now available, e.g. *Brachiaria* hybrids with improved dry season tolerance, preparations began in September 2004 to establish a new grazing experiments in San Dionisio to assess the production potential of these materials in the dry hillsides of Nicaragua. The effect of *Arachis pintoi* on animal production under dry hillsides condition has to be further explored, as well as the search for a drought-tolerant pasture legume that associate well with the new generation of *Brachiaria* grasses.

Photo 37. *B. brizantha* cv. Toledo (CIAT 26110) associated with *Arachis pintoi* CIAT 18744/22160 at Wibuse, San Dionisio, Nicaragua.

4.1.10 Potential and constraints of cowpea (*Vigna unguiculata)* in Honduran hillsides: A farmers' assessment

Contributors: C. Reiber, R. van der Hoek, V. Hoffmann, R. Schultze-Kraft (University of Hohenheim), H. Cruz and M. Peters (CIAT)

Rationale

Deteriorating soil fertility, low crop yields, food shortage and inadequate supply of animal feed in particular during the dry season are some of the problems faced by poor smallholders in the central-northern Honduran hillsides. To address these challenges CIAT investigates the potential of various multipurpose forages for improving smallholder production systems. In this context cowpea (*Vigna unguiculata*) was identified as a promising multipurpose legume that can play an important role for human nutrition, animal feed and soil improvement.

Material and Methods

Cowpea is the most important pulse and staple crop in West and Central Africa, with similar importance as the *Phaseolus* bean in Central America. While in other parts of Honduras cowpea has been cultivated since the time of the first settlers, in 2002 different cowpea accessions were introduced to farmers of the Yorito area. These materials were tested at different altitudes. The objective of this research is to assess the biophysical and socio-economic opportunities and constraints of different cowpea accessions for integration into smallholder farming systems. Considering theories on adoption and diffusion of innovations (with special focus on cover crop technologies) and the hypothesis of this work that the further use of cowpea depends on its relative advantage compared to common bean (or other crop innovations), the following research questions are addressed:

1. What are the most severe problems perceived by farmers?

2. What is farmers' perception of the potentials (benefits/opportunities) and constraints of cowpea?

3. Which accessions are the most promising?

4. What is the potential for adoption and diffusion?

Participatory evaluations structured interviews based on a standardized questionnaire were conducted with all farmers in the Yorito area experimenting with cowpea. The questionnaire focused on the experience farmers had so far had with cowpea (and other "new" crops), on the management of the trials and on the perception of differences (advantages and disadvantages) between cowpea and common bean. During group meetings the taste of different cowpea accessions prepared in different forms and the seed appearance (both consider common bean) were evaluated and ranked. Important crop characteristics (e.g. yield, taste, resistance) were ranked using the matrix ranking method. Farmers' perspectives and assessment criteria were complemented by formal measurements (yield, biomass).

In order to better assess cowpea acceptance and its potential for adoption it was crucial to focus not only on cowpea itself but also on experiences with other 'new' multipurpose leguminous crops (acceptance, constraints and diffusion status), general objectives of farmers, farmers' assessment criteria as well as its complementarity with common bean.

Results and Discussion

The following results were obtained:

1. Most severe climatic and agricultural problems perceived by farmers are: a) Increasing temperatures, decreasing predictability and increased variability of rainfall distribution. Drought, storms and heavy rains tend to become more extreme; and b) decreasing soil fertility and increasing presence of pests and diseases in common bean. This leads to food insecurity for farmers living in the hillsides possessing no or only little (infertile) land and who can't afford buying inputs and/or food.

2. Farmers' perception of the major potential (advantages) of cowpea is the high drought tolerance, low disease infestation, good taste, yield, biomass production and the high acceptance of the green edible pods. Mainly due to its multipurpose use and its similarity to common bean cowpea was assessed as better than other crops like soybean (*Glycine max*), mucuna (*Mucuna spp*.), pigeon pea (*Cajanus cajan*), dolichos (*Lablab purpureus*) and canavalia (*Canavalia ensiformis*).

3. Major constraints (disadvantages) of cowpea were the low adaptability to altitudes above 1500 m.a.s.l. and problems due to 'pulgón' (Aphis craccivora), leaf-cutter ants (Atta spp.) and rabbits.

4. The most promising accessions for grain production were FHIA, IITA 716 and CIDICCO 2; for biomass production as feed and green manure cv. Verde Brazil and IITA 637/1; suitable dual-purpose accessions were CIDICCO 1, CIDICCO 2, CIDICCO 4, IITA 284/2 and IITA 9611.

5. Farmers are still in a trial and evaluation stage. They continue to test different accessions on a small scale. Cowpea has a number of characteristics that can facilitate adoption at a larger scale and diffusion. It matches farmers objectives, it is rather complementary than substitutive, has the potential to remove bottlenecks (food scarcity (esp. March-June), low soil fertility, lack of high quality feed) and farmers regard cowpea as a feasible option to improve their livelihoods.

6. Due to its relative advantages compared to common bean concerning disease and drought tolerance, less input requirements and high biomass production to increase soil fertility and reduce danger of soil erosion, the combination of cowpea and common bean can contribute to increase short-term as well as long-term food security.

Based on the above listed aspects, the potential for adoption and diffusion of cowpea is high, mainly as a complement to common bean.

It is recommended that in order to facilitate further adoption the organizations involved (e.g. FIPAH, DICTA and CIAT) continue to work with farmers in conducting participatory research on cowpea, supply information on its importance and its management (cropping methods, integrated pest control) and look for varieties (not excluding other multipurpose leguminous species) that are more resistant to pests, more tolerant to cold, waterlogging and shade, and mature evenly.

4.1.11 Farmer Participatory Research: Selection and Strategic Use of Multipurpose Forage Germplasm by Smallholders in Production Systems in Hillsides of Central America

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Rationale

The goal of the project (funded by BMZ, Germany) was to increase the diversity of forage germplasm based technologies available to small farmers to enhance crop and livestock productivity in the Central American hillsides. Specifically the objective was to adjust participatory methods to develop forage-based technologies adapted to the needs of different types of farmers and farming systems in hillsides environments. The project was executed by a team of researchers from CIAT (Forage Genetic Resources, Geographical Information Systems, Participatory Research and Soils) together with farmers, development projects, Non-Government Organisations (NGOs), NARS and other relevant institutions from the region and Germany.

Some of the main strategies followed by the project were:

1. Farmer Participatory research was combined with strategic and applied research. The project applied and, when needed, developed participatory methods for research with farmers involving the targeting, testing and evaluation of multipurpose forage germplasm in diverse production systems. The participatory research focused on crop-livestock interactions and the development of methods for farmer evaluation of forages with combined animal feed and soil quality traits as well as other key traits to farmers. In the *Promotion of seed multiplication efforts* – with farmers' involvement – we placed special attention to opportunities to increase farm income from seed production. This was designed to promote feedback to researchers and early adoption of technologies, which ensures continued diffusion of developed technologies beyond the project lifespan and areas of direct intervention.

2. Strategic on-station research complemented Participatory research on methods for the simultaneous evaluation of feed and soil quality traits to improve research efficiency in the development of multipurpose forage germplasm.

3. Forage germplasm responding to particular demand of farmers was identified and evaluated and particular emphasis was given to annual legumes for multipurpose uses

4. Targeting of germplasm for different uses and environments integrated information on agro-ecological and socio-economic adaptation generated by researchers thereby improving

the selection of germplasm for specific environments and production systems (details reported in Section 4.7.2).

5. Dissemination of results to smallholder farmers in the hillsides at reference sites and other places in the region through joint work with other relevant organizations (development projects, NGOs, farmer organizations, governmental agencies etc.) focused on extension and application of technologies. The work of these organizations was strengthened by the project through participation in the research process, training in the appropriate use of technologies, and use of specific methodologies.

6. Collaboration of local, country and regional organizations was achieved through active networking. The participating institutions can extrapolate and scale-up project results to other communities in participating countries and other countries of the region and, regarding methodology, outside the region.

Major Findings

Development of participatory research methods to identify and evaluate multipurpose crop (forage) based technologies (PhD thesis of Rein van der Hoek and Luis Alfredo Hernández, Prof. V. Hoffmann, University of Hohenheim)

A key objective of the research conducted in Central America was to understand how interactions between people, biophysical and socio-economic environments affected decision-making processes in selecting forage technologies. The research (and development) process used a range of different approaches and types of experimentation that fostered farmer involvement. Since forage technologies have different management requirements and end-uses, the research identified the approaches that were best able to facilitate the adoption of specific forage technologies.

Figure 47 is a summary representation of the R&D approach employed by the project. The left side presents the initial conditions consisting of the different perspectives (Participatory research) surrounded by the contextual elements consisting of the human environment (Farmers' perspective), the biophysical environment (Farming systems perspective) and the technology intervention (Multipurpose forage crop perspective). The right side displays – and the research procedure as affected by the processes and the expected conclusions.

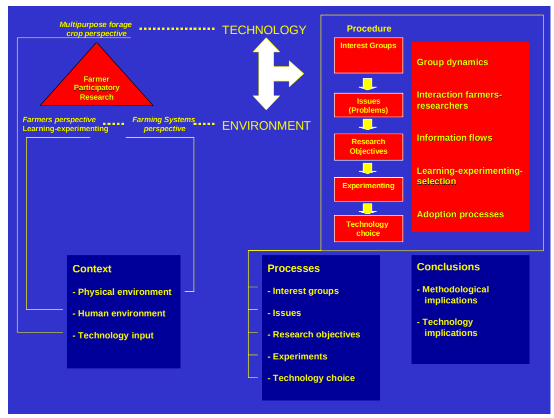

Figure 47. Forage participatory research approach.

The comprehensive methodology included problem identification and prioritization, farming system analysis, formulation of research objectives and implementation and evaluation of experiments. All of these activities were conducted using participatory methods to better appreciate farmers' demands. In the final analysis, the detailed descriptions of processes, methods and approaches were used to define strategies for different farmer interest groups (Note: Under method we understand a specific set of steps to follow to obtain a specific result; under approach we understand a combination of methods and the (philosophical) framework to reach the purpose that smallholder farmers utilize multipurpose forages and technologies suitable to their conditions).

A procedure that is widely applicable and scalable was developed. The procedure integrates the analysis of quantitative and qualitative data from farmer participatory experiments, thus allowing the simultaneous selection of forage materials by farmers and the feed back to and hence better targeting of on-station research. Since the procedure is applicable across countries and not location specific, it can be adapted to widely different production systems. Application and testing in Colombia is underway as part of a different research project.

The procedure comprises the following steps:

a. *Diagnosis, training and planning:* Identification of institutional collaborators and sites and exposing farmers (and technicians) to a range of forage options.
b. *Exposing farmers to different forage options:* A range of methods from nurseries for farmer selection and evaluation to demonstration plots to farmer led experimentation is employed.
c. *Database development.* A central database that includes information on farmer selection criteria across sites was developed.
d. *Selection criteria* for forage technologies, based on farmer input. Farmers refer to these criteria (such as dry season production, ease of establishment) for assessing forage technologies.
e. *The criteria* are then *stratified* according to their similarity to allow a qualitative analysis. I.e. different farmers in different regions utilize different terminology, which need to be translated into and grouped.
f. *Criteria analysis* to determine relative importance using summary statistics (frequencies), Principal Component Analysis (PCA) and/or Factorial Correspondence analysis.
g. *Final analysis and interpretation* of data to identify technologies that match farmers' demands, and consequently are more likely to be adoptable.
h. *Supporting activities:* training modules of high farmer interest complement the R&D process. Seed production technology is an example of such training, along with pasture management.

Farmer involvement in the germplasm selection process increased their knowledge and confidence to progressively assume more responsibility in evaluating technology options. In cycle 1 of the process, farmers were exposed to new forage options. Smaller areas (nurseries) were planted and a large part of the investment risk was assumed by scientists/technicians. According to their limited resources (land, time, capital), farmers selected or rejected technology components, utilizing their own criteria. Through interactions with technician/researchers and experimenting with technologies suitable to their farming conditions farmers gained knowledge and experience on forage germplasm traits and management, leading to an improved farmer ability in employing such technologies on a wider scale at a reduced risk. As a result in cycle 2, farmers increasingly planted larger areas and experimented with more forage species (Figure 48).

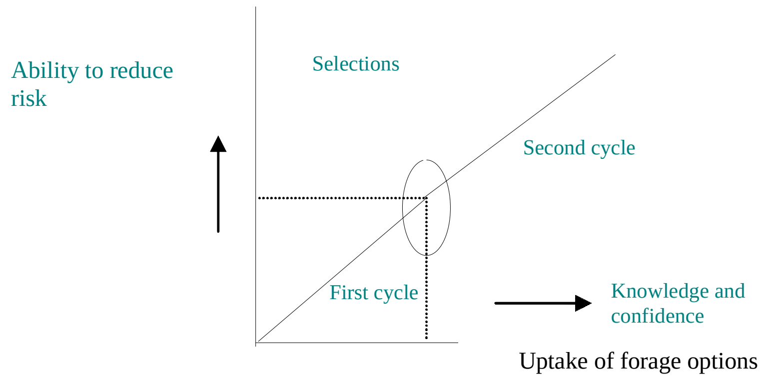

Figure 48. Relation of ability to reduce risk and uptake of forage options over different cycles of a Participatory procedure to forage selection and development.

Another result of the dialogue between farmers and researchers was a build-up of shared knowledge, trust and confidence. In our framework, we assume that knowledge and experience and the ability to take risk are correlated, hence both increase over time as a result of iterative learning process. Farmers were enabled to plant larger areas of chosen technology options, increasingly managed, adapted and adopted by themselves. Technicians/ scientists gain knowledge by monitoring and analyzing these processes. As part of this process, farmers are also enabled to evaluate more complex technologies.

The different selection criteria obtained through farmer participatory evaluation were classified using Principal Component Analysis and Factorial Analysis of Correspondence to reduce variability and identify priority criteria. The Factorial Analysis of Correspondence was particularly suitable to incorporate quantitative and qualitative data. According to a cross tabulation of frequencies across all forage technologies (i.e. grasses, shrubs, herbaceous legumes, and green manures), plant color was the most important criteria in farmer assessment. Across seasons, this parameter was given more importance in the dry season (greater frequency), indicating the importance of alleviating a feed constraint that farmers face during the 5 to 6 dry months. Yield was the next important criterion, followed by cover, leafiness and competitiveness. The analysis then disaggregates the forages into specific technologies, i.e. grasses, shrub legumes, green manure and cover legumes (data not presented in detail, see Annual Report to BMZ 2002 and CIAT Annual Report 2003, page 151-152).

Specific forage-based technologies selected by farmers: Forage technologies were classified into grasses, shrub legumes, short-term multipurpose legumes, and green manures. Over the wet and dry seasons *Brachiaria brizantha* cv. Toledo and *Brachiaria* hybrid cv. Mulato were the grasses that best matched to farmers´ criteria, the latter having a particular high acceptance in the dry season. Farmers preferred the grasses because of their growth, drought resistance and seed production characteristics, which enables them to increase pasture areas and to generate income by selling seed. Even non-cattle owners could plant pastures and produce seed.

The grasses are suitable to altitudes up to 1600 meters. For cut and carry purposes, *Pennisetum* sp. Camerún and King Grass almost always produced satisfactory results, the former was slightly preferred because of the absence of '*guate*', which causes itching while carrying the stalks. Among the shrub legumes, the most preferred species across seasons were *Leucaena leucocephala* CIAT 17263 and *Cratylia argentea* CIAT 18668, the latter especially attractive for its outstanding drought tolerance. There was a limitation of *C. argentea* at higher altitudes and a constraint of slow establishment under alkaline soil conditions. Among the short-term multipurpose legumes, cowpea is of considerable interest to farmers due to its high versatility of use in systems to improve food security, enhance soil fertility and animal nutrition. System trials to define the best temporal niches for cowpea are still underway. Among the forage materials used for green manure, crop residue improvement and green manure *Canavalia brasiliensis* gained increasing acceptance by farmers mainly due to its vigorous growth, drought tolerance and adaptation to a wide range of environments, including soils of very low fertility.

Farmers were less interested in herbaceous legumes for pasture improvement than in grasses, green manure/cover crop and shrub legumes. However *Centrosema pubescens* CIAT 15160 had the highest overall attributes related to farmers´ criteria, with *Centrosema plumieri* being an additional option for the dry season and *Stylosanthes guianensis* CIAT 11844 and *Arachis pintoi* CIAT 22160 potential options for the wet season.

Lessons Learned: Main lessons learned from the project are summarized as follows:

1. Results from participatory evaluations can be analyzed not only qualitatively but also quantitatively. In addition to a more profound understanding of farmer demands, participation allows feedback and better targeting of on-station research results

2. Different entry points for forage technologies need to be evaluated. In Central America, farmers first selected forage grasses followed by shrub legumes and cover crops. Herbaceous legumes for grass-legume mixture are a more complex technology requiring more time for adoption

3. Participatory methods for forage germplasm selection are different from those for more complex technologies such as forages for soil improvement, silage and grass-legume pastures. The latter require more learning processes. A successful uptake of forage germplasm options is, however, an entry point for the adoption of more complex technologies. To achieve wide scale impact, these differences should be acknowledged by future projects with more easily adoptable technologies before moving into more complex ones.

4. A strong demand from farmers to address particular production system constraints along with proven success and good relations between scientists/technicians and farmers encourages farmers to experiment and adapt technologies. Such efforts often continue even in the case of initial failures. In our project, the variable results with the shrub legumes *Cratylia argentea* on soils with higher pH leading in some cases to poor performance at least in the year of establishment serves an example. As farmers recognize the potential of the technology – as it has been demonstrated to function at some sites - they make an effort to improve management or test the technology at other sites.

Future Research Needs: The project identified a need to further develop forage alternatives for the dry season. A potential for silage and hay technologies adapted to smallholder situations has become evident. Either livestock or non-livestock owners can produce these silages and hays. Research is needed to define the usefulness and acceptability by farmers of such technologies through on-station and on-farm studies. Further research is also needed into the facilitation of farmer innovation, focusing on the adaptation of new forage-based products to smallholder farm constraints, and innovations that facilitate a market between producers and end users. Success in this area would have an impact on income generation and livelihoods of smallholder farmers. The efficiency of approaches facilitating innovation versus more traditional extension approaches needs to be evaluated (i.e. promotion of innovation versus promotion of adoption). Such research should be cognizant of the changing role of NARS in technology delivery. It is anticipated that through the facilitation of innovation, better-adapted forage technologies will emerge and demands for alternative technologies articulated.
The two above mentioned research questions are the core of the recently funded BMZ proposal ‘Demand-Driven Use of Forages in Fragile, Long Dry Season Environments of Central America to Improve Livelihoods of Smallholders’.

