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

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

Highlights

- For farmers in Uganda total forage yield was not a priority indicator to select new forage species. The value of new forages (improved Brachiaria cultivars) was mainly associated with dry season performance.

- The legume Stylo CIAT 184 was seen as an excellent option for dry season feeding, by farmers in Uganda but seed availability limits its use and diffusion. Development of farmer led forage seed systems linked to commercial components is of high priority.

4.1.1 Lessons learned from participatory evaluation of improved forages with farmer groups in Tororo, Uganda

Contributors: Ralph Roothaert (CIAT/ ILRI, Ethiopia); Grace Nalukwago, Paul Nyende (Africa 2000 Network, Uganda)

Rationale

Eighty percent of the Ugandan people depend on agriculture for their livelihood (Aliguma and Nyoro, 2004). Tororo district is one of the poorest areas in Uganda with more than 60 % of households falling below the absolute poverty line (Thornton et al, 2002). The farming system is characterised by annual crops, local cattle and goats. Although Tororo lies in a tsetse fly infested area, there is potential for improved dairy production for smallholders which can contribute to increased farm income, and better nutrition for children and sick household members. A few NGOs are introducing dairy production using improved breeds.

A participatory diagnosis conducted in 2003 by the NGO Africa 2000 Network (A2N) and CIAT revealed many problems related to productivity of the farming system:

- High incidence of pests and diseases in crops.
- Lack of seeds and knowledge of improved crops varieties.
- Feed shortage for improved dairy and goat breeds, and for cross breds, especially during the dry season which lasts from December to March.
- Cross border trade with Kenya causing labour shortage.

In addition to problems described, the soils are infertile and deficient in K, P and N. The district has a high population density, (more than 280 people per km^2). 82% of the land is under cultivation . As population increases, so does the demand for land.

Partnerships for research to improve soil management

In 1997, a consortium of district based R&D organisations was formed to improve soil fertility to overcome food insecurity and poverty. The consortium was called INSPIRE and consisted of the district government's department of production, Africa 2000 Network (A2N), Sasakawa Global 2000 (SG2000), Tororo District Farmers Association (TODIFA), Cash Farm, Plan International, DATIC, CARITAS, Appropriate Technology (AT) Uganda, and various national and international research institutes. A2N has been coordinating the activities. Among different soil fertility improvement strategies, research was carried out with farmers to evaluate the performance of several cover crops: *Crotalaria grahamania*, *C. pancilla*, mucuna, canavalia, sesbania and tephrosia. Although the evaluation criteria were mostly agronomic in nature, an additionally appreciated attribute of mucuna was its use as animal feed.

Objectives of the experimentation with forages

A2N works with 45 farmer groups in Tororo District, and some of these groups have received Friesian cattle through a dispersal scheme to start up dairy production. In 2003, CIAT and A2N selected two groups to start participatory evaluation of improved forage varieties. Some farmers of one group, Katamata, had already received a cow. In the other group, Umoja, selection had been made of farmers who would qualify to receive a cow. Although INSPIRE had tested forage crops for soil fertility improvement with farmers, most of the species used in these experiments were not that suitable for animal feed, due to palatability, digestibility or toxicity problems. On the other hand, farmers were already growing and feeding napier, calliandra, leucaena and sesbania to their livestock. Napier is a good forage in many aspects, but it needs high soil fertility and continuous rainfall throughout the year. Calliandra, leucaena and sesbania are especially useful to supply dietary protein for cattle, but their establishment and management is more intensive than other forage crops.

One objective of the new initiative was to evaluate alternative forage varieties which would provide high amounts of high quality feed for dairy cows during the critical dry season from December to March. The other objective was to study the research process and develop methods that optimise learning and impacts for forage systems with resource poor farmers in East Africa. Secondary objectives were to increase fodder availability for goats, and improve soil fertility.

Approach and methods

An action research approach was chosen to obtain the research outputs and to enhance learning and change among all parties involved. Several iterative cycles of planning-action–reflection–planning were envisaged over a period of two years. The first cycle started with reflection of past farmer experiences and collaborative participatory planning of on-farm forage evaluation experiments. The research was carried out with two farmer groups within a range of 10 km from Tororo town; Katamata and Umoja groups. Research was carried out simultaneously and separately with both groups. Both groups had mixed gender composition of members.

Results and Discussion

First cycle, Feb. – June 2004

Past experiences with livestock and forages were reflected with both groups. Seventeen women and 20 men farmers were part of the initial discussions. Ownership of local goats, local cattle, local pigs, and exotic cows were 59, 57, 24 and 11% respectively. Although none in Umoja group owned a dairy cow, 14 members were expecting to receive one soon. Farmers of both groups were familiar with the following fodder trees: Sesbania sesban, Calliandra calothyrsus and Leucaena leucocephala. Sesbania was said to be good for milk production; calliandra was said to be drought resistant, and leucaena was liked by goats and cattle. Experiences with other forages were also mentioned: Pennisetum purpureum grows well on deep soils, Lablab purpureus increases appetite of animals. Mucuna is dual purpose; it improves soil fertility, feeds cows and goats, and grows well during the rainy season.

Planning. Members of the groups expressed interest to experiment with new forage legumes and grasses that would provide high quality feed for their animals. Most members preferred to experiment on an individual basis rather than in a group; in previous group experiments the contribution of labour from group members had been skewed and unsatisfactory. Unfortunately there was not enough seed for experimentation on individual basis for everyone; a maximum of 5 replicates per forage species per group was possible. A compromise was reached in both groups: experimental plots would be established on 5 individual farms per group, and other members would choose the farm they would want to be associated with and contribute labour to. By contributing labour for an experimental plot, the member would have priority to use of fodder, seeds or planting materials produced from the plot. Consensus was reached for 5 men and 5 women to be allowed to take the lead and establish experimental plots on their farms. Each of them would become sub-group leader, and 4 additional members were allocated to each sub-group, making a total of 50 members directly involved in the experiment. A scientist described new forage varieties and explained their agronomic and nutritive attributes.

A plot layout was proposed by the scientist, and farmers suggested some modifications in terms of space. The agreed layout contained 4 grass species, 7 herbaceous legumes species and varieties, one tree legume, and a live hedge of the

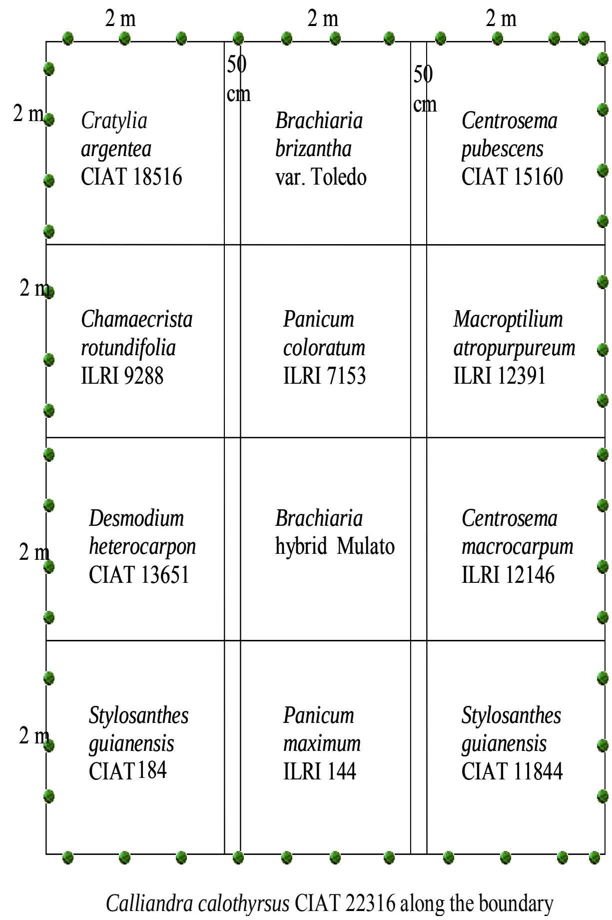

Figure 64. Experimental plot layout for farmer sub-groups in Tororo District.