4.1.12 Potential and constraints for animal feed as an objective of poor farmers in Central-America

Collaborators: R. van der Hoek (University of Hohenheim), M. Peters (CIAT), V. Hoffmann (University of Hohenheim), and H. Cruz Flores (CIAT)

Rationale

Multipurpose forage crops can play an important role in improving the environmental and socio-economic sustainability of smallholder production systems in fragile environments. However, since the forage technology development framework has not been sufficiently applicable for poor farmers, adoption of especially legumes has been generally low (Peters *et al.*, 2001). In a participatory research effort with smallholder farmers in Honduras, focused at forage-based technologies, food security turned out to be the main selection criterion whereas animal feed was secondary. Since animal feed related activities (farmer-led forage seed systems, production of dry season feed) have been identified as promising income generating options for poor farmers in the hillsides of Central-America, a further analysis was carried out to identify the (mainly household related) factors inducing or inhibiting farmers to opt for production of animal feed.

Materials and methods

A group of 150 farmers with different levels of resource endowment representing the typical maize and beans based agricultural system of central Honduras conducted over 200 experiments in their own fields with several grasses (e.g. *Brachiaria brizantha*), leguminous crops (mainly several varieties of *Vigna unguiculata*) and shrubs (e.g. *Cratylia argentea*).

The choice of research methods and parameters was determined simultaneously by both farmers and researchers. A dichotomous logistic regression model was used to examine the variables influencing the inclusion of animal feed as an objective (Table 72). The independent variables were identified by a Principal Component Analysis.

Results and Discussion

Altitude had no significant influence on the inclusion of animal feed production as an objective. Full or semi landownership increased the chance of feed being an objective by 24%, controlling for other variables in the model (p=. 005).

Farmers who depend on purchased maize from outside are 17% more willing to include feed production as an objective than those who are self sufficient in maize production (p=. 025). Every extra 100 kg/ha urea application on maize increases the chance of feed being an objective by 22% (p=. 025). A yield increase of 100 kg/ha maize augments the chance of feed being an objective by 1% (p=. 033). An increase of one unit of cattle increases the chance of feed being an objective by 2% (p=. 001).

In summary, results indicate that farmers owning land, applying fertilizer and owning cattle are more likely to include animal feed as a research and production objective than the poorer farmers, except for those who are not self-sufficient in maize. Farmers without full decisive power over their land are reluctant to engage in animal feed production for sale in the market. Whereas research and development work can continue to be directed at all farmer categories in Central-American hillsides, special attention is justified for farmers without full land ownership and those who depend on outside acquired basic grains for their food security.

Table72. Definition of variables used in animal feed regression model.

$$\ln(\text{ObjectiveFeed}) = \beta_0 + \beta_1\text{Altitude} + \beta_2\text{LandTenure} + \beta_3\text{BuyMaize} + \beta_4\text{Ureamaiz}$$
$$\beta_5\text{MaizeYield} + \beta_6\text{CattleNr} + e_i$$

Variable	Definition
Objective Feed	1: yes, 0: no
Altitude	1: low (< 800 masl), 0: other (? 800 masl)
Land Tenure	Land tenure: 1: full or semi land ownership, 0:
Buy Maize	Maize bought for consumption: 1: yes, 2: no
Urea maize	Level of urea application on maize (kg/ha)
Maize Yield	Maize yield (kg/ha)
Cattle Nr	Number of cattle

4.1.13 Multilocational analysis of a collection of cowpea targeted to multipurpose needs of clients in hillsides of Central America and Colombia

Contributors: M. Peters, A. Schmidt, P. Argel, H. Cruz, C. Davies, L. H. Franco and G. Ramirez (CIAT)

Rationale

A Genotype x Environment experiment was conducted to test the performance of cowpea selected accessions across sites and to identify the most resilient accessions to recommend over a wide range of environments. An adaptability index was calculated to assess the response of a set of 14 cowpea accessions accross different climates and soils in Honduras, Nicaragua, Costa Rica and Colombia. Accessions best adapted across environments but responding to improved environmental conditions were IT90K-284/2, IT89KD-391, IT95K-1088/4, IT95K-1088/2, IT86D-716, IT93K-637/1 (Figure 49). In farmer participatory evaluations in Honduras and Nicaragua IT90K-284/2 was selected as one of the most preferred materials due to superior agronomic performance in terms of forage and grain yield (dual purpose type).

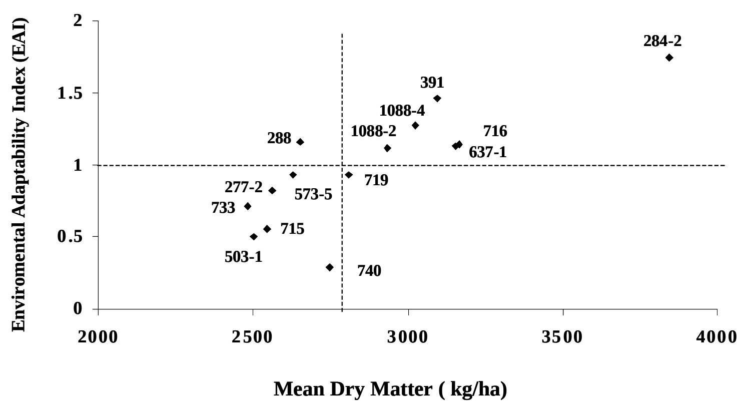

Figure 49. Adaptability Index for dry matter production of a collection of *Vigna unguiculata* evaluated in contrasting environments in Honduras, Nicaragua, Costa Rica and Colombia.

4.1.14 Promotion of seed multiplication and scaling of forage options in Hillsides of Honduras and Nicaragua

Collaborators: H. Cruz, M. Peters, A. Schmidt, L.H. Franco, G. Giraldo, (CIAT), C. Burgos (DICTA), M. Mena (INTA) and C. Davies (CIAT)

Rationale

The adoption of forage technologies is intimately related to the availability of good quality seed at reasonable prices. Therefore, taking into account the current seed market in Central America, the promotion of seed supply systems with a focus on farmer-led enterprises is one of our strategies for scaling up selected forage technologies. At the same time, seed production offers a means of income for small farmers.

Honduras

A farmer group in Honduras working now under their own label – ‘PRASEFOR’ (Productores

Artesanales de Semillas Forrajeras) produces seed since 2002; this farmer- led seed enterprise was established with very limited financial support (i.e. less than US $ 2.000), hence the approach could easily be replicated at other locations. The farmers in PRASEFOR, with assistance from NARS and NGO partners, are constantly exploring market demands. Seed quality and packaging were identified as important criteria to meet seed production targets for the local and wider market. In 2002, production in Honduras began with 400 kg of seed. During 2003 a total of 1,200 kg of *Brachiaria brizantha* cv. Toledo was produced by the 15 members of PRASEFOR on 17 ha, and for 2004 the production target is >1.6 tons. The warehouse to store seed was finished during 2004.

Since the formation of this enterprise, farmers have doubled their seed production areas and are still expanding. The total market value of the seed produced in 2003 reached 14,600 US$, turning seed production into a highly profitable operation for theses farmers. Though the initial focus was on grass seed production (*B. brizantha* cv. Toledo), the enterprise is now exploring the feasibility of diversifying into seed production for the shrub legume *C. argentea*, annual legumes such as cowpea for the elaboration of feed concentrates, and maize for silage.

Nicaragua

In Nicaragua we are also promoting farmer-led forage seed systems with groups of farmers in Pantasma, Jinotega. With technical assistance from INTA, a total of 5 farmers harvested 110 kg of classified seed of *Brachiaria brizantha* cv. Toledo in December 2003. Half of the seed where sold in the region, the rest was utilized by the group to expand their own pasture areas. During 2004, based on these experiences, INTA established in all regions seed multiplication plots in collaboration with farmers adding up to 7 ha of *Cratylia argentea* and 4.5 ha of *Brachiaria brizantha* cv. Toledo. Together with INTA's seed production unit (UNISEM) a forage seed production plan covering all regions of Nicaragua (Table 73) was developed focusing mainly on grasses with high demand (*B. brizantha* cv. Marandu, cv. Toledo, *P. maximum* cv. Tanzania) and *Cratylia argentea*. It is expected that at least one farmer group/ enterprise will be formed in each region providing good quality seed at reasonable prices. In contrast to the above mentioned groups, the PES ("Pequeña Empresa de Semillas") at San Dionisio, Matagalpa, which normally multiplies maize and bean seed, addressed the growing demand for *Vigna unguiculata* (cowpea) and *Canavalia brasiliensis* harvesting 50 kg of cowpea and 15 kg of *Canavalia brasiliensis* to be sown by farmers in the postrera season 2004. Areas will be expanded in 2004/2005 and *Lablab purpureus* will be also included on the multiplication list in San Dionisio. Discussions with larger scale seed distributors in Central America have been initiated to enhance the demand for farmer-led seed production.

In summary, seed production offers an income opportunity to smallholder farmers. For farmer-led seed enterprises to be sustainable over time, they need to be based on a sound business plan. On the other hand, for sustained uptake of forage technologies, a focus on interested farmers and the sustainability of forage seed enterprises is crucial. Support to farmers in provision of seed and free inputs should be limited; in particular not to compete with farmer-led enterprise activities. Rather than large and financial support, there is a need to invest time with farmers and in providing basic seed material for initiating small plot on farm testing and seed multiplication.

Scaling forage technologies in Honduras and Nicaragua:

Scaling and adoption of forage options depends to great extent on availability of good quality seed, socio-economic constraints and farmer knowledge about characteristics and specific features of forage technology options. The approach developed by the project since 2000 combines these elements with participatory selection procedures.

Table 73. Seed production plan (UNISEM-INTA-CIAT) 2005-2008 for Nicaragua.

Year	2005		2006		2007		2008		Total	
Species/Region	Area (ha)	Seed (Kg)	Area (ha)	Seed (Kg)	Area (ha)	Seed (Kg)	Area (ha)	Seed (Kg)	Area (ha)	Seed (Kg)
Marandú										
Pac. Norte	5	100	5	150	5	150	5	150	20	550
Pac. Sur	5	100	5	150	5	150	5	150	20	550
Las Segovias	0	0	0	0	0	0	0	0	0	0
C. Norte	0	0	0	0	0	0	0	0	0	0
C. Sur	0	0	0	0	0	0	0	0	0	0
Total	10	200	10	300	10	300	10	300	40	1100
Tanzania										
Pac. Norte	5	400	5	850	5	1300	5	1750	20	4300
Pac. Sur	4	320	4	680	4	1040	4	1400	16	3440
Las Segovias	0	0	0	0	0	0	0	0	0	0
C. Norte	0	0	0	0	0	0	0	0	0	0
C. Sur	0	0	0	0	0	0	0	0	0	0
Total	9	720	9	1530	9	2340	9	3150	36	7740
Toledo										
Pac. Norte	0	0	0	0	0	0	0	0	0	0
Pac. Sur	8	360	8	880	8	1400	8	1920	32	4560
Las Segovias	10	450	10	1100	10	1750	10	2400	40	5700
C. Norte	10	450	10	1100	10	1750	10	2400	40	5700
C. Sur	10	450	10	1100	10	1750	10	2400	40	5700
Total	38	1710	38	4180	38	6650	38	9120	152	21660
Cratylia										
Pac. Norte	2	0	3	800	3	2000	5	3200	13	6000
Pac. Sur	4	0	4	1600	4	3200	4	4800	16	9600
Las Segovias	0	0	0	0	0	0	0	0	0	0
C. Norte	5	0	5	2000	5	4000	5	6000	20	12000
C. Sur	2	0	3	800	3	2000	5	3200	13	6000
Total	13	0	15	5200	15	11200	19	17200	62	33600

In Tables 74 and 75 we show results from the adoption of forage options at our reference sites in Nicaragua and Honduras.

In Nicaragua, uptake of forage options is gaining speed. More than 250 farmers in San Dionisio are testing and employing new forage options. Preferred options are *B. brizantha* cv. Toledo and *Brachiaria* hybrid cv. Mulato. However, there is a recent interest in the cover legume *Canavalia brasiliensis* and the shrub legume *Calliandra calothyrsus,* the latter to be used as fuel wood.

In Honduras, approximately 600 farmers are now testing and employing forage options in about 100 ha. The largest areas are planted with *Brachiaria* hybrid cv. Mulato (CIAT 36061) and *B. brizantha* cv. Toledo. The increase in area of Toledo has been driven by the availability of seed mainly through PRASEFOR. Though areas planted are still small, there is an increasing farmer interest in *Cratylia argentea, Vigna unguiculata* and *Lablab purpureus.*

Projects led by the NARS and NGO partners are now employing and adapting the participatory methods developed by CIAT with funds from BMZ. For example, INTA in Nicaragua, is currently establishing in all regions germplasm sites and validation plots which are frequently visited by farmer groups. Other institutions,

Table 74. Distribution of forage materials at reference site San Dionisio, Nicaragua, 2002-2004.

Material	2002		2003		2004		Total	
	Area (ha)	Farmers No.	Area (ha)	Farmers No	Area (ha)	Farmers No.	Area (ha)	Farmers No.
B. decumbens	0.2	4					0.2	4
B. brizantha 26110	1.5	37	5.4	19			6.9	56
B. hibrido 36061	1.8	44	4.1	14	0.7	8	6.6	64
C. calothyrsus			0.3	35			0.3	35
Vigna unguiculata			1.4	35	0.9	28	2.3	63
Canavalia brasiliensis			1.4	35	0.5	6	1.4	41
Total	3.5	85	12.6	138	2.1	42	16.9	263

mainly development projects and NGOs, have initiated similar work to adopt new forage-based technologies. Increasing requests from these projects and organizations for forage germplasm and larger amount of seed, especially of *Cratylia argentea*, are addressed through the already existing farmer-led seed enterprises and/or our Seed Unit in Atenas, Costa Rica. As a result, we have reached now more than 2500 farmers in Honduras and Nicaragua. In 2004, a project was initiated in Colombia utilizing the participatory methods developed in the BMZ funded project. To foster further uptake and expansion, a set of extension publications were published. In addition, an interactive internet-based access to some of the extension publications is in development.

Both the application of results by participating institutions and uptake of forages have exceeded our expectations. An unforeseen success was the formation of income generating, self sustained farmer-led seed enterprises in Honduras. Seed multiplication and area expansion increased very quickly, driven by farmer-seed production. In addition, the utilization of results in other core and special project activities of CIAT and its partners was not anticipated at such a scale.

Table 75. Distribution of forage materials at reference site Yorito, Honduras, 2001-2004

Material	2001		2002		2003		2004		Total	
	Area (ha)	Farmers No.	Area (ha)	Farmers No.	Area (ha)	Farmers No.	Area (ha)	Farmers No.	Area (ha)	Farmers No.
A. gayanus 621	0.2	6			0.1	2			0.3	8
B. dictyoneura 6133	0.6	12							0.6	12
B. brizantha 26110	1.1	25	16.3	19	3.4	37	0.7	6	21.5	87
B. hibrido 36061			12.3	6	45.1	23	0.2	1	57.6	30
P. maximum 16031	0.7	17							0.7	17
P. purpureum	0.6	16	0.5	3					1.1	19
A. pintoi 22160	0.1	1					1.2	2	1.3	3
C. argentea 18668	2.3	15	3.4	24	0.8	6	4.1	9	10.6	54
C. pubescens 15160	0.1	2							0.1	2
L. leucocephala 17263	0.6	11							0.6	11
Lablab purpureus	0.1	1			0.3	30	0.3	11	0.7	42
Vigna unguiculata			0.2	2	1.3	195	5.1	62	6.6	259
S. guianensis 184	0.1	6							0.1	6
M. pruriens IITA BENIN	0.1	1			0.1	1			0.2	2
Canavalia. brasiliensis					0.1	3			0.1	3
Canavalia ensiformis					0.1	6			0.1	6
Total	6.4	113	32.7	54	51.3	303	11.6	91	102	561

4.1.15 Improved dry season feeding systems for smallholder dairy cattle in the hillsides and high mountainous tropics of LAC

Contributors: H.D. Hess (ETH Zurich), A. Schmidt (CIAT), C. Perez (Intercooperation), C.A. Gómez (National Agricultural University of Peru), H.M. Romero (ETH Zurich), H.-R. Wettstein (ETH Zurich), F. Holmann (CIAT/ILRI) and M. Kreuzer (ETH Zurich)

Rationale

This project builds on major outputs of two preliminary activities realized during 2003, in which three major problems related to dry season feeding of dairy cattle in the hillsides and high mountainous tropics of LAC were identified: (i) large gaps in knowledge about effects of feeding measures in the dry season and of high altitude on milk composition; (ii) huge7 variation in availability and quality of feed resources depending on rainfall distribution which directly affects income of smallholder dairy farmers; and (iii) insufficient exchange of information and lack of coordination of current projects of local research and extension institutions.

To address these problems a project was designed with the specific aim of developing more efficient feeding systems in different agro-ecological zones of tropical Latin America, based on local knowledge and locally available and introduced feed resources. We expect to demonstrate how these systems contribute to sustained milk production and improved milk quality during the dry season and reduce the dependence on purchased supplements.

Planned activities

The objective of the project will be achieved through (i) assessing the availability and quality of local forage and feed resources, (ii) identifying experimentally the effects of dry season feeding (independent of high altitude and cow genotype) in milk production and quality, and (iii) designing optimal forage management strategies for dry season feeding in several target regions in Nicaragua and Peru. The participatory assessment of utility and viability of alternative dry season feeding options will be a transversal issue throughout this activity. Involvement of farmers in all proposed activities will allow the simultaneous evaluation of biophysical aspects for research purposes and of utility and viability of the new options for the end-users. By means of including NGOs and various participatory approaches, dissemination of scientifically derived results will take place.

Results and Discussion

Major outputs of a stakeholder workshop held in Managua

The results of a consultation workshop in Nicaragua identified the following factors related to the inadequate nutrition of livestock in the dry season: (a) low availability and quality of forage, (b) limited diversity of forage resources, (c) deficient supplementation with mineralised salts, (d) inadequate use of agro-industrial by-products, (e) lack of knowledge about the nutritional value of feed ingredients, (f) deficient management of pastures and other forage resources, and (g) a lack of dry season feeding options which are adapted to the diverse agro-ecological and socio-economical conditions. On the other hand, the participants were able to identify some 30 available dry season feeding options, of which only three were considered to be widely adopted at present. Namely these were the use of maize and sorghum straws, supplementation with cut and carry grasses and supplementation with purchased grass hay. The reasons for the low adoption rates of the other potential dry season feeding alternatives were high cost and lack of knowledge on the nutritional quality of the feeds and the requirement of animals. In addition to the technical problems, it was clear from the workshop made also clear that there is insufficient exchange of information and a lack of coordination of current projects of national research and extension institutions.

Major results of a survey conducted in Peru

A survey was conducted to collect data and perform analyses on the status of feed resources and milk production and quality on four different farms at contrasting altitudes in the Peruvian Highlands (3200 to 4250 m a.s.l.) during the rainy and the dry season. On three of the experimental farms included in the study, cattle production was based on cultivated pastures (perennial ryegrass and white clover) and one farm relied on native grassland. Forage quality (described as crude protein and fiber content) of cultivated pastures was higher ($P<0.01$) than that of native grassland. On average, milk production per cow was 20% lower ($P<0.05$) in the dry season as compared to the rainy season, but differences among individual farms were large.