Table 63. Description of forage types and spacing for planting in experimental plots.

Type	Botanical name	Accession number/ variety	Local name	Spacing
G	*Brachiaria* hybrid	Mulato 1	Mulato	Lines 40 cm
G	*Brachiaria brizantha*	Var. Toledo	Toledo	Lines 40 cm
G	*Panicum coloratum*	ILRI 7153	Makarakara	Lines 40 cm
G	*Panicum maximum*	ILRI 144	Odunyo	Lines 40 cm
HL	*Centrosema macrocarpum*	ILRI 12146	Centro 2	40 x 40 cm
HL	*Centrosema pubescens*	CIAT 15160	Centro 1	40 x 40 cm
HL	*Chamaecrista rotundifolia*	ILRI 9288	Chama	30 x 30 cm
HL	*Desmodium heterocarpon*	CIAT 13651	Desmodium	Lines 30 cm
HL	*Macroptilium atropurpureum*	ILRI 12391	Siratro	40 x 40 cm
HL	*Stylosanthes guianensis*	CIAT 184	Stylo 1	Lines 30 cm
HL	*Stylosanthes guianensis*	CIAT 11844	Stylo 2	Lines 30 cm
TL	*Calliandra calothyrsus*	CIAT 22316	Calliandra	1 m
TL	*Cratylia argentea*	CIAT 18516	Cratylia	1 x 1 m

G = grass, HL = herbaceous legume, TL = tree legume fodder tree calliandra surrounding each total plot (Figure 64; Table 63).

All forages were planted directly in the soil through using seeds which were scarified when appropriate. The location of the plots would be near roads, so that it would generate interest of passers-by.

Second cycle, June – Aug. 2004

Farmers suggested many parameters to be measured from the plots, and the methods of monitoring were discussed (Table 64). In addition, ease of management, wood production, and milk production were mentioned to be measured, but it was decided that assessment of those parameters would be more appropriate during a following season, since they would require a longer period after planting.

Group discussions were held in June 2004 on the first season's evaluation. Things that reportedly went well, in terms of forages performance and experimental process, were timely seed availability and planting, and growth of some species. The facilitators had been visiting the groups regularly.

The following factors were associated with problems encountered:

- Identification of germinating and emerging forages were difficult; farmers did not know what kind of plants to look for. This delayed weeding. On the other hand, some farmers recognised the patterns of lines or matrices in which the forages germinated, and had started weeding.
- There was some damage by stray animals feeding on the young plants.
- Some farmers found the plots too small; they would rather start feeding large quantities from the plots at once.
- Cratylia was attacked by unidentified pests.
- Several species germinated 4-5 days after planting, but the panicums and siratro did not germinate well, even after weeks.
- Although farmers had a good impression about germination variability, no quantitative records were taken. Equally, the other planned

Table 64. Agreed parameters to be measured and their methods for forages in the experimental plots.

Parameter	Method and time
Germination	Visual estimated percentage of emergence, one month after planting.
Growth and vigour	Visual observation and ranking of species and varieties, 2 months after planting.
Pest and disease resistance	Visual observation and description of symptoms and insects, 3 months after planting.
Plant height	Tallest plant per species or variety in cm, 3 months after planting.
Fodder biomass production	Harvesting demarcated sections of 1 x 1 m per species in each plot, 3 months after planting. Fresh fodder is weighed using simple scales.
Maturity	Time after planting of flowering and seed setting.
Drought resistance	Visual observation and ranking of species and varieties, one month after rains stopped.
Palatability	Separate for cattle and goats. Small heaps of different forages are placed on the ground. One animal at a time is allowed to nibble at the heaps. A few farmers observe the behaviour of the animal. The preference of forage is ranked for each individual animal. The test is repeated with fresh materials for 5 cattle and 5 goats. A relaxed environment is provided for the animals during observation.
Seed production	Seeds are harvested from plots whenever they are mature. They are stored in paper bags and weighed by facilitating staff.
Best general performance	Group discussion, ranking of species and recording reasons.