While the decrease in milk yield on the most intensively managed farm at 3200 m a.s.l. was only about 10%, milk yield was 30% lower on the most extensively managed farm at 4250 m a.s.l. during the dry season than during the rainy season. Also milk composition was affected by season. Fat, protein and casein concentrations were lower ($P<0.01$) during the dry season than during the rainy season. Differences among farms were large and the decrease in milk constituents was much more pronounced on the extensively managed farm at 4250 m a.s.l. than on the remaining farms. On this farm, fat concentration decreased by over 20% and protein and casein concentration by 10% during the dry season. Because both milk yield and milk quality were decreasing at the same time, the unfavorable effects of the dry season were amplified. When processing the milk to cheese or similar dairy products, the loss of income is multifold as (i) less milk, (ii) less cheese yield due to the lower fat and protein content of milk, and (iii) cheese quality may be impaired due to the less favorable milk renneting properties associated with reduced protein (casein) content. Efficient dry-season feeding strategies are required to overcome this unfavorable situation.

4.2 Partnerships in Asia to undertake evaluation and diffusion of new forages alternatives

Highlights

- The Forages and Livestock Systems Project (FLSP) Laos entered into an expansion phase. District teams doubled the number of villages in which they work a year early than expected. By the end of the 4th rainy season the project expects to be working in >105 villages and with >1300 farmers. New extension approaches have been developed and new cases of impact are emerging and being documented.

- Following successful adoption of forage technologies at project sites in Southeast Asia, the Livelihood and Livestock Systems Project (LLSP) is developing participatory methodologies to improve livestock/forage production systems, including marketing constraints and opportunities.

- The *Brachiaria* Mulato hybrid was by CIAT to Southeast Asia in 1996 as part of a large *Brachiaria* variety trial. In Thailand, The Thai Department of Livestock Development (DLD) selected Mulato and seed production trials were initiated in 2003 with 7 small farmers. This year 1793 farmers planted 700 ha of Mulato to produce 140 tons of seed thanks to a guaranteed market by Papalotla.

4.2.1 The Forages and Livestock Systems Project (FLSP)

Contributors: Viengsavanh Phimphachanhvongsod (Researcher, National Ag. & Forestry Research Institute), Viengxay Photakoun (Researcher, National Ag. & Forestry Extension Service), Peter Horne (Agronomist and Team Leader, CIAT) and John Connell (Extension and Agroenterprise specialist, CIAT)

Rationale

CIAT has been conducting forage research in Southeast Asia since 1992, commencing with forage varietal selection and evaluation, both in experimental plots and on farms, in seven countries. One main outcome of this work was the identification of ~40 broadly adapted and robust forage varieties with demonstrated potential to deliver significant impacts on smallholder farms throughout the region. The outcomes of this research are documented in several CIAT publications (Horne and Stür, 1999; Stür et al., 2000; Stür and Horne, 2002; Stür et al., 2002).

In 2000, CIAT secured funding from the Australian Agency for International Development (AusAID) for a five year project to integrate forage and improved livestock management strategies into upland farming systems of Laos using participatory research approaches. The project works with 36 partner staff from national, provincial and district government agencies, conducting research and extension aimed at:

- Increasing income by improving the productivity of small and large livestock;
- Increasing labor efficiency and reduce women's workloads in the livestock production systems;
- Enhancing sustainable cropping systems by increasing soil fertility and reducing soil erosion; and,
- Sustaining livestock production within the national policy of stabilizing shifting cultivation

Progress with forage technology development

In the first field season (June 2001), the project supported small scale testing on farms during which time farmers tested the forage varieties, sorted out which ones they preferred and wanted to expand. This was a time when the DAFO and PAFO staff also learned about the varieties, their environmental adaptation and the process of working in partnership with farmers.

Building on the experiences of the first year, the second field season (June 2002) was a period of expansion based on targets set by the project (e.g. the number of villages was doubled and the number of farmers tripled) or targets set by farmers (based on the desire to get large enough areas of forages to have some significant quantities of feed for their animals). Farmers sometimes (but not always) reduced the number of varieties and, more significantly, started to look for ways of utilizing the forages to help resolve current problems or to develop new opportunities. During that second year the project challenged field staff with new villages, new technologies and many new farmers to encourage them to move away from a dependence on the very intensive one-to-one processes that had been used in the first field season and move more towards farmer group processes.

Leading up to the third field season of the project (June 2003), some interesting, sometimes novel, often unexpected impacts had started to emerge. The district staff had become very familiar with the processes of working with farmers. Indeed these processes are now becoming their 'comfortable norm' back to which they will retreat naturally, given the support of their organizations. Further expansion will not now be driven by project targets but by impacts. This focus on "impacts driving extension" will continue for the next two wet seasons.

This fourth year (2004) was a year for expansion based on impacts. District teams will double the number of villages in which they work which will mean we almost reach the target number of villages for the project a year earlier than expected. A major focus of this year will be on developing different extension approaches for new farmers and experienced farmers; for new villages and experienced villages. New cases of impacts are emerging and being documented as we go (>20 have been documented so far). We are engaging with the development community to provide another avenue of expansion of impacts. We are also about to embark on a doubling of the numbers of experienced staff. By the end of this fourth wet season we expect to be working in >105 villages with >1300 farmers. District staff estimate that about 350 of these farmers will be experiencing significant livelihood impacts from intensifying their livestock systems. By the end of this season, the project will be supporting the most experienced and confident farmers as field extension workers to help with the expansion of impacts to more people and more villages. The expansion that has occurred in the first four field seasons of the project is summarized in Figure 50.

The total number of farmers working on forage technologies with the FLSP is expected to rise from 803 in 2003 to >1300 in 2004. Of this total, about half are expected to come from new villages. This is a reflection in a change in strategy of the project in 2004.

In 2003, the project focused on:

- Consolidating emerging impacts.
- Expansion to new farmers through emphasis on impacts.
- Emergence of second level problems (such as nutrient decline in cut forage plots) and opportunities (such as improving livestock management to maximizing market returns).
- Documenting cases of impacts for further future expansion.
- An extension approach based on cross visits, village planning meetings and working with separate production groups in villages (small animals, large animals).

In 2004, the project aimed to significantly expand to new villages while consolidating the progress made in old villages. The challenge was how to ‘ramp up’ the expansion beyond the steady increase from year to year that has happened so far? This steady increase has been necessary so that (i) farmers and district staff can learn about technologies and methods and (ii) impacts can be consolidated. Now that both of these have been achieved, we have the chance to scale out.

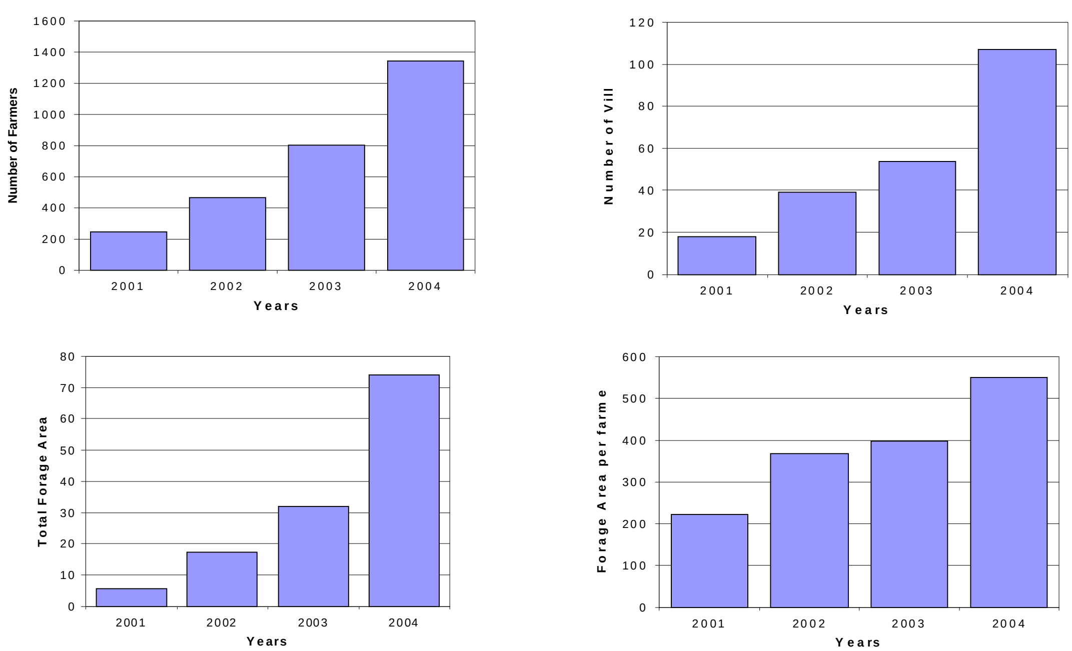

Figure 50. Expansion of number of farmers and area planted with forages as a result of interventions by the FLSP.

The varieties preferred by farmers at this time are *Brachiaria brizantha* cv Marandu, *Brachiaria* hybrid cv Mulato", *Panicum maximum* "Simuang" and *Stylosanthes guianensis* "Stylo 184". Other productive varieties but with particular uses or adaptation are the grasses *Andropogon gayanus* "Gamba", *Paspalum atratum* "Terenos" and *Setaria sphacelata* "Solander" and the legume *Gliricidia sepium* "Retalhuleu".

4.2.2 The Livelihood and Livestock Systems Project (LLSP)

Contributors: Werner Stür, Francisco Gabunada, Phonepaseuth Phengsavanh, Jindra Samson and John Connell (CIAT)

Rationale

The Asian Development Bank (ADB) funded 'Livelihood and Livestock Systems Project' (LLSP) started in January 2003 for a period of three years. The LLSP is a collaborative research for development project bringing together livestock researchers and extension workers in seven countries in Southeast Asia. The purpose of the project is to improve (i) sustainable livelihoods of smallholder farmers in the uplands through intensification of crop-livestock systems, using farmer participatory approaches to improve and deliver forage and feed technologies, and (ii) delivery mechanisms for the dissemination of these technologies.

The LLSP follows the Forages for Smallholders Project (FSP), which developed forage technologies with smallholder farmers and disseminated these to other farmers in target districts in partner countries in Southeast Asia. The activities of the new project are broader as it works with farmers to maximize the benefit from having planted forages through the development of improved livestock production systems (with emphasis on feeding), analysis of production and marketing constraints and opportunities, and the efficient dissemination of new technologies to new areas and farmers. In each partner country, the project collaborates with a national research and/or development agency (Table 76).

Table 76. National coordinating agencies collaborating with the LLSP

Country	National Coordinator	Agency
Cambodia	Dr. Sorn Sam	National Animal Health and Production Investigation Centre, Department of Animal Health and Production, Phnom Penh.
PR China	Prof. Yi Kexian	Chinese Academy of Tropical Agricultural Science (CATAS), Danzhou, Hainan.
Indonesia	Mr. Yakob Pangedongan (National coordinator) Mr. Djodi Suparto (Liaison officer)	Livestock Services of East Kalimantan, Samarinda, East Kalimantan Directorate General of Livestock Services, Ministry of Agriculture, Jakarta.
Lao PDR	Mr. Bounthavone Kounnavongsa	National Agriculture and Forestry Research Institute (NAFRI), Vientiane.
Philippines	Mr. Eduedo Magboo	Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD), Los Baños, Laguna.
Thailand	Dr. Chaisang Phaikeaw	Department of Livestock Development, Ministry of Agriculture and Cooperatives, Bangkok.
Viet Nam	Mr. Le Hoa Binh	National Institute of Animal Husbandry (NIAH), Ministry of Agriculture and Rural Development (MARD), Hanoi.

Within countries, one or more provinces and districts are involved in the project with site coordinators (provincial or district) and several extension workers involved at project sites. A summary of sites and collaborating staff is provided in Table 77.

Table 77. LLSP project sites and partners

Country	Main project sites	Main collaborators	Agencies
Cambodia	Kampong Cham province	Mr. Chea Socheat	Provincial Agriculture and Forestry Office, Kampong Cham
Indonesia	East Kalimantan province	Mr. Yacob Pangedongan and Mr. Ibrahim	Provincial Livestock Services, East Kalimantan and District Agricultural and Livestock Extension offices
Lao PDR	Savannakhet province	Mr. Bounmy Phewvankham	Provincial Livestock Office, Savannakhet
P.R. China	Hainan province	Mr. Yi Kexian and Mr. Tang Jun	Chinese Academy of Tropical Agricultural Sciences
Philippines	Bukidnon and Misamis Oriental provinces	Dr. P. Asis, Ms. N. Jacutin, Ms. G. Cania, Ms. J. Saguinhon	City Veterinary Office Cagayan de Oro and Municipal Agricultural Offices in Bukidnon
Thailand	Nakornratchasim	Ms. Ganda Nakamanee and Dr. Chaisang Phaikaew	Animal Nutrition Research Center Pakchong, DLD
Viet Nam	Daklak and Tuyen Quang provinces	Mr. Nguyen Van Ha, Dr. Truong Tan Kanh and Ms. Vu Hai Yen	Provincial Agricultural Office and Tay Nguyen University, Daklak and District and Provincial Department of Agriculture and Rural Development Tuyen Quang

4.2.2.1 Integrated feeding systems for livestock that optimize the use of improved and indigenous fodders and crop residues, and farm labor

The previous FSP project successfully introduced forage accessions to Southeast Asia (>500 accessions), conducted nursery and regional evaluations to select a set of approximately 50 broadly adapted, robust forage varieties, and evaluated these with smallholder farmers in a broad range of farming systems using a farmer participatory approach. The combination of well-adapted forage varieties and a participatory approach was successful in introducing forages to farmers in systems where no forages had previously been planted, and farmers relied purely on naturally occurring feed resources. As farmers started to integrate forages into their farming systems (e.g. contour hedges, intensive plots near houses, etc.) and use them in a variety of ways (e.g. night feeding for cattle, grasses for fish), the project and its partners started to disseminate forages to other farmers and new areas, using tools such as cross visits, development of multiplication systems (seed and vegetative), and training of extension workers and key farmers. Many of these farmers are expanding their forage areas and receive benefits, such as reduced labor needs for feeding livestock, improved income from sale of animals and manure, improved soil fertility through application of manure, and improved soil conservation by planting of contour hedgerows and cover crops.

However, few farmers are intensifying or expanding animal production and many achieve only a moderate level of animal productivity. Some farmers are feeding insufficient quantities of feed, most farmers are feeding forages that are too old (poor quality) and almost all farmers are feeding insufficient amounts of protein (e.g. protein supplements of forage legumes) to achieve high levels of animal production. At sites with extremely low soil fertility, such as in East Kalimantan, planted and native forages are lacking in minerals required for animal production, leading to poor animal production and susceptibility to diseases. Planting forages has changed the way animals are raised; with many benefits and advantages for farmers. There has been a big increase in the confinement of animals in pens or tethering near houses as farmers now have a feed resource located conveniently near the house enabling them to provide at least supplementary feed to their animals. They do not have to spend time bringing animals to far-away fields for grazing when they are busy with other tasks, and they can collect manure easily, which can be sold or used on their own crops. Also, parasites are less of a problem and animals have less contact with other animals thus limiting the spread of diseases. On the other hand, animals can no longer select the feed they eat but depend on the farmer for selecting the diet and as animals were previously allowed to graze freely farmers have limited knowledge of feed requirements. These issues require a lot of farmer (and extension worker) learning as well as the introduction of new technologies.

The project conducted a review of the most important livestock systems at each site and selected one or two of these systems for intervention by the project. These include cattle fattening, cow-calf production, dairy cattle, cattle for draught and saving, rabbit production, goat production, dairy buffalo, fish production, fresh forage for sale and forage seed for sale. At each site, collaborators held consultations with the communities and formed farmer groups interested to work with the project. Together, they analyzed the production system and identified constraints and opportunities for improvement. They then designed farmer experimentation to evaluate options or designed farmer field school-type training to improve the selected livestock production systems. These are currently being carried out, and results of farmer experimentation and their impact on production improvement will be reported in the next Annual Report.

The main objective of farmer experimentation is farmer (and technician) learning and generating farmers' interest in improving feeding systems; not the collection of accurate data as these is known and predictable. The main strategic output is the process and methods of working with farmers and extension services to intensifying and improving livestock production systems. The project is attempting to combine farmer experimentation with ways of disseminating the generated information by included key farmers and extension workers from other areas with similar livestock production systems in the design, monitoring and analysis of farmer experiments as well as any training associated with experimentation. At one site in Daklak, Viet Nam, site partners also conducted field days and produced videos and television programs of the farmer experimentation.

4.2.2.2 Improved methods to develop forage feed systems and extend them to new farmers, optimizing the use of M&E for feedback to others in the community

An analysis of the process of participatory technology development and dissemination methods and tools used by LLSP partners commenced with three workshops in Viet Nam and is continuing in other countries. Methods clearly vary between sites and countries, with factors such as capacity and enthusiasm of the extension worker, institutional support (and 'culture') for participatory approaches, distance to 'successful forage-feed system examples' and the need for capacity building emerging as important determinants of success. Three scenarios are emerging:

- Dissemination within villages or districts: The simplest form of dissemination is by assimilation; where farmers learn from other farmers nearby who are already at an advanced level of developing forage and feed technologies. This is most successful when farmers are already experiencing significant positive impacts of improve livestock feeding systems, and where there are enthusiastic, well-trained extension workers in the area who actively facilitate dissemination through field days, cross visits and farmer-to-farmer learning.

- Dissemination to new villages or districts in the same geographical region (e.g. same province): This requires an additional process of 1) identifying new areas with high potential, 2) winning institutional and political support for working in the new villages or district, 3) training of extension workers in the new area in feed and livestock technologies and in participatory approaches, and 4) establishing forage multiplication sites in the new area to ensure access to planting materials. This is relatively simple if successful farmer examples of improved feed and livestock technologies are available in nearby districts, and cross visits, field days and trainings can be arranged in the successful areas. Once a small number of farmers have started to evaluate improvement options and are experiencing benefits then similar methods and processes as described in (1) can be applied. Other options to create awareness of successful technologies are the use of radio, television and printed media.

- Dissemination to new villages or districts in a different geographical region: Added challenges are that there are no easily accessible examples of successful feed and livestock technologies nor trained extension workers or farmers nearby, and involvement at the national level is likely to be required for selection of new areas and winning of institutional support. In this situation, many of the most successful methods and tools such as cross visits and farmer-to-farmer extension are not immediate available and new examples (and capacity) need to be developed before dissemination can be successful.

The three workshops held in Viet Nam documented and reviewed forage technology development and dissemination at LLSP (and previous FSP) sites in Daklak and Tuyen Quang provinces. The first workshop with key partners from LLSP sites in Daklak and Tuyen Quang was held in Nha Trang from 6-9 January 2004. During the workshop, the basic methodology employed at the two sites was described and discussed.

This first workshop was followed with site visits by John Connell, Francisco Gabunada and Le Hoa Binh and with more comprehensive discussions and workshops with a wider range of extension workers in Tuyen Quang from 8-11 June and Daklak from 14-16 June 2004.

Results showed that adoption and spread of forage technologies was faster in areas with more intensive, market-oriented agriculture. In these areas, farmers consider cattle / livestock production as an income-generating enterprise (not as a means of accumulating capital) and farmers are more willing to invest in inputs for livestock production. The types of forages adopted in these areas were high quality, productive varieties requiring external inputs (organic/inorganic fertilizers, management).

In both provinces forage and livestock technology has reached a point where the farmers themselves visit the extension workers to ask for technical assistance. Another aspect for the rapid spread of forage technologies in intensive areas was the relatively close distance between farms and households. This proximity aided a rapid spread of successful technologies and information from farmer to farmer without major inputs by extension workers. Often, extension workers could advise information or technology seeking farmers simply to go and visit other farmers or a village where they have achieved a lot of progress already without the extension workers. This encouraged farmers to seek informal contact and they often bought planting material from the farmers they visited thus providing an additional incentive for experienced farmers to share their experiences and advice.

The spread of forage technologies was slower in more extensive agricultural systems and areas in both Daklak and Tuyen Quang provinces. Often, farmers in these areas kept livestock in extensive grazing systems, accepting seasonal variation of communal feed availability as inevitable. They tend to adjust to this situation by manipulating cattle numbers or simply accepting the fact that their animals become thin during the dry season when there is little feed available. Moving towards a more intensive type of livestock production with at least some stall-feeding requires a significant change in attitude and production system.

Also, farms and houses are located further from each other, thereby slowing the flow of informal and direct exchange of information and technologies between farmers. Extension worker need to invest a lot of time and effort into organizing farmers and providing information and advice.

In both provinces, it was observed that there was little opportunity for feedback from farmers to the extension services. What tends to happen is that the knowledge and experience of extension workers and the farmers who first worked with the extension workers were used as basis for generation and promotion of technologies. As forage technologies became successful, a lot of effort went into expanding these technologies to new districts and more farmers.

The methods used were a simplified form of participatory diagnosis, selection of interested farmers, organization of cross visits by some key farmers, provision of planting material and some basic training for extension workers and farmers. There was little follow up after the initial provision of planting material as the same procedure was followed in other districts.

The experiences of farmers planting forages and utilizing these for improving animal production was not harnessed nor did these farmers receive a lot of support to assist them with maximizing the benefits from having intensified livestock production. This limited the progress of innovation and improvement of farmers' livestock production.

Based on the experiences with documenting dissemination methodologies in Viet Nam, the Project will conduct similar workshops at selected LLSP in other countries and compare these to the results from Viet Nam.

4.2.2.3 Increased capacity in DMCs, at different levels, to expand the use of improved forage and feed systems, and respond to local needs

The LLSP builds capacity of project partners in many different ways. These include:

- Annual project review and planning meetings of national coordinators and selected site collaborators to review progress, share experiences, discuss project strategies and develop work plans for each site.
- National and/or provincial review and planning workshops where project staff and country coordinators facilitate sharing of experiences, review activities, plan future activities and provide relevant training at project sites to enable our collaborators to carry out the next phase in their work plan.

- National and local training courses for site collaborators (extension workers and key farmers) on particular aspects such as forage agronomy and utilization, participatory approaches, animal nutrition and health by national and site coordinators and supported by project staff.
- International training courses for national coordinators and selected site collaborators on subjects important to the project such as agroenterprise development. Participants to these courses are expected to develop and organize training courses in their countries.
- Mentoring of all project partners by project staff (and experienced partners) through site visits, cross visits to other sites and short-term attachments to experienced staff.

Building the capacity of project partners to be able to work with farmers to improve forage-feed systems and disseminate these to other farmers requires skills and knowledge that are difficult to learn in formal training courses. We found that the most effective way of building the capacity of site partners is to keep the formal part of training course short (review experiences, discuss options for improvement, present additional options/knowledge/skills), then go into the field and demonstrate new skills, ask participants to practice with other farmer groups, get back together and review experiences and discuss difficulties and ways of overcoming these difficulties. Participants then return to their own sites and apply their new skills. A follow-up training is then planned which reviews progress and takes site partners to the next level. This type of programmed, on-the-job training can be fully integrated with review and planning workshops and are clearly targeted at the needs of our local partners and the needs of the project.

A list of training courses by project staff is presented in Table 78. Additionally, site collaborators carry out a large number of training courses for extension workers and farmers. For example, project partners in PR China conducted two training course for 50 farmers and 20 extension workers at CATAS. In Viet Nam, site partners in Daklak and Tuyen Quang held training courses for technicians, extension workers and key farmers, who in turn held training courses for a large number of farmers. All site partners as part of their regular farmer groups meetings and extension activities carried out training of farmers in forage establishment, management and utilization.

The project also supports training in Agricultural English for key project partners. Four national / site collaborators attended a 6-week course at the International English Language Training Center in Vientiane, Lao PDR, from 13 October to 21 November 2003. Participants were Mr. Tang Jun (Site coordinator, CATAS, P.R. China), Mrs. Vu Hai Yen (Site coordinator, Tuyen Quang, Viet Nam), Mr. Yacob Pangendongan (National coordinator, Livestock Services of East Kalimantan, Indonesia) and Mr. Bounthavone Kounnavongsa (National coordinator, NAFRI, Lao PDR). All participants benefited greatly from attending this language course and the course has already resulted in improved communication with LLSP staff and with other project partners. Part of the training was a 1-week visit to FLSP sites in northern Lao PDR to learn and discuss technology development and the process of working with farmers in this project with FLSP collaborators.

4.2.2.4 Comparison of development opportunities, and market and logistic constraints, for intensification of smallholder livestock systems across sites in five countries

Following the participation of five LLSP members in the Southeast Asian Course on "Sustainable agro-enterprise development in a micro-regional context" in Viet Nam in early 2003, the first part of a market study was conducted in Daklak, Viet Nam, from 9-18 December 2004. The study was aimed at providing a better understanding of the livestock production to market chain at project sites in Daklak. The study commenced with a series of

Table 78. Training courses, workshops and cross visits organized by the LLSP.

Date	Title	Staff involved as resource person	Place	No. participants Male	Female
2-6 Jun 03	Participatory livestock research and development training course (organized by PCARRD)	F. Gabunada	Small Ruminant Center, Central Luzon State University, Philippines	9	8
23-27 Jun 03	LLSP planning workshop and write-shop	F. Gabunada	Cagayan de Oro City, Philippines	18	11
1-3 Sep 03	Training course on forage selection and establishment	P. Phengsavanh	Animal Health and Production, Kampong Cham, Cambodia	10	3
4-5 Aug 03	Planning workshop with LLSP collaborators	W. Stür, F. Gabunada	Penajam, Indonesia	15	3
18-23 Aug 03	Cross visit of FLSP partners in Tuyen Quang	P. Phengsavanh, F. Gabunada	Tuyen Quang, Viet Nam	15	2
23-26 Sep 03	Training course on animal nutrition and experimentation with small farmers	F. Gabunada	BPLB, Sempaja, Indonesia	13	1
11-14 Nov 03	Training course on participatory diagnosis and evaluation	J. Samson, P. Phengsavanh	Kampong Cham, Cambodia	13	1
22-29 Nov 03	Cross visit of Tang Jun, Vu Hai Yen and Yacob Pangedongan to FLSP sites	P. Phengsavanh	Luang Phabang, Lao PDR	2	1
11-14 Dec 03	Livestock market study workshop	J. Samson, P. Phengsavanh	Ea Kar & M’Drak District, Viet Nam	38	25
15-17 Dec 03	Annual Review and planning workshop of LLSP Philippines	F. Gabunada	Cagayan de Oro City, Philippines	8	8
6-12 Oct 03	Training course on forage seed production for LLSP collaborators from Viet Nam	C. Phaikaew, G. Nakamanee	Mukdahan Animal Nutrition Station, Thailand	6	4
7-8 Jan 04	Dissemination methodology workshop	F. Gabunada, W. Stür, J. Connell, P. Phengsavanh, J. Samson	Tuyen Quang and Daklak Province, Viet Nam	9	3
21 – 27 Jan 04	Training course on developing forage technologies with small farmers	F. Gabunada	BPLP in Sempaja, Samarinda, Indonesia	12	3
15-19 Mar 04	Training course on production system analysis and planning workshop for field staff	F. Gabunada	East Kalimantan, Indonesia	8	2
6-10 Apr	Training course on	F. Gabunada,	CATAS, PR. China	20	2

meetings with the key stakeholders involved in livestock production and marketing in Daklak. These included (1) authorities such as agricultural planners, credit providers, extension services and provincial and local government representatives, (2) livestock farmers from project sites, and (3) traders. Each group was met separately to keep participant numbers for each meeting to a manageable size, avoid potential conflicts between stakeholders and allow focused discussion. The meetings were held over 3 days with each meeting lasting half a day with wrap-up sessions and summaries following each meeting. The meetings were facilitated in an informal way with open-ended and probing questions, and the use of a range of PRA tools. Farmer and trader groups identified a range of constraints to production and marketing with considerable differences in perception between the two groups. For example, farmers felt that trader were paying low prices for their animals while traders explained that farmers often try to sell old, thin and sick animals which have a low value. They are willing to pay high prices for good-quality animals and reasonable prices for thin animals as long as they look like they can be fattened before marketing or sold on to other farmers. Farmers tend to have few options on how to sell their cattle since there are no local markets and transport for small number of cattle to the provincial markets is too expensive. Local traders buy individual cattle from farmers for some time and only transport them once they have a large number of animals assembled. Farmers have limited knowledge about current market prices and the trader bases the sale price on weight estimates.

In June 2004, the second phase of the market study was conducted in Ea Kar district, Daklak. The LLSP team conducted three separate feedback meetings – one for each stakeholder group (farmers, traders and local government) – to present the results (problem identification) of the first phase of the market study which was conducted in December 2003. During the meetings, the problems/issues identified by each stakeholder group during the first phase of the market study was presented and each issue was opened for discussion and brainstorming of options for addressing the identified issues. The meetings were very positive and participation was active and constructive. Farmers were keen to immediately start evaluating production improvement options, traders were offering to train farmers in judging quality and weight of animals, and entering in partnerships with farmers to ensure a steady supply of good-quality animals, and government agreeing to support activities with credit and investigating the possibility of establishing livestock marketing opportunities. Table 79 shows the issues identified in phase 1 and possible solutions and actions identified during the feedback meetings.

During the meetings, the idea of forming a stakeholder committee was raised to coordinate and take forward the ideas and proposed actions generated during the meetings. This was accepted and each stakeholder group elected representatives to this stakeholder committee (SC). Membership of the SC comprises 4 farmers, 1 trader, 1 bank representative, 1 extension officer (who will also represent the local government) and a representative of the LLSP. The formation of the SC was supported by the chairman and vice chairman of Ea Kar district; they expect the SC to develop policy recommendations, which enhance livestock development in the district. The first Stakeholder Committee meeting was held on 26 June 2004 with representation from the LLSP. The Head of the Extension Office was elected to coordinate activities of the SC. The SC discussed its role, objectives and official status, and decided to apply for registration of the group with the People’s Committee to ensure that the SC is well integrated into the development process of the district. The date of the next meeting was set for 10 July 2004. The formation of the SC is critical to ensure the continuation of activities started during the LLSP, but requiring a longer-term commitment. Also it ensures that the outputs generated are clearly contributing to the development strategy of the local government. The lessons learnt from the Daklak market study experience will be documented in a comprehensive report and plans are being prepared to conduct similar production to consumption studies at some other LLSP sites.

Table 79. Result of feedback meetings with farmers, traders and government in Ea Kar, Daklak

Problems	Solutions	Opportunities	Actions
Traders' issues:			
• Farmer always ask for very high price • Farmers don't exactly know about the price. Prices are always changing • Lack of capital • Lack of place where to buy & to sell • Low supply of cattle (farmers always want to keep their cattle for reproduction to increase number) • Farmers lack knowledge/technology to raise good quality cattle • Access to capital Traders can borrow from the local bank, but the loan is not enough for them to buy substantial number of cattle to gain good profit. They also find it difficult to borrow from the bank due to the many processes & requirements.	• If farmers have the capital & the capability/knowledge to raise good quality animals, then possibly they can keep the best breeder to produce more calves. • Traders think that the authorities should support them by developing good policies / projects where both farmers & traders can buy & sell (trading place) good quality animals • The authorities should provide easier access to capital to help the farmers & the traders in buying animals • Improve knowledge of farmers on cattle production and management so that traders can buy more improved type of animals and achieve a more steady supply to meet the demand of the market	• Demand for cattle is higher than the supply because • lack of capital for both traders & farmers • lack of technology to produce quality animals • farmers prefer keeping the thin animals for their farm use • Traders are willing enough to discuss possible solutions with the different players. • There are some companies & traders who are willing to lend capital to farmers, so that they can benefit together.	• Generate information on prices • Improve market information through extension officers by training farmers on how to measure the weight of the cattle • EW train farmers how to recognize the breed / quality / type of cattle • EW bring together farmers & traders to discuss & understand each other about the activities involved in buying/selling of cattle • Develop the skills on cattle production (raising) in the village
Farmers' issues:			
• Price of cattle for breeding is high, farmers can't afford to buy enough • Farmers don't know how to measure the weight of cattle • Farmers would like to know the price trends (when is the price at its highest & lowest). • Lack of feed for cattle • Farmers don't know how to buy good quality cattle • Farmers find it difficult to look for good quality cattle for breeding • Lack of skills to plan the activities on raising cattle • Farmers find it difficult to forecast the price	• Establish a market place for cattle • Provide studies to bring information on the market (in general) • Organize a group of people who are interested to raise cattle • Train farmers how to measure the cattle, how to get the weight of the beef • Help the farmer to sell the cattle by using a scale as basis of weight		• Train the farmer about the technology (e.g. animal health, nutrition, production / breeding, forage technology) • Train and guide the farmers to develop plans on how to raise better cattle, suitable quantity of animal, amount of feed needed, types of feed, animal health & animal housing, etc. • Train farmers to make plans on how to compute for economic benefits, right timing to raise & sell cattle in order to maximize benefit • Formation of farmer interest groups on cattle production. So they can help each other to exchange information on technology techniques, market and get capital (credit) easily from banks • Attend seminar on how to loan money from the bank and how to use the money to get benefits

4.2.3 Seed Production of new Brachiaria hybrids in Southeast Asia

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Thailand

Several species of the grass genus *Brachiaria* have high potential as a source of feed for livestock production in the tropics. All of these species, however, have significant limitations. For example, one of the most common varieties, *Brachiaria decumbens* "Basilisk", grows well in the dry season, but produces very little seed in most areas of Southeast Asia. *Brachiaria ruziziensis* "Ruzi" produces high yields of good quality feed in the wet season, but is poorly adapted to the long dry season and soon dies out. In the mid 1980s, CIAT scientists started a breeding program to try to combine the best characteristics of different *Bracharia* species into new hybrids. The first of these was released in 2001 in a public-private partnership between CIAT and the international seed company, Papalotla. This *Brachiaria* hybrid, known as Mulato, combines the best qualities of its parents, *Brachiaria ruziziensis* and *Brachiaria brizantha*, into one plant. That is, it has both excellent dry season tolerance and produces higher quality feed than most *Brachiaria* varieties. Most significantly, whilst it is a hybrid, a peculiarity of the reproductive biology of the *Brachiaria* genus ('apomixis') means that the seed collected from this hybrid remains true to the parent. Thus, it is a hybrid that does not lock smallholder farmers into regularly buying seed from large companies, as is the case with most hybrid crops, such as hybrid corn.

Mulato is ideally suited to moderately fertile to fertile soils, in intensive livestock systems or in crop/pasture rotations. It does not grow well in very infertile soils or waterlogged areas. Recent research in Colombia has shown that cows grazing Mulato can produce an extra 1.0 to 2.0 liters of milk per day compared with cows grazing other grass varieties. In Honduras, steers grazing Mulato gained 900 g/day compared with 600 g/day on *B. decumbens* cv. Basilisk. The *Bracharia* Mulato hybrid was first introduced by CIAT to Southeast Asia en 1996 as part of a large *Brachiaria* variety trial in Thailand. The Thai Department of Livestock Development (DLD) identified the *Brachiaria* hybrid cv. Mulato as the most promising variety for livestock production in the seasonally wet-dry climates and poor soils of the northeast. They commenced seed production trials on-station in 2000 and, because of the promising results, commenced on-farm trials in 2003 with 7 smallholder farmers near Khon Kaen. On the strength of the results, Papalotla provided a guaranteed market in 2004 that allowed 1793 farmers to plant 700 hectares for seed production (Photo 38). An estimated 140 tons of seed will be produced primarily for export to Latin America, India and other Asian countries. Farmers producing Mulato seed will earn 25% more income than producing seed of Ruzi grass. One limiting characteristic of Brachiaria hybrid cv Mulato is its low seed yields (<180 kg/hectare). A new Brachiaria hybrid (Mulato 2), which is agronomically very similar to Mulato except that it produces double the seed yields, has been developed by CIAT. Ubon Ratchatani University and Papalotla are working with 105 farmers in 2004 to produce an estimated 10 tons of seed of Mulato 2.

Photo 38. Thai farmer harvesting Mulato seed

Lao PDR

The potential for production of seed from the hybrid Brachiaria hybrid cv Mulato in the uplands of Lao PDR, both as a cash crop and as an alternative to shifting cultivation for smallholder farmers, is high. The biophysical conditions are nearly ideal (and similar conditions occur in relatively few other areas of the world), there is a strong market and the seed crop requires relatively simple management methods that are ideally suited to smallholder farming. Madeleen Husselman, an MSc. Student from Wageningen Agricultural University, is evaluating this potential with small plot and on-farm trials on the Bolovens Plateau in southern Lao.

4.3 Partnerships in Africa to undertake evaluation and diffusion of new forage alternatives

Highlights

- CIAT, ILRI and ICRAF reviewed ongoing forage research activities in East and Southern Africa and outputs that could be achieved in short term were identified. Principles for a long-term forage research strategy for the region were defined.

- CIAT, ILRI and EARO jointly evaluated forage germplasm with farmers in highly degraded highland of Ethiopia. Farmers preferred Napier, lablab and vetch. Farmers produced significant amount of planting materials and seeds with their own resources, to expand the forage areas in the next planting season.

4.3.1 Development of strategic alliances

Contributor: R. Roothaert (CIAT-PRGA/ILRI)

The development and scaling out of forage technologies are a common objective for three CGIAR centres which operate in East and Southern Africa: CIAT, ILRI and ICRAF. CIAT has bred and selected improved forage germplasm for the low altitude, humid, and sub-humid agro-ecological zones. CIAT has also demonstrated success with participatory approaches and large numbers of farmers adopting forages in LAC America and SE Asia. ILRI forage germplasm is well suited for the arid, semi-arid, and highland agro-ecological zones. ICRAF has demonstrated success with woody forage legumes in the highlands of East, Central and Southern Africa.

Delegates form the three centres met in Nairobi, December 2003, to discuss a common strategy for research on forage technologies for East and Southern Africa. The areas for collaboration were grouped into (1) important activities, which have been identified by the centres in projects and proposals already, and (2) long term strategies.

The following activities and outputs are expected to be implemented in the short term:

- Development of improved forage germplasm on-station and participatory work to deploy forages in collaboration with partners.
  - CIAT – ILRI collaborative work has started with NARS and NGOs in Ethiopia, Malawi and Uganda, in 2003.

- Development of seed supply systems as an important prerequisite for the scaling process.
  - In Malawi, the Department of Agricultural Research Services (DARS) established one hectare of forage seed multiplication plots at the Chitedze Agricultural Research Station, in 2003-2004. More than 100 grass, herbaceous and woody legume species and accessions obtained from ILRI, CIAT, ICRAF, and CSIRO have been planted.

- In Uganda, plans were made for establishing central seed multiplication systems through the National Agricultural Research Organisation (NARO) in collaboration with Makarere University, in 2004. The NARO stations selected for multiplication are Mukono (intensive, sub-humid systems), Mbarara (grazing systems) and Serere (semi-arid systems). In Mbarara, 20 species and accessions from CIAT and ILRI were established in 2004.
- Vegetative propagation of selected grasses and herbaceous legumes has started by two farmer groups in Tororo, Uganda in 2004.

- Development of forages for monogastric animals and fish as an important research issue.
  - A farmer group in Ukwe, Malawi, planned the evaluation of maize, molasses, and legume forage for pig raising, in 2004.

- Linking farmers to markets.
  - Careful choice of locations and production systems is necessary and clear definition of strategic research issues that need to be addressed to make proposals attractive to donors.
  - Market chain analysis has been conducted with communities in Uganda and Malawi for livestock enterprises, starting in 2003.

- GIS supported targeting of forage germplasm.

- Training in forage agronomy, seed systems, participatory methods and market development.
  - A training on participatory research methods was held in Ethiopia, in 2003.

- Monitoring and Evaluation of Forage / Livestock projects, with emphasis on improving livelihoods.
  - ME systems have been developed with partners and communities in Uganda.
  - An ME workshop was conducted in 2004 in collaboration with ILRI for the DFID fodder innovation project in Nigeria. Participants learned about participatory methods for process monitoring, developed partnerships, and made regional ME plans.

The following points were related to a long term forage research strategy for East and Southern Africa:

- Working through existing networks should be utilized wherever possible, instead of creating new ones.
  - A regional interest group on participatory research methods for feed and forage systems have been established with IARs, NARS and NGOs in Ethiopia, Kenya and Uganda. Funding is being sought through the Association for Strengthening Agricultural Research in East and Central Africa (ASEARECA). The group intends to work in close association with the ASARECA Animal Agriculture Network (AAARNET).

- Involvement in Challenge Programs, such as African Sub-Saharan Challenge Program and Water and Food Challenge program.

- Define the role of forages in systems and how does forage research relate to livestock research.
  - To revise characterization done in the region, e.g. systems related to forages and feeds, leading to define demand; relative importance of forages in contrast to feeds and other aspects such as animal health.

- Define the comparative advantage of ILRI, ICRAF, CIAT to work jointly on some of the issues coming out of characterization, in contrast to other research and development stakeholders.

- Process and technology research need to go hand in hand.

- Opportunities for scaling out and a poverty focus should be defined before implementation of larger initiatives.

4.3.2 Partnerships and adaptive forage research in Ethiopia

Contributor: R. Roothaert (CIAT-PRGA/ILRI)

Rationale

In 2003, a pilot project was started with ad hoc resources from ILRI, CIAT and the Ethiopia Agricultural Research Organisation (EARO), to work with communities in the degraded watershed of Mt. Yerer. The purpose was to introduce improved NRM technologies towards better and sustainable livelihoods. Forage technologies were chosen as an option towards alleviating the chronic feed shortage for draught and dairy animals, and for the potential of reversing land degradation. Severe gully erosion and nutrient depleted soils were major problems for food production and infrastructure. Although many forage options for the Ethiopian highlands had been developed on-station in the past, very little research had been carried out with farmers. The objectives of the study were to develop integrated forage technologies with farmers, and to evaluate improved forages through farmers' perceptions.

Materials and Methods

Meetings were held with committee members of two Peasant Associations (PA), Yerer Selassie and Gende Gorba, representing 600 and 1200 households, respectively. Discussions were held about PRA conducted a year before, and the potential to address some of the described problems through forage technologies. A field visit and workshop was organised for each PA for interested farmers to view forage plots at the nearby ILRI station, Debre Zeit, and to plan participatory trials on-farm. The PA committees selected 57 farmers, of whom 10 women farmers, to participate in the experiment. The farmers came from 6 villages. The altitude varied from 1900 – 2100 masl. Soils were heavy vertisols at the lower altitudes, and sandy loam at higher altitudes. Average annual rainfall is 815 mm, mostly falling within June – September.

During the planning workshops with farmers, they suggested a range of niches for the forages to be planted: in the backyard within the compound, in the fenced area adjacent to the compound, along contours in the field, and in the gullies. For this season, however, everyone wanted to plant either in the compound or in the adjacent fenced areas, because they valued the experiments too much and did not want them to be disturbed by stray livestock. They also preferred a controlled environment for seed and planting material production, so that they could plant larger areas in the unprotected fields the following season. The materials were planted between 20 and 30 June 2003. The forage species and amounts made available to farmers are listed in Table 80.

The performance of the forages was evaluated in terms of (1) germination and survival, (2) establishment in the early growth phase, (3) forage yield or biomass, and (4) general farmer preference. Technicians visited each farm between 30 Sept. and 20 Oct. 2003, when the rains had stopped, to facilitate farmers' evaluations.

Table 80. Forage species and planting materials distributed to farmers in six villages of Mt. Yerer watershed, 2003.

Species and accession	Number distributed per farmer
Napier grass (*Pennisetum Purpureum*) acc. 14984	200 stem cuttings
Setaria (*Setaria sphacelata*) acc.142	25 root splits
Vetiver grass (*Vetiveria zizanioides*)	25 root splits
Vetch (*Vicia dasycarpa*) 6213	100 grams
Lablab (*Lablab purpureus*) 6529	100 grams
Neonotonia (*Neonotonia wightii*) 6762	100 grams
Macroptyloma axillare, 6756	100 grams
Pigeon pea (*Cajanus cajan*) 11560	100 grams
Sesbania (*Sesbania sesban*) 15019	100 grams
Leucaena pallida (14203)[1]	5 seedlings
Leucaena diversifolia (14193)[2]	5 seedlings
Calliandra (*Calliandra calothyrsus*) 15143	5 seedlings
Tagasaste (*Chamaecytisus palmensis*) 15378[3]	5 seedlings

[1] Four villages only: Buti, Korke, Babugaya, G/Gorba
[2] Two villages only: Mekanna, Godetti
[3] In Korke village (high altitude) only.

A matrix drawn on a manila sheet of paper was used to evaluate the planted species against the four criteria. Some follow up visits were made during the season. Final feedback and planning meetings with the farmers in the two PA were held on 15 and 17 Dec. 2003.

Results

The species that scored best for germination, survival, establishment, and early biomass production were lablab, vetch, and napier (Table 81). Pigeon pea and setaria also received a mean score of above 7 for germination, survival, and establishment. The tree and shrub species took longer time to establish, as could be expected. Napier, lablab and vetch ranked highest for overall preference (Figure 51).

Pigeon pea, setaria and vetiver followed after that. Although only 19 % of the original contact farmers were women, 34 % of the respondents were women, indicating a gradual shift of involvement in the experiment from men to women. Disaggregating the responses by sex did not show any differences in terms of rating for germination, survival, establishment, and early biomass production. The six most preferred species were also the same for men and women. Women showed higher preference for tagasaste, and lower preference for calliandra and *L. pallida* than the men did.

Farm visits and meetings provided additional qualitative information about preferences of forages. Farmers had started to feed small quantities of feed to their animals and assessed palatability. Napier, vetch and lablab were the most palatable species. Setaria, vetiver and pigeon pea were also fed, and ranked slightly lower in palatability. Farmers also mentioned the importance of being able to produce seeds or planting materials. Almost every farmer had produced vegetative planting materials of napier and setaria for expansion in the next season. Out of the 34 farmers who attended the feedback meetings, 14 farmers had multiplied vetiver; 13, 9 and 8 farmers respectively had collected seeds of pigeon pea, vetch and lablab by December 2003.

Additional criteria were mentioned: pigeon pea was often appreciated for its dual purpose, food and feed; napier was appreciated for its good feed value.

In terms of planning for the next season, many suggested that they would expand vetch and lablab to the cropping areas, as these places would be protected during the growing season. After that these areas could be grazed. They would also be able to produce enough seeds of these crops to continue planting in the following seasons. In addition, they requested seeds of oats from ILRI, so that they could experiment with intercropping vetch and oats. They had heard about this technology from other farmers. Farmer visits in January 2004 revealed that lablab was regrowing after harvest, well into the dry season. It was also continuing to produce significant amount of seeds.

Discussion

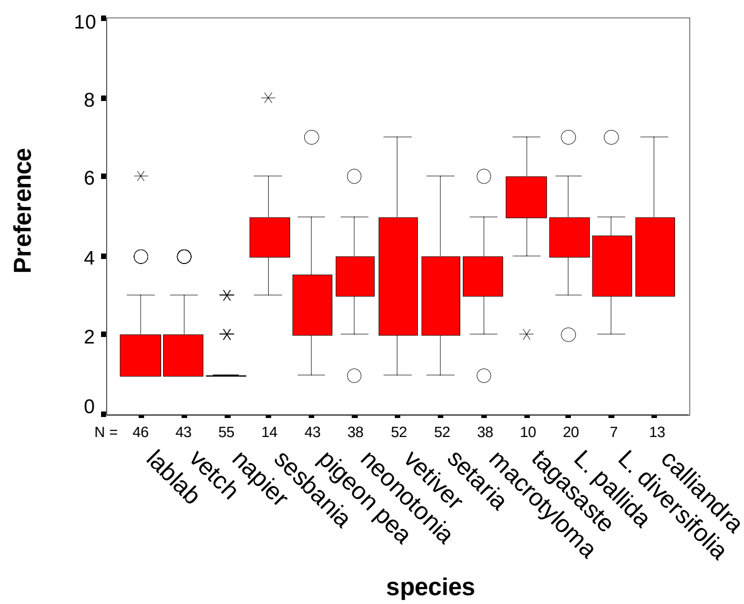
One season of participatory evaluation showed that six out of thirteen species were clearly performing better and more preferred by farmers. These were napier, lablab, vetch, pigeon pea, setaria and vetiver. The shrubby species didn’t rank high, but farmers also mentioned that it was too early to conclude anything about those species, because seedlings were very small and they take long to establish.

There is a keen interest to expand forages on-farm. Grass splits will already be sufficiently available form the farms, and they could be established along contours in the cropping land. Farmers want to plant herbaceous legumes in the cropping land, but would probably still need to be helped initially with some seeds.

Farmers appreciated the ILRI-CIAT facilitation of the on-farm research. They wanted some more information about intercropping technologies. Perhaps the most rewarding outcome of the research was the following comment expressed during a group meeting: “At the start both parties were fearing each other. We were a bit suspicious; we did not believe that

Table 81. Mean scores of germination, establishment and yield of forage species rated by 57 farmers in Mt. Yerer watershed, 2003. 10 = highest, 1 = lowest.

Species		Germination/ Survival	Establishment	Yield/ Biomass
lablab	Mean	8.65	8.61	8.20
	S.d.	2.1	2.2	2.4
vetch	Mean	8.30	8.58	8.30
	S.d.	2.3	2.1	2.2
napier	Mean	8.87	8.87	8.44
	S.d.	1.9	2.1	2.3
sesbania	Mean	6.43	5.79	4.21
	S.d.	2.5	2.2	1.7
pigeon pea	Mean	7.51	7.56	6.00
	S.d.	2.1	2.6	2.4
neonotonia	Mean	5.89	5.87	4.76
	S.d.	2.6	2.5	2.1
vetiver	Mean	7.35	5.94	4.96
	S.d.	2.2	2.3	2.3
setaria	Mean	7.88	7.19	5.94
	S.d.	2.4	2.5	2.4
macrotyloma	Mean	5.89	5.87	4.76
	S.d.	2.6	2.5	2.1
tagasaste	Mean	6.90	4.80	3.60
	S.d.	3.0	2.4	1.2
L. pallida	Mean	5.15	3.70	2.75
	S.d.	3.7	2.4	1.7
L. diversifolia	Mean	5.71	5.71	5.29
	S.d.	2.4	2.0	1.5
calliandra	Mean	5.23	4.38	3.85
	S.d.	3.3	2.1	2.1
Total	Mean	7.37	6.98	6.08
	S.d.	2.7	2.7	2.8



Key: **Red box: Contains 50 % of observed responses (farmers)**

Line in red box: Median
O: Outlier
*** : Extreme value**
N: number of responses (farmers)

Figure 51. Distribution of farmers' general preference ranking of forage species tested on their farms, Mt. Yerer, 2003. 1 = highest preference, 10 = lowest preference.

ILRI [and CIAT] would actually help us, or that ILRI [and CIAT] would follow up on the initial activities. ILRI [and CIAT] scientists were also suspicious about the farmers; they did not believe that farmers would have enough land to plant forages. Now that we have worked together for a whole season, those suspicions have gone. We are all appreciating the forage experiment and we will be able to work much better together in future."

4.4 Forage Seeds: Multiplication and delivery of experimental and basic forage seeds

Highlights

- More than 1 t of seed was produced by the Seed Unit at CIAT. Seed distributions totaled 222 kg.

- A total of 1084 kg of experimental and basic seed was either produced in the Atenas Seed Unit or procured from associated collaborators. The bulk of the seed distributed was formed by *Cratylia argentea* (195.0 kg) and *Brachiaria* hybrid cv. Mulato (740.5 kg)

4.4.1 Multiplication and delivery of forage seeds in the Seed Unit of Palmira

Contributors: A. Betancourt; J. Muñoz and J.W. Miles (CIAT)

The delivery mechanism for our technology (in the form of improved germplasm) is seed. For many of the materials we are developing, no commercial seed supply exists. While we seek to encourage private initiative in supplying seed, we recognize that in the early stages of development a need for seed for experimental purposes and initial distribution can only be met by internally generated supplies. The Project maintains a modest seed multiplication and processing capacity to meet this demand.

Seed multiplication field plots are established and maintained at headquarters (CIAT-Palmira) and at substations at CIAT-Popayán and CIAT-Quilichao. Final seed processing and all aspects of seed distribution are handled at CIAT headquarters, where routine seed quality determinations are also conducted.

More than 1 t of seed was produced by the small seed multiplication unit at CIAT (Table 82). Nearly half of the total (545.7 kg, total for 12 accessions) was seed of *Cratylia argentea*. Significant quantities of *Lablab purpureus* (189.25 kg, 50 accessions) and *Canavalia brasiliensis* (132.0, 1 accession) were also produced. Smaller quantities of seed of 16 species (30 accessions) completed the total.

Seed distribution was only about one-fifth of the total produced (222.34 kg: Table 83). A total of 153 samples was distributed to 10 different countries and a diversity of categories of users including public agricultural research institutions, NGOs, public universities, private producers' organizations, and individuals.

These samples were sent to ten (10) countries: Bolivia (3); Costa Rica (1); Germany (14); Honduras (2); Nicaragua (2); Philippines (1); Uganda (7); Venezuela (1); Virgin Islands (1); and Colombia. Within Colombia, seed was distributed to collaborators in: CIAT (23); NGO (1); Universities (1); Private individuals (68); Agroamazonia (1); Agrogenética Global (1); Umata (15); CENIPALMA (3), Futuro Verde (1); COOLECHERA (1); DELAGRO (1); Fundamaz (1); Corpoica (4).

Table 82. Seed multiplication at the CIAT-Quilichao, CIAT-Popayán, and CIAT-Palmira experimental stations. (September 2003 to September 2004), totals by species.

Genus *	Species	Number of Accessions**	Harvest (Kilograms)
Brachiaria	*brizantha*	10	89.000
Brachiaria	*lachnantha*	1	3.500
Brachiaria	cv. Mulato	1	7.000
Brachiaria	sp.	3	27.500
Calliandra	*calothyrsus*	4	8.700
Canavalia	*brasiliensis*	1	132.000
Centrosema	*macrocarpum*	1	3.500
Centrosema	*molle*	1	10.000
Cratylia	*argentea*	12	545.700
Desmodium	*heterocarpon*	1	30.000
Flemingia	*macrophylla*	4	36.800
Lablab	*purpureus*	50	189.246
Leucaena	*leucocephala*	1	34.000
Mucuna	*pruriens*	1	11.000
Pueraria	*phaseoloides*	1	1.000
Stylosanthes	*guianensis*	1	0.400
Total		**93**	**1,129.346**

*16 Genera
** 93 distinct genetic materials (accessions)

Table 83. Seed dispatched from CIAT forage seed multiplication unit (September 2003 to September 2004).

Genus	Kilograms	Number of samples
Brachiaria	0.678	8
Cajanus	0.024	1
Calliandra	0.114	3
Canavalia	0.5	1
Centrosema	1.774	3
Cratylia	57.100	30
Desmodium	101.299	22
Flemingia	0.124	6
Lablab	39.066	23
Leucaena	1.620	6
Mucuna	0.050	1
Pueraria	0.024	1
Stylosanthes	0.468	2
Vignas sp.	19.5	46
Total	**222.341**	153

4.4.2 Multiplication and delivery of selected grasses and legumes in the Seed Unit of Atenas

Contributors: Pedro Argel and Guillermo Perez (CIAT)

Rationale

Seed multiplication activities of promising forage germplasm continued during 2004 at the Atenas Seed Unit (Costa Rica) in collaboration with the Escuela Centroamericana de Ganadería (ECAG). The seed produced is destined to support advanced evaluations and promotions of forage germplasm both by CIAT's projects and regional research/development institutions.

From September 2003 through August 2004 a total of 1084.1 kg of experimental and basic seed was either produced at Atenas or procured from associated collaborators. The bulk of the seed was formed by *Cratylia argentea* (195.0 kg), *Brachiaria* spp. (9.5 kg), *Brachiaria* hybrid cv. Mulato (740.5 kg), *Arachis pintoi* (12.5 kg), *Leucaena* spp. (10.0 kg), *Centrosema* spp. (5.7 kg), *Panicum maximum* (8.9 kg) and *Paspalum* spp.(3.40 kg). Small quantities of experimental seed was also produced of *Canavalia brasiliensis*,*Vigna* spp., *Chamaechrista rotundifolia* sp. *grandiflora* and other forage species.

During the period September 2003-August 2004 a total of 379.7 kg of experimental and basic seed was delivered by the Seed Unit of Atenas (Costa Rica).

In Table 84 we show that 49 seed requests were received from 9 countries, where most of the requests came from Costa Rica, the host country

Table 84. Countries, number of requests and amount of experimental/basic forage seed delivered by the Unit of Atenas (Costa Rica) during the period September 2003-August 2003.

Country	No. of Requests	Forage species (kg)			
		Brachiaria spp.	*Arachis pintoi*	*Cratylia argentea*	Other species
Brasil	1	0.5		0.2	
Colombia	2	0.1			1.1
Costa Rica	32	24.1	4.7	20.6	29.2
Guatemala	2		105.0	18.0	
Nicaragua	7	6.7	0.3	44.3	9.0
Panamá	2	6.0		0.5	0.4
Perú	1	1.0			
Puerto Rico	1		7.5		
Venezuela	1	0.5			
Total	49	38.9	117.5	183.6	39.7

of the forage project. However, a significant amount of experimental seed was delivered to Guatemala (123.0 kg) and to Nicaragua (51.3 kg), both countries involved in forage projects with the participation of CIAT.

A high amount of basic and experimental seed of the promising shrub *Cratylia argentea* (183.6 kg) was delivered, and of *Brachiaria* species, particularly of cv. Mulato, the new hybrid of this genus that is being promoted regionally with the assistance of the private sector.

4.5 Enhancing livestock productivity in Central America

Highlights

- Approximately 30% of pastures in Honduras are in a severe state of degradation, loosing 284,106 MT of fluid milk and 48,271 MT of beef (live weight) annually, equivalent to 48% of the annual production of milk and to 37% of beef. In economic terms, these losses in milk and beef yields are worth US$63 and US$48 million annually, respectively

- A large demand for high quality hay for feeding during the dry season in Honduras and Nicaragua was identified. Production of hay silage in plastic bags in the wet season for use in the dry is an alternative that will be examined by the Forage Project in the future.

4.5.1 Estimation of the trade-offs of livestock productivity and income with pastures under different stages of degradation in Honduras

Contributors: F. Holmann (CIAT/ILRI), P. J. Argel, L. Rivas, D. White (CIAT), R. D. Estrada (CIP/CIAT), C. Burgos (DICTA), E. Perez (ILRI), G. Ramirez, and A. Medina (CIAT)

Rationale

Objectives of this study were to: (a) estimate milk and beef yields obtained from cows grazing pastures in different stages of degradation; (b) estimate income losses as a result of the degradation process; (c) estimate the proportion of pasture areas found in each stage of degradation within the six administrative regions of Honduras; and (d) identify different strategies and costs to recuperate degraded pastures.

Materials and Methods

Data came from two surveys executed during a workshop carried out in March 2004. The subjective perceptions of 25 livestock producers and 8 extension agents of the 6 administrative regions of Honduras were obtained to estimate the losses of animal productivity within the farm, region, and country. A 4-level scoring of pasture degradation was defined – where 1 was for the best condition (i.e., non-apparent degradation) and 4 was for the worst (i.e., severe degradation). Regressions, explaining the animal productivity losses at each level of pasture degradation, were generated according to the subjective and descriptive information (Figures 52, 53).

Results and Discussion

Comparing the perception of the degraded areas, producers considered that in Honduras the extent of pasture degradation is lower compared with extension agents. According to producers, 29% of the pasture area in the country is at Level 1 (i.e., no degradation) compared with only 19% of extension agents. Moreover, producers perceived a lower proportion of pastures with a level of severe degradation (i.e., Level 4, 27%) in comparison with almost 31% perceived by extension agents. In the intermediate degradation levels (i.e., Levels 2 and 3), both groups were similar. The country is sacrificing milk and beef production due to the process of pasture degradation. According to estimations from producers, Honduras is loosing 284,106 MT of fluid milk and 48,271 MT of beef (live weight) annually in the pasture areas found in Level 4 (i.e., severe degradation), equivalent to 48% of the annual production of milk and to 37% of beef. In economic terms, these losses in milk and beef yields are worth US$63 and US$48 million annually, respectively. The perception of extension agents is even more alarming. Honduras could produce 66% more milk and 50% more beef annually if livestock producers renovated their pastures before they reached level 4, equivalent to US$94 million in less revenue from milk sales and US$66 million from less beef sales. Both groups perceive that pastures, in an early stage of degradation (i.e., Level 2), are more economical, practical and rapidly to recuperate. Also, as the process of degradation advances (i.e., to Levels 3 and 4), both cost and time of recuperating such pastures increases significantly. According to producers, the recuperation of a pasture from Level 4 to Level 1 costs $140/ha and takes almost half year (i.e., 5.6 months). Extension agents estimate this cost of recuperation 27% higher ($178/ha) with 5% more time (i.e., 5.9 months). At the national level, to recuperate all pasture areas found in Level 4 would cost $57 million according to producers and $84 million according to extension agents. However, this amount represents, in the opinion of producers, 51% of the $111 million, and according to extension agents, 52% of the $160 million in milk and beef sales not received annually due to lower animal production from cows grazing Level 4 pastures. Producers perceive that grasses spend proportionately less time in going from Level 1 to 2 (i.e., 2.9 years) and as the process of degradation continues, pastures remain longer at advanced degraded levels (i.e., 3.1 years in going from level 2 to 3, and around 4.0 years in going from level 3 to 4). Moreover, producers think that the average productive life of improved grasses is about 10 years, while extension agents think that grasses degrade faster, with an average productive life of 8.4 years, 16% less than producers. According to producers and extension agents, pastures degrade at an annual rate of 10% and 12%, respectively. With these rates, Honduras would maintain its current level of degradation between levels 2.48 and 2.65. However, the renovation of pastures at an annual rate of 10-12% does not solve the problem, but maintains it.

Producers argued that the current financial situation does not allow the necessary cash flow to renovate their plots, and the option of credit is not viable since real interest rates are high (i.e., 10%). After simulating this scenario, it was demonstrated that farmers are able to generate the additional income necessary to pay a credit, but only if this credit is taken with interest rates similar to those found in the international market (i.e., 3%). In order to eliminate the degraded areas found in Level 4 at the country level, it is necessary a one-time investment of $57 million. The benefit obtained from this investment would result in a daily increase of 156,000 liters of milk and 26,500 kilograms of beef, equivalent to $22 millions/yr. Therefore, there are significant economic and productive incentives for the private and public sectors to develop and execute a plan of action to recuperate pasturelands in advanced stages of degradation.

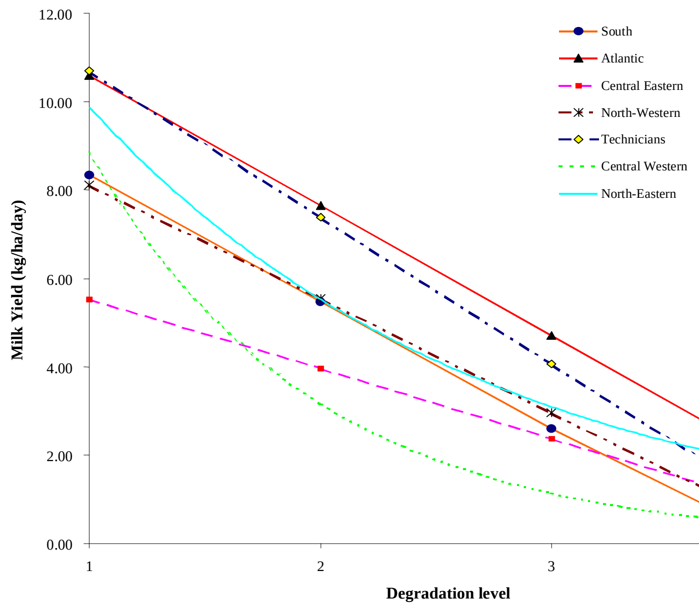


Figure 52. Perceived milk yield by level of degradation.

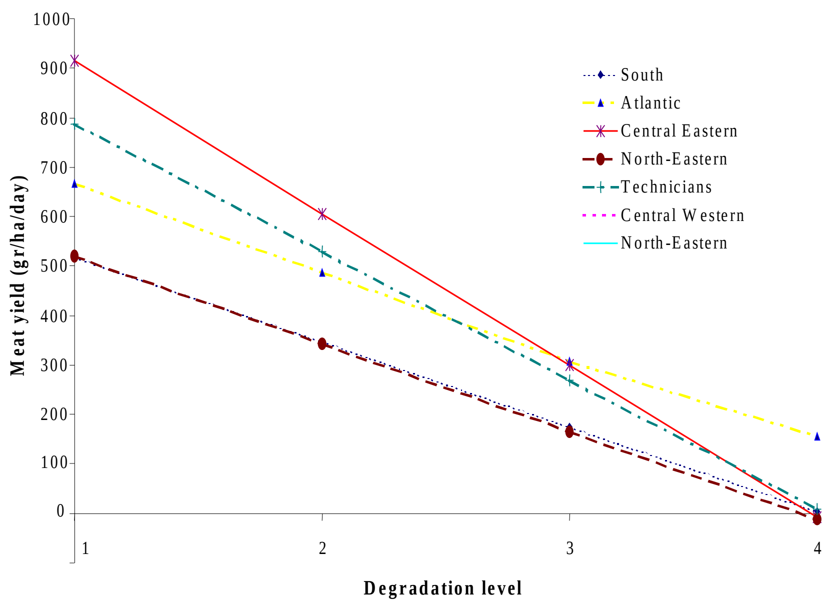


Figure 53. Perceived beef yield by level of degradation

4.5.2 Demand for forage technologies for dry season feeding in Nicaragua and Honduras

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Rationale

Smallholders with dual- purpose (milk and meat) cattle in much of Honduras and Nicaragua are faced with a long (4-8 month) dry season in which livestock feed is scarce and/or expensive. As a result, they produce substantially less milk in the dry as compared to the wet season. Livestock feed alternatives in the dry season range from native pasture and crop-residue grazing to silage and cut-and-carry forages to purchase inputs, with the higher costs of the more productive alternatives serving as a disincentive to higher dry season output. CIAT, ILRI, and partners in Honduras and Nicaragua are working with producers to develop effective, affordable, and adoptable alternatives for dry season livestock feeding systems. Diagnostic surveys were conducted as an initial step in order to understand animal feeding systems within a whole farm context. Among other objectives, the surveys were designed to estimate the demand for forage-based products such as ("little bag") hay and silage and improved forage germplasm.

Material and Methods

The diagnostic surveys were conducted in May 2004 in areas of Honduras (Juticalpa) and Nicaragua (Ocotal-Somoto-Esteli) featuring long dry seasons. Teams in each country consisted of 10-12 persons from NARS (DICTA, INTA) an NGO (SERTEDESO), ILRI and CIAT. Interviews were conducted by team members working in pairs. The surveys consisted of interviews of 65 livestock owners in Honduras and 53 in Nicaragua using informal structured open-ended interviews. No written/printed interview form was employed. Interviewers were asked to conduct thoughtful, interactive conversations open to new topics and issues rather than a follow-the-recipe form-filling exercise.

The team used this diagnostic survey as a training exercise to replicate it in different regions of both countries during the months of June and July. In August, ILRI and CIAT scientists will travel to the region to discuss, synthesize and consolidate the information from the other regions and a final draft of the study is expected to be ready by October 2004. The following preliminary results are from the initial survey:

Results and Discussion

Proportions of the different sizes of livestock operations encountered in the two countries were essentially the same: 15% small (1-12 head of cattle), 55% medium (13-70), and 17% large (>70) in Honduras and 17% small, 58% medium, and 25% large in Nicaragua. The largest herd sizes were encountered in Honduras where large holders had a mean of 178 head compared to 148 in Nicaragua (a difference possibly due to sampling error). Total farm size was somewhat larger in Nicaragua where small holders (recall that relative classes are based on numbers of cattle and not land holding) had 18, medium had 48, and large had 226 ha. Honduran small operations had 11, medium had 38, and large had 85.8 ha.

Almost all farms cropped maize and beans, with largest areas farmed by medium operators in both countries: small operators dedicated roughly 3, medium about 5, and large roughly 4 ha to annual crop cultivation (Table 85). Some farmers reported limiting basic grain production to meeting household consumption needs as a response to low prices paid for maize and beans.

Livestock feeding systems consisted of different combinations of alternatives from a reliance on natural pastures for low input-output systems to reliance on such sources as silage of forage maize and sorghum, cut-and-carry forages, hay, and concentrates for higher input-output systems (Table 85). Each of these components is considered in order from least to most intensive in terms of cash and labor requirements. Each is also considered in terms of possible future related research (synthesized in Table 85).

Based on producers' estimates, wet season milk production in Honduras and Nicaragua is probably quite similar across scales of operation. Large-scale producers in Honduras had the highest dry season outputs, however, reflecting inclusion of more favorable areas surveyed and intensification in those areas based on use of remittances, with intensification in the form of greater use of concentrates, cut-and-carry, purchased hay supplements, and silage of forage maize and sorghum. A contrasting situation was encountered in Nicaragua where small holders (compared to medium and large) obtained the highest production per lactating female: among small holders were those who maintained very few milk cows, often of improved breeds (Holstein) and provided them with intensive care. It appears that, overall dry season milk production will remain significantly lower than wet season production—in spite of high economic incentives in the dry season—because of the relatively high cost of increasing dry season production, including the opportunity costs of land, labor, and capital associated with increasing dry season outputs. However, research may be able to change the equation by offering lower-cost alternatives for the currently used dry season animal feed forms of improved pasture, hay, forage trees, concentrates, cut-and-carry forages, and silage of forage maize and sorghum.

Table 85. Farm characteristics, milk production, and animal feeding by farm size in Honduras and Nicaragua.

		Honduras			Nicaragua		
		Small (n = 10)	Medium (n = 36)	Large (n = 19)	Small (n = 9)	Medium (n = 31)	Large (n = 13)
Farm characteristics							
Cattle (head)		9	43	178	7	29	148
Farm size (ha)		11	38	86	18	48	226
Cropped (ha)		2.8	4.7	3.8	3.1	5.3	4.0
	(% of farm)	26	12	4	18	11	2
Head/ha		0.5	0.8	0.9	0.2	0.5	0.5
Milk production							
% No dry season milk		20	3	0	33.0	10	0
Number cows milked		4.3	12	41	1.6	10	40
Milk dry season (liters)		3.2	4.2	5.4	5.1	2.1	3.3
Milk wet season (liters)		-	-	-	6.8	5.1	6.7
Dry/wet milk ratio		-	-	-	75	41	49
Animal feeding							
Crop residues (%)		60	40	10	66	84	77
Rice straw (%)		-	-	-	44	42	46
Rent land (%)		40	20	10	22	26	42
Improved pasture (ha)		1.0	5.3	57	1.1	4.4	89
	(% of farm)	9	14	66	6	9	86
Forage trees (%)		Low	Low	low	56	71	77
Concentrate (%)		30	30	60	11	48	69
Hay (%)		10	30	50	20	10	55
Cut-carry (%)		20	30	70	11	35	62
Irrigated land (%)		10	10	30	0	24	42
Forage maize/sorghum		-	-	-	78	68	92
Silo (%)		0	10	40	0	10	42

Collaboration with the various development projects and NGO efforts will also be appropriate: their efforts are dealing with, among others, potable water (wells and hand pumps), subsidized motorized pump use for limited irrigation, household sanitation (outhouses), biogas for cooking, introduction of new forage materials, house construction, and reforestation and aforestation.

4.6 Impact of forage research in LAC

Highlights

- The area planted with *Brachiaria* cultivars during 1990 to 2003 amounts to 6.5% of the total area of permanent pastures in Mexico, 12.5% in Honduras, 1% in Nicaragua, 18.7% in Costa Rica, and 0.1% in Panamá. Species of *Brachiaria* dominate the forage seed market. During the last 5 years, 84% of all grass seed sales in Mexico and Honduras, 90% in Nicaragua, 85% in Costa Rica, and 97% in Panama have been of *Brachiaria* species (i.e. *B. decumbens* and *B. brizantha* cv. Marandú).

- The net present value (NPV) of technological benefits from the adoption of *Brachiaria* hybrids resistant to spittlebug was estimated at US$4166 million, of which 54% would be generated by additional beef production and the rest by milk. Most of the benefits were concentrated in Mexico, US$2831 (68%); followed by Colombia, US$960 million (23%), and Central America, US$363 million (9%). The NPV is equivalent to 44% of the value of beef and milk produced in 2003, ranging between 16% in Honduras and 78% in Nicaragua.

4.6.1 Impact of the adoption of grasses from the *Brachiaria* genus in Mexico and Central America

Contributors: F. Holmann (CIAT/ILRI), L. Rivas, P. J. Argel (CIAT), and E. Perez (ILRI)

Rationale

In Latin America and the Caribbean (LAC) there has been an important effort to develop new pastures technologies to increase livestock productivity for the extensive systems prevailing in the tropical lowlands. This multi-national and inter-institutional effort was initiated through the International Network for the Evaluation of Tropical Pastures (RIEPT, by its name in Spanish), which operated from 1976 to 1996 under CIAT leadership. RIEPT became a platform for institutions to train technicians, share forage material from existing gene banks, study the behavior of new germplasm under different environments, and established the exchange of scientific information to extrapolate research results (Toledo, 1982). RIEPT trained 645 agronomists from 24 countries in LAC in subjects related to forage agronomy and pasture evaluation.

The training was key for the success of RIEPT because these professionals carried out evaluations of new and improved forages under contrasting ecosystems and provided feedback. In addition, during this period participating institutions in RIEPT released 11 selected grasses as commercial cultivars, most of them from the *Brachiaria* genus, as well as 16 forage legume cultivars (CIAT, 2003). In Central America and Mexico these cultivars were released between 1990 and 1996. Forage evaluation activities in this region continues at present through a joint research agenda between CIAT and ILRI through special projects as well as between CIAT and the private seed sector. Of all pasture cultivars released, grasses from the *Brachiaria* genus currently dominate the market. Namely, about 84% of all grass seed sales in Mexico and Honduras, 90% in Nicaragua, 85% in Costa Rica, and 97% in Panama during the last 5 years (Holmann et al., 2004). The objective of this study was to estimate the adoption of *Brachiaria* grasses released through RIEPT on the basis of seed sales during the period 1990-2003 to assess its impact in terms of animal productivity and income of adopters.

Material and Methods

The methodology to estimate the adoption of *Brachiaria* grasses on the increase in animal productivity and income was from Sáez and Andrade (1990), which estimated the planted areas based on the volumes of seed marketed in each country. To calculate the marginal production of milk and beef due to the adoption of *Brachiaria*, the planted area was multiplied by the difference in productivity between the traditional and the improved technology (Holmann et al., 2004). In addition, the marginal value of milk and beef due to this adoption was obtained by multiplying the marginal production of milk and beef by the producer prices received during the period 1990 to 2003.

Results and Discussion

As observed in Figure 54, during the first years (i.e., first half of the 90's) the adoption was low because grasses were recently released and as a result, there was little knowledge and information among producers on productivity responses with these new options. However, as the planted areas with Brachiaria cultivars expanded and became more familiar to producers, seed sales grew rapidly up to being exponential at the beginning of the millennium, behaving similarly to the theoretical pattern of adoption.

Areas planted with Brachiaria grasses. It is assumed that most of this seed was allocated to renovate pastures in advanced stages of degradation or naturalized pastures with low productivity. The largest volumes of seed sales and planted areas correspond to Mexico (9,100 mt of seed with 2,616,130 ha planted). Costa Rica is the country in Central America with the largest seed sales and planted areas (1,692 mt of seed and 437,516 ha planted), followed by Honduras (671 mt and 186,788 ha), Nicaragua (134 mt and 35,822 ha) and Panamá (40 mt and 10,952 ha). During this period the annual increase rate in seed sales was respectively 32% in Mexico, 62% in Honduras, 45% in Nicaragua,

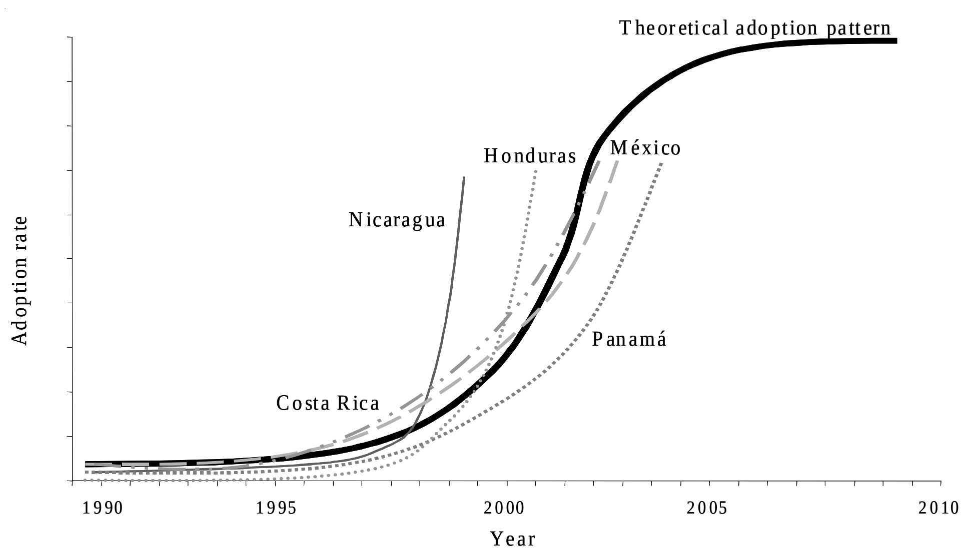

Figure 54. Theoretical adoption pattern of new forage technologies and adoption curves in México and Central America based on *Brachiaria* seed sales (Holmann et al., 2004).

39% in Costa Rica, and 54% in Panamá. Total area planted with Brachiaria cultivars during this period amounts to 6.5% of the total area of permanent pastures in Mexico, 12.5% in Honduras, 1% in Nicaragua, 18.7% in Costa Rica, and 0.1% in Panamá.

Additional milk and beef production. The main beneficiary from the adoption of Brachiaria cultivars has been Costa Rica, since more than 55% of the national milk production and almost 18% of the beef produced in 2003 was due to the marginal increase in the productivity of Brachiaria pastures compared to the traditional technology from degraded or naturalized grasses. These benefits are followed by Mexico where the increase in productivity from the adoption of Brachiaria cultivars amounts to 24% of the national milk production and 5% of the production of beef. In Honduras the marginal increase in milk and beef production is equivalent to 25% and 12% of national production, respectively. In Nicaragua and Panamá the adoption of Brachiaria grasses has been the lowest in the region. As a result, the additional increase in milk in Nicaragua and Panama amount to 11% and 5% of the national production, respectively. In the case of beef production, the additional increase in Nicaragua and Honduras has been 2% and 1% of domestic production, respectively. These figures suggest that adopters of Brachiaria grasses are producers oriented toward dairy and to a lesser proportion, to beef. Given the production systems existing in this region, it can be argued that the main adopters of these grasses have small and medium been dual-purpose livestock farmers.

Conclusions

The underlying hypothesis addressed by RIEPT was that lack of adaptation of commercial cultivars selected in other continents could be overcome by the selection of locally adapted forage germplasm. This in turn required a large effort on multi-locational screening of germplasm for adaptation to prevailing biotic and abiotic constraints. Likewise, the participation of the private sector, through commercial seed enterprises, was key to ensure wide adoption of improved forages. The results presented in this section indicate that the investments of public funds in Central America and Mexico to support a forage evaluation R&D network paid of in terms of adoption of improved grasses and increased supply of beef milk, staple food commodities for consumers across income levels in the region. The process of adoption of new Brachiaria cultivars has been stimulated by the availability at reasonable prices of commercial seed produced elsewhere and sold regionally by local seed companies. The region dos not have comparative advantages for Brachiaria seed production, particularly in terms of soil and climatic conditions and the availability of proper technology. However, grass seed production is a large commercial activity in countries such as Brazil, and much of the Brachiaria cultivars released locally, are readily taken by Brazilian companies as new seed products to be commercialized in response to an increasing forage seed demand along the region.

4.6.2 Potential Economic Impact from the adoption of new *Brachiaria* grasses resistant to spittlebugs in livestock systems of Colombia, Mexico and Central America

Contributors: L. Rivas (CIAT) and F. Holmann (CIAT/ILRI)

Rationale

Cattle raising in Tropical Latin America is one of the main productive activities in the region. Its economic importance is based on the use of significant quantity of available lands from all agro-ecosystems, from the contribution to the food supply, and because of its importance for employment and income generation, especially among small and medium farms dedicated to dual-purpose systems (i.e., beef and milk production).

One of the main constraints faced by producers is the limited forage supply regarding to quantity and quality, which is more critical during the dry season. *Brachiaria* grasses are a partial solution to this problem, because of the broad scope of adaptation, the tolerance to acid and infertile soils, and the high level of productivity, compared to other alternative forage materials. These African grasses were disseminated in the continent during the 1960s and 70s, particularly *B. decumbens,* the most utilized species: it is estimated that nearly 40 million hectares are currently planted with this variety.

Pasture research led by CIAT and many national institutions during the 80s and 90s, contributed with new *Brachiaria* species with various characteristics and uses, that were incorporated with incomparable success, in livestock systems of the Latin American lowlands. *B. brizantha*, *B. dictyoneura*, *B. humidicola* and *B. ruziziensis* are some of the forage materials released by research institutions in the region. Despite its indisputable advantages, the *Brachiaria* genus presents limitations because of its low tolerance to intense and prolonged droughts and its high susceptibility to spittlebug, a pest that causes considerable economic losses to the cattle-raising industry. Thus, most recent research in the *Brachiaria* breeding program has focused on the development of a second generation of *Brachiaria* grasses: outstanding agronomic characteristics, establishment vigor, good sprout capacity, high yield, high nutritional quality, good seed production, resistant to *Rhizotocnia* and to multiple spittlebug species. The results of this effort have conveyed to the recent release of Mulatto grass, the first hybrid of the *Brachiaria* genus obtained by CIAT's genetic improvement program.

In the waiting list of the second generation of *Brachiaria grasses* is the hybrid #4624 (CIAT 36087), to be released in 2005, having a similar forage quality as Mulato and with all the attributes defined for the second generation of *Brachiaria* grasses. Moreover, several other hybrids are in advanced stages of evaluation and close to being released as commercial cultivars.

Materials and Methods

The potential economic impact of the adoption of new *Brachiaria* grasses on the livestock systems was evaluated using the Economic Model MODEXC. Two regions were considered in Colombia: the Northern Coast and the Eastern Plains. In Mexico, the tropical region; and in Central America, its six constituent countries. The model estimates the economic benefits attributable to the utilization of the new materials, disaggregating per country, region, ecosystem, system of production and large social groups (both consumers and producers). It works with two types of parameters: the technical ones that characterize the new technology and its process of dissemination, and the economic ones representing the conditions of supply and demand in the markets of products (beef and milk) affected by the technical change.

The technical parameters are based on previous research projects from the countries considered in this study, including the opinion of experts in the subject. The economic ones were set based on various studies about the beef and milk marketing in the region.

The benefits of the new technology (from the year 2007) were calculated for a period of 20 years and the results were expressed in terms of the net present value (NPV) and annuities (A). The estimates were made using alternatively an economic framework of open and closed economy.

Results and Discussion

In a closed economy, without international trade, the NPV of the technological benefits was estimated at US$4166 million, of which 54% would be generated by marketing beef and the rest by milk. Most of the benefits were concentrated in Mexico, US$2831 (68%); followed by Colombia, US$960 million (23%), and

Central America, US$363 million (9%). In order to have criteria on the extent of the estimated technological benefits, the value of the beef and milk yield during 2003 was calculated in the reference countries. The NPV is equivalent to 44% of the value of that year, ranging between 16% in Honduras and 78% in Nicaragua. The results show the great importance of the dual-purpose livestock production system. In most countries, more than half of the technological benefits were generated in this system: Colombia 70%, Central America 62%, and Mexico 50%.

When a country is self-sufficient and the surplus resulting from the technical improvements is marketed domestically, the benefits are transferred to the consumers, who are favored with the reduction in prices, making possible for them to increase the consumption. In the current case of a closed economy, consumers would capture 83% of total benefits. Trade liberalization implies a re-distributive process favoring producers. Export purchases increase total demand and restrain the fall of domestic prices. In an open-market economy, the share of benefits to producers would rise to 46%.

Research investment is conceived as a primary mechanism to achieve two of the most basic social goals: 1) poverty reduction and the improvement of equity, and 2) the promotion of economic growth. Having this premise, in order to establish to what extent this technical change contributes to the fulfillment of these goals, the acquired benefits were estimated for the most vulnerable population groups: a) The two quintiles of poorer population, representing 40% of total population, and b) the smaller producers. In both schemes, open or closed economy, both groups receive more than one-fourth of the benefits of the technical change, 27% and 31%, respectively. This is equivalent to a NPV ranging between US$1137 - 1303 millions.

Despite the definition of the levels of critical variables, especially those associated with the productivity and the adoption of the new *Brachiaria* grasses, conservative criteria were considered in order to avoid overestimating the benefits; it is important to evaluate the sensitivity of these, against undesirable changes of those variables. For this purpose, three alternative scenarios were established: 1) The reduction of 50% of the area cultivated with new *Brachiarias,* 2) the reduction of 10% in the yields of the new materials, and 3) the increase of 50% in the total time of adoption.

It is concluded that the most critical variable in the determination of the amount of benefits is yield (productivity) of the new technology, in terms of beef and milk per hectare. The elasticity of the benefits regarding the yields was estimated at 2.2 for Colombia and 1.8 for Central America and Mexico. This suggests that if the yield declines by 1%, the reduction of the social benefits is more than proportional.

The social benefits are less elastic with regard to the area planted with new *Brachiaria* grasses or the time of adoption. For example, in Colombia, if the area with improved materials declines in one percentage point, the benefits will diminish at approximately six tenths of one point. In all the proposed alternative scenarios, the investment in the development of these new pastures turns economically attractive, despite the adverse circumstances proposed in those scenarios.

The technological benefits expressed as an annuity (a fixed payment received for a specific number of years) shows that the investment for the development of new forage options is very low, less than US$ 20 million, compared with the annual benefits resulting from the use of these new materials.

4.7 Expert systems for targeting forages and extension materials for promoting adoption of forages

Highlights

- Information on adaptation, uses and management of over 200 forage species was gathered from the literature, research reports and memories of experienced forage agronomist and was incorporated in the SoFT database and selection tool.

- The spatial decision support system coined CaNaSTA (Crop niche selection for tropical forages) was compared with three existing forage knowledge bases and tested with forage experts. Results indicated several strengths of CaNaSTA: (a) facilitates for data input, (b) allows spatial variability to be made explicit and (c) the score and ranking system allows more suitable forage species for a given niche to be considered first.

- It was demonstrated that using GIS, sites could be found where multiple forage species with distinctive distribution might be brought together to coexist as part of a strategy for in situ conservation of forage species.

4.7.1 Selection of Forages for the Tropics (SoFT) – a database and selection tool for identifying forages adapted to local conditions in the tropics and subtropics

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Rationale

Rising populations and incomes in developing countries are likely to double demand for livestock products by 2020 (Delgado et al. 1999). This strong demand has potential to improve profitability for farmers but will require improved animal feeding in both semi-intensive crop-livestock and more extensive livestock systems. Forages are commonly the most cost-effective option to supply feed demands, particularly for ruminant livestock, but also for pig and poultry production. Selecting the most suitable forages for the local system and conditions is critical. Smallholder and even larger-scale farmers depend heavily on advice from extension and development agencies, and from seed companies, but this advice is often limited by inexperience and the difficulty in accessing reliable information. Expert information on an extensive range of tropical forages is now readily available through the SoFT database.

Database development and structure

Forage research over the last 50 years has identified many useful tropical grasses and legumes. Information on their adaptation and use has resided in peer-reviewed literature, research reports with limited distribution and, often most importantly, in the memories of forage agronomists with decades of experience.

The SoFT database has accessed these information sources to define the adaptation and use of over 200 forages, and has integrated this knowledge into a user-friendly database.

The database has four main features: (i) information in fact sheets on the adaptation, uses and management of forage species, cultivars and elite accessions; (ii) a selection tool built on LUCIDä that enables easy identification of best-bets based on 19 criteria (Table 86); (iii) a bibliography of more than 6,000 references and

Table 86. Selection criteria available in the SoFT database for selecting the most suitable forages for environments and uses.

Climate/farming system attributes	Soil environment attributes	Plant attributes
Latitude x altitude	Soil pH	Plant family (legume or grass)
Rainfall (average annual)	Level of available soil Al/Mn	Life cycle
Length of dry season	Level of soil salinity	Growth form
Inundation	Soil drainage	Stem habit
Intended forage use	Soil texture	Cool season growth
Grazing pressure	Soil fertility	Frost tolerance (foliage damage)
Shade environment		

abstracts on forage diversity, management and use; (iv) a collection of photographs and images of species to help in their identification and use. The database selection tool is an expert system based on the experiences of more than 50 forage specialists who have worked for many years in tropical and subtropical regions of Africa, Tropical USA, Central and South America, South and South-east Asia and Australia.

Conclusions

This year members of the SoFT project summarised information on tropical forage adaptation and use from available literature and experiential sources. On CD and the Internet, the SoFT database will allow researchers and advisors to select those forages most suitable for local conditions. It is also a valuable teaching tool for colleges and universities. Updates of SoFT will be undertaken by CIAT.

4.7.2 CaNaSTA – Crop Niche Selection for Tropical Agriculture, a spatial decision support system

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Rationale

Farmers in the developing world frequently find themselves in uncertain and risky environments, often having to make decisions based on very little information. Risks for smallholder farmers are often critical because of their poverty. In addition, in the tropics and subtropics, the natural environment is spatially and temporally variable and often harsh, thereby increasing the uncertainty faced by these farmers. Forage-based technologies are an excellent option for intensifying meat and milk production.

The research aims to improve forage adoption decisions in the developing world, thereby increasing sustainable intensification and ultimately contributing to increased sustainable world food production and the alleviation of under-nutrition.

A spatial decision support can facilitate the decision process by making available relevant data and knowledge. Spatial Decision Support Systems (SDSS) work with explicitly spatial data, and outputs usually include maps. An SDSS has been developed called CaNaSTA (Crop Niche Selection for Tropical Agriculture) (*canasta* is Spanish for basket, and the tool aims to offer a basket of options to farmers).

Materials and Methods

The engine used to develop CaNaSTA is Bayesian probability modeling tool. The following main criteria were used for selecting the model: (a) the ability to work with small datasets, (b) the ability to work with expert knowledge and (c) the ability to predict a range of species' responses. In addition, a low structural complexity is required as well as ease of communication and the ability to implement the DSS spatially.

Probability calculations

In Bayesian probability modeling, if Y is a response variable, then the prior probability of Y is denoted $P(Y)$. $P(Y, X)$ is the joint probability, and $P(Y \mid X)$ is the conditional probability of Y given X, i.e., P(forage adapts | rainfall is suitable) denotes the conditional probability of a forage adapting given that rainfall is suitable. Conditional probability can be calculated from prior and joint probability values (Eq. 1). Posterior probability of an outcome Y occurring given a number of events is proportional to the conditional probability of each event occurring, assuming all variables are conditionally independent (Eq. 2).

$$P(Y \mid X) = \frac{P(Y, X)}{P(Y)} \qquad (1)$$

$$P(Y \mid X^1, X^2, \ldots, X^n) \propto P(Y) \prod_k \left(\frac{P(Y \mid X^k)}{P(Y)} \right) \qquad (2)$$

In CaNaSTA, $P(Y)$ is the probability of adaptation, with values of 'excellent', 'good', 'adequate' or 'poor'. The predictor variables X^k are elevation, annual rainfall, length of dry season, soil pH, soil texture and soil fertility. Model outputs include a score value based on the probability distribution and a certainty value associated with the distribution, derived from trials data and expert knowledge, including the forage knowledge base SoFT. Stability measures are derived from changes in distribution when variables change states. From these, a ranked list of recommended species is calculated, along with suitability maps.

Results and Discussion

Results from CaNaSTA when compared with results from three existing tropical forage knowledge bases and direct elicitation from forage experts, highlighted a number of strengths of the tool. Firstly, species are not automatically excluded when one variable is unsuitable, as all other variables may be highly suitable. Secondly, the score and ranking system allows more suitable species to be considered first, rather than the user being presented with an unranked list of all species, which fit the criteria. Finally, CaNaSTA produces suitability maps dynamically; most other available knowledge bases do not have inherent spatial functionality and maps can only be produced on an ad-hoc basis.

Conclusions

Incorporating spatial capabilities into an agricultural DSS, as in CaNaSTA, facilitates data input, allows more informative output of results, and allows spatial variability to be made explicit, both of results and of uncertainties related to the results. Even with limited data, results can be obtained which support the technician farmer's decision-making process. When uncertainties are made explicit, technicians working with farmers can then make less-risky decisions by taking these uncertainties into account. Providing access to decision support through an SDSS, such as CaNaSTA, ensures that the information is delivered in a consistent and robust manner. Trial data and expert knowledge previously inaccessible to farmers are made available so that decisions taken are better informed.

4.7.3 Identifying areas for field conservation of forages in Latin American disturbed environments

Contributors: Michael Peters, Glenn Hyman and Peter Jones, with collaboration from B. Hincapié, G. Ramirez, G. Lema, V. Soto and E. Barona (CIAT)

Rationale

An attractive new idea has come out of CIAT this year. Originally proposed by Dr D. Debouck; the conservation of critical germplasm on roadsides in Latin America has many attractions. We therefore investigated the feasibility of this approach using key forage legume species that have been identified in CIAT research and that definitely fulfill the role of conservation premia.

In situ conservation can complement *ex situ* conservation that can be very costly. It also allows for continuing evolution and adaptation of plant species. However, to be successful, *in situ* conservation projects need to pay attention to the socio-economic components of biodiversity (Brush 2000). In their original conception, large areas must be set-aside for all time, so conventional *in situ* conservation can be even more expensive than germplasm collections. Here we concentrate on field conservation of some species that could be considered a subset of *in situ* conservation and could avoid many of the high costs of complete set aside conservation.

Many forage plants have evolved in environments affected by human or animal activity, it is highly likely that they can be conserved in disturbed environments with less restriction of use than required in natural reserves. The number of natural reserves is limited; thus the approach that we suggest could complement conservation in natural habitats.

Latin America has only 3% of the world's roads, with less than 20% paved. However, there are over 10,000 km of *freeways*, and there is a growing trend towards the development of public toll roads managed by the private sector. The verges of main roads in Latin America are mainly publicly owned and are herbaceous. Often they are cut or grazed to maintain low, disturbed vegetation as part of normal road maintenance. Apart from establishment and monitoring, the costs for maintenance of roadside forage conservation areas are not envisaged to be much greater than those that road maintenance authorities currently incur. We recognize that in some areas the roadsides are cultivated. These areas would not be selected when identified in further analysis.

Materials and Methods

We used DIVA, and FloraMap® software to determine two probable distributions. DIVA deals only with the actual presence of a sighting of the species and therefore maps the *known* area of extent. FloraMap on the other hand creates a probability model of the *possible* distribution and so maps the extent of environments that could potentially be host to the species in question. This difference was the crux of our analysis. We postulated that there were two main reasons for trying to conserve species on roadsides. The first was to establish populations of genetic diversity within their area of origin, the second to establish mass reservoirs of the germplasm wherever they could be established. Both of these are credible aims. Even though the second might be much harder to achieve. We selected forage legume species based on size of collections held in CGIAR germplasm banks, importance, and knowledge of species. *Stylosanthes* sp. is probably the most researched and widely distributed tropical forage legume genus, with *S. guianensis* (Aublet) Sw. and *S. scabra* Vogel best adapted to acid soils, and the pH neutral *S. hamata* (L.) Taubert probably best known. These are complemented with *S. viscosa* Sw. and *S. capitata* Vogel. *Centrosema pubescens* Benth., *C. macrocarpum* Benth., and *C. brasilianum* (L.) Benth. have been researched in depth. *C. pubescens* is broadly distributed in the tropics as feed, cover crop, and green manure. More recent interest in forage legumes has been in *Arachis pintoi*, showing initial adoption as pasture in grass legume associations and as cover in plantations. *Aeschynomene histrix* Poiret has been adopted in West Africa as forage and for improved fallow.

We defined two scenarios; first, to conserve the germplasm within the known area of its abundance, second, to form mass reservoirs where it would be likely to be adapted.

The DIVA analysis gave us the clearest indication for the first scenario, but left us wanting on the second. FloraMap results gave us the best indication for the second case. FloraMap produces probability surfaces for the potential distribution of a species. In order to find the most promising areas to search we had to combine the probability surfaces.

Combining probability surfaces. Determining the best *in situ* conservation sites for the greatest number of the 10 species examined in this study requires the combination of the 10 probability surfaces. We tried a number of different ways to combine the probabilities; most were unsatisfactory, but one appeared to give us what we needed:

$$p = \frac{1}{n}\sum_{i=1}^{n}(p_i \geq a) \quad (1)$$

Equation 1 forms an index from the number of species where the probability, p_i, exceeds a threshold, *a*. We decided to use a threshold probability of 0.5, and used this equation to map species richness. Because this index if freed from actual accession observation, a low or zero value indicates low probably of diversity, and not just lack of knowledge as in the case of DIVA.

Defining potential road verges. We defined the potential for establishing *in situ* conservation sites along roadsides using the digital road maps of Latin America and the Caribbean at 1:1,000,000, from the Digital Chart of the World (DCW). We improved on this map, where possible, by adding finer scale data from national road maps, supplementing the DCW, and allowing us to verify the road conditions. These maps were then overlaid on the species richness maps to determine the probable sites with accessible lengths of roadside environment suitable for the conservation of the maximum number of species together.

Results

Evaluating diversity in the areas of origin: Scenario 1: Most of the 10 forage species studied were collected in Central America, Colombia, Venezuela, and south and eastern Brazil (Figure 55). The map shows four areas where six or more forage species were found within the same 1-degree grid cell. These include an area in Central Panama near the town of Anton, an area in eastern Venezuela between Cumana on the coast and El Tigre to the south, and two areas in Brazil from Salvador westwards into Bahia State and in central Mato Grosso. The Venezuelan site showed the highest concentration of forage species richness.

Evaluating diversity of mass reservoirs outside areas of origin: Scenario 2: We produced individual distribution maps for each species, including the accession points used to calibrate each model. For the ten species distributions, we combined the probability distributions using Equation 1. The result, demonstrated in Figure 56, shows the concentration of species having a probability greater than 50% of finding an environment similar to areas of origin. We overlaid this map on the road distribution, and selected those areas where significant numbers of pixels with high species richness index also showed major road access. This eliminated two significant areas—the first in Western Brazil, where access is limited, and the second in Venezuela, south of the Orinoco, which is likewise highly remote.

Discussion

Can we form stable associations of legume species? Results from work with legume mixtures show that through compensation and complementation of individual legume species, mixtures are seasonally and temporally more stable than single stands. The complementarity of species signifies that although some less competitive species may reduce in the sward over time, a stable mixture of several species in a sward can be formed. Successful legumes have included *Stylosanthes*, tree legumes and niche legumes such as forage *Arachis* species. Their characteristics varied greatly but, with some exceptions, they demonstrated persistence, vigor and longevity under grazing or cut-and-carry systems, ease of establishment (with the exception of *Leucaena*), and either high seed yield or ease of vegetative propagation.

Genetic drift within the populations. Genetic drift is expected in the populations once established), but by selecting areas most climatically similar to the areas of origin we hope

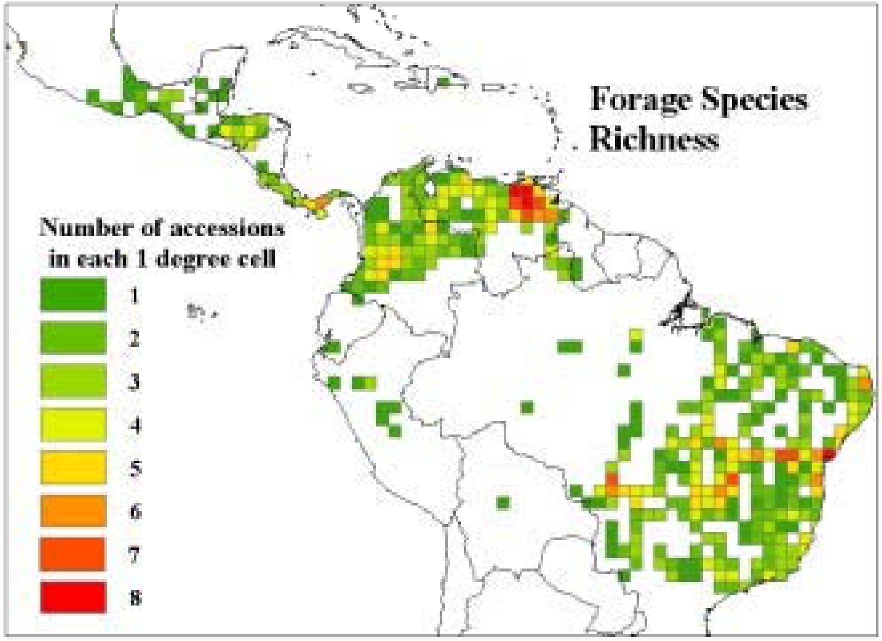

Figure 55. Species richness of 10 forage species in Latin America.

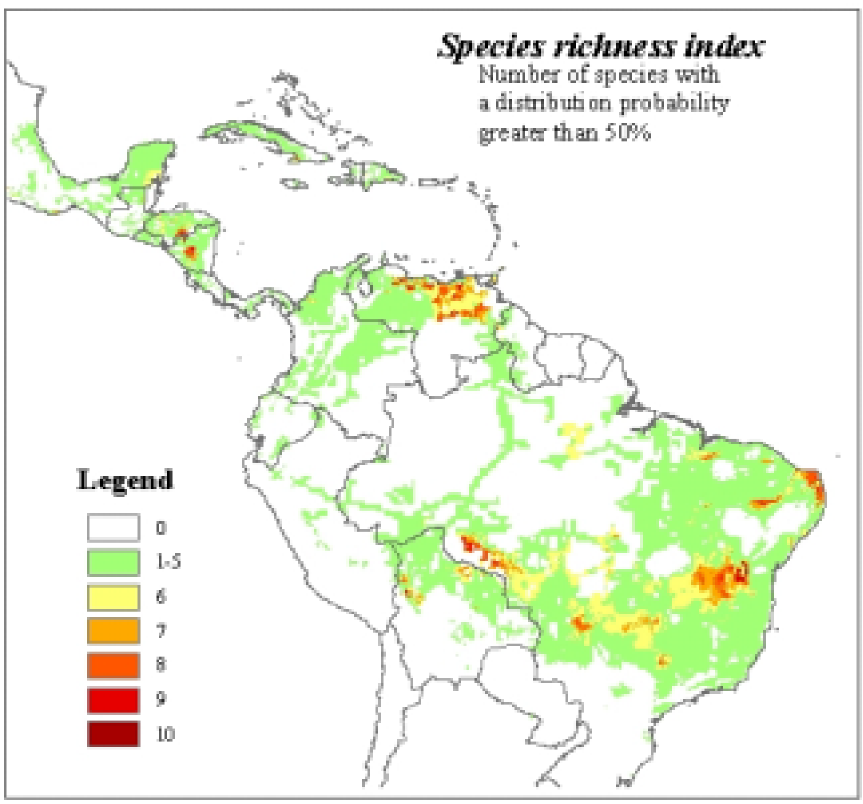

Figure 56. Potential areas for *in situ* conservation outside areas of origin. The concentration of species having a probability greater than 50% of finding an environment similar to areas of origin.

that this will be minimized. Legume persistence in tropical pastures can be problematic under heavy grazing pressure, but is much easier to control under light grazing There are a few exceptions to this rule since legumes such as *Arachis pintoi* and *Desmodium hetercarpon* subsp. *ovalifolium* require heavy grazing for persistence. Road verges often can have a variety of these characteristics. We propose that test ecotypes could be taken from a core collection of each species to ensure including the full range of available genetic variation. A general problem emphasizing areas of species richness is that they may miss outliers of plant species with particular characteristics. Conversely, an area suitable for all 10 species may mean that some or all will be adapted marginally, resulting in rapid selection and genetic drift. We have attempted to limit this possibility by requiring a high threshold probability of 0.5 for the inclusion of a species in the diversity index, but we accept that the roadside sites will not guarantee full conservation of a collection. Having a range of sites may be necessary to conserve as much diversity as possible.

The difference between FloraMap and DIVA. The coincidence between the species richness maps produced by the DIVA and FloraMap methods in those areas where actual existence of accessions occurred gives us confidence in the FloraMap analysis. The advantage of the latter method is that it can predict potential areas without the necessity of actually having observed the plants there. However, the DIVA analysis guarantees that all species actually have been present in the area selected, and may be the most appropriate for strict conservation in areas of known origin.

Conservation in areas of origin

Our results suggest that four areas could hold suitable sites for *in situ* conservation in the areas of origin for eight forage species (Figure 55). Since establishing conservation plots in these areas of origin involves limited risk, our maps identify priority areas that can guide conservation specialists and policymakers. Detailed mapping and local knowledge of these potential sites is needed to plan for pilot projects. The potential sites that we identified can be studied in greater detail using remote sensing data. High-resolution imagery or air photos possibly could provide useful information, even of the verges. Soil information is needed to assess the diversity of soil environments for conservation sites. If a detailed soil map of the area is available, this assessment could be carried out in the office. Eventually, researchers and local experts will need to carry out field reconnaissance to verify whether the identified sites could be set up as conservation areas.

Mass reservoirs, not necessarily in areas of origin

An advantage of having an *in situ* conservation area with public access in an area where forage legumes have a niche in farming systems is that the populations will serve as an ongoing adaptation trial. Eventually, farmers will be able to select promising ecotypes well suited to their area, directly from the conservation area. Thus, mass reservoirs can be seen to fulfill two roles, that of conservation and that of selection of adapted material. These could be viewed as conflicting ends, and may require careful balancing. Detailed studies under controlled conditions are necessary to assess implications of such reservoirs. The area around El Tigre, Venezuela, and in Bahia State in Brazil may provide ideal study grounds since they combine areas suitable for conservation in the areas of origin (Figure 55) and for mass reservoirs (Figure 56), hence reducing the risks of genetic drift, and introduction of harmful weeds.

Conclusions

This study used temperature, precipitation, elevation, transportation infrastructure, and species passport information for selecting possible locations for *in situ* conservation of plant genetic resources on roadsides. We have shown that, using geographic information systems (GIS) technology, sites can be found where multiple forage species with distinctive distributions might be brought together to coexist. There may be biological problems to overcome and we have outlined some of them with possible solutions and caveats. However, it would appear that there could be good precedent for putting together easily maintained mixtures of legume species. The actual operation of this type of conservation will require local support; we feel this is eminently feasible and should be tried. If it can be made to work with forage legumes, it might be an option with other colonizing species, and a low cost solution to the conservation of valuable wild crop relatives.

4.8 Facilitate communication through journals, workshops, and the Internet

Highlights

- As the Journal Pasturas Tropicales celebrates its 20th Anniversary it continues to be an important vehicle for forage researchers in LAC to publish their work. During 2004, three volumes with 20 research papers from Brazil, Colombia, Mexico and Paraguay were published.

- The Forage Web site continues to be an excellent media to reach large audiences interested in Forage R&D. Late last year we launched the Spanish Forage Web in order to reach researchers and development workers in LAC. Half of the hits (32,631) recorded in 2004 were for the Spanish Web version.

4.8.1 Publication of Pasturas Tropicales

Contributors: A. Ramírez (Independent Publisher) and Carlos Lascano (CIAT)

During 2004 three issues, corresponding to Volume 26, were published. The contributions of research papers from Brazil (13), Colombia (5), Mexico (1) and Paraguay (1) are summarized in Table 87. As in previous years, the number of contributions has been high. Twenty-two documents are pending to be published in coming volumes. This high number of contributions is an indicative of researcher's preferences and of the high international visibility of the forage related publication.. This year Pasturas Tropicales is celebrating its twentieth anniversary of circulation. This, in addition to the fact of having been qualified by Colciencias in its Index Series of Colombian Scientific Magazines, consolidates even more its position as an effective means of communicating forage research in Tropical Latin America. Timely circulation of the magazine was an important advance during 2004. This was accomplished by transfering the tasks of editing and designing the magazine to staff of CIAT's Forage Project.

Table 87. Topics and number of contributions published in Tropical Pastures during 2004.

Topics	26(1)	26(2)	26(3)	Institution	Country
Covers	_	1	_	Corpoica	Colombia
Pastures Rehabilitation	1	2	2	Embrapa-Ro. (3)	Brazil
				Corpoica (1), CIAT (1)	Colombia
Seeds Phenology	_	1	_	INIFAP	Mexico
Silvopastoril systems	_	2	_	Embrapa-Agrobiología	Brasil
Forage quality- trees			1	CIAT	Colombia
Establishment	_	1	_	UdeA	Colombia
Intake	1	_	_	Embrapa-Amazonia	Brazil
Fertilization	3	_	_	Embrapa-Ro (1), Univ. Rural de Rio Janeiro (2)	Brazil
Establishment	1	_	_	Embrapa-Agrobiology	Brazil
Animal production	_	_	1	Embrapa-Amazonia	Brazil
Impact of forage adoption	_	_	1	CIAT	Colombia
Simulation growth model	_	_	1	ESALQ	Brazil
Colection of Arachis	_	_	1	USDA-Univ. do Paraná	Paraguay
Total	6	7	7		

4.8.2 Update on the Forage Web Site

Contributor: Simone Staiger and B. Hincapie (CIAT)

The Tropical Forages Project, web site is the result of teamwork between all Project members, under the general Web site coordination of the Communications Unit and with the support of both the Systems and the Information and Documentation Unit. The Web site has allowed us to disseminate our research results extensively and to promptly communicate important news. Late last year we launched the version in Spanish of the Forage Web page in order to reach a large audience in LAC (universities, research institutes, donors, and the scientific community in general). The site is accessible under the URL http://www.ciat.cgiar.org/forrajes/index.htm

In Figure 57 we show the number of hits in the period October 2003 – August 2004, for the English and Spanish versions. A total of 64,459 hits were recorded out of which half (32,631) were for the Spanish version.

In Table 88 we summarize downloads of different documents placed in the web page. To date their has been 106, 038 documents downloaded, the most popular being the Technical Bulletin of *Brachiaria brizantha* cv. Pasto Toledo with 27,077 downloads, followed by the recently launched Index of Pasturas Tropicales.

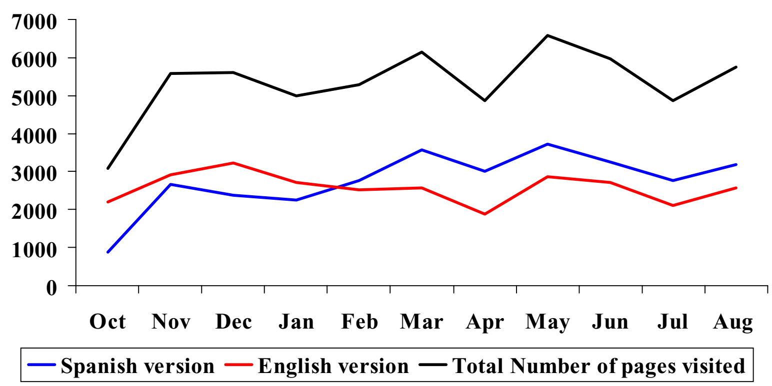

Figure 57. Number of visits to the Forage Web sites (English and Spanish) during the October 2003 to August, 2004 period.

Table 88. Download of documents in the Tropical Forages Web site (October, 2003 to August 2004).

Downloads	Number
Technical Bulletin: Cultivar Pasto Toledo	27077
Pasturas Tropicales Indice de Autores y Especies Forrajeras	26612
Technical Bulletin: Cratylia argentea cv Veranera	24165
Methods: Evaluación Pasturas con Animales	12010
Annual Report 2003	7459
Producción Artesanal de Semillas de Pasto Toledo	4551
Informe MADR 2003	4164