monitoring of parameters described in Table 64 proved ambitious; most was not done. The groups needed to prioritise on what o measure, also considering that they already had monitoring and evaluation plans associated with other activities. Forage experimentation needed to be integrated in these plans.
- One group experienced organisational problems, there was a dispute about leadership. This might have affected recording exercises.

Planning. The following actions were planned:

- Address the problem of stray animals damaging the experimental plots. Local leaders would be invited to a meeting. There would be an opportunity to agree on a by-law for restricting movements of stray animals in the location and enforcement of the by-law.

- Reduce number of parameters measured by farmers to the ones of greatest interest by the community: palatability, pests and diseases, and drought resistance. Fodder biomass production remained of great interest to scientists and it was agreed that facilitators would take data from the plots. A portion of 1 x 1 m of each variety or species in each plot was reserved for these measurements. The plots were maintained for another rainy season and the subsequent dry season. The facilitators would also measure seed production from the plots.

Third cycle, July – September 2004

Palatability tests had been conducted with local and dairy cattle and with local goats. Although repetitions of the tests with individual animals had been recommended and explained, in order to increase reliability of results, farmers observed all animals together during the same test. There was consensus about the ranking of palatability of the forages. Tests for grasses and legumes were done separately. For the local cattle, Mulato ranked highest (in terms of animal's first choise and quantity consumed), followed in rank by Toledo, *Panicum maximum*, and *P. coloratum*. Among the legumes, they only ate stylo. The dairy cattle ate all grasses and legumes without any noticeable preference.

Palatability of grasses by goats was observed as follows with decreasing ranks: *P. maximum*, Toledo, Mulato, *P. coloratum*. Palatability of legumes by goats was ranked as follows with decreasing ranks: *Desmodium heterocarpon*, *Centrosema pubescens*, *C. macrocarpum*, Chamaecrista, siratro, stylo 184, Cratylia and stylo 11844.

Vigour of forages was discussed in a meeting. In both groups, Mulato, Toledo, and stylo 184 were among the top three forages in terms of yield (Table 65). No disease or pest was recorded, except for mole rats infestation which affected the whole plot.

There was a discussion about the functioning of the sub-groups. Not all members contributed labour equally for weeding and data collection, which was the cause of some dissatisfaction. It was decided that members were free to leave the group if they didn't feel happy there, or join another group. Active sub-group members would benefit from harvested forage and seeds. It was acknowledged that not every sub-member had an interest in forage, which cleared the confusion.

Planning. Several farmers reported that the plots were too small to harvest substantial amounts of feed. Thus plans were made to expand the forages to other areas on the farms. Recommendations were made on which species would be suitable for intercropping, barriers, cut and carry from fodder banks, or grazing, and how they needed to be managed.

Fourth cycle, September 2004 – March 2005

During the rainy season, biomass was harvested from the species and varieties in every plot. Results are summarised in Table 65.

Meetings were held in December 2004 and Feb 2005. Rains had been bad in the past season, to the extent that it had not been possible to expand and plant forages in other places. One farmer

Table 65. Fresh biomass production tonnes/ha of forages planted in Tororo, 2 harvests.

Species or hybrid	Accession	Sept. 04	June 05	Total
Brachiaria hybrid	Mulato 1	36.6	19.6	56.2
Brachiaria brizantha	Var. Toledo	32.2	23.1	55.4
Panicum coloratum	ILRI 7153	6.0	5.3	11.3
Panicum maximum	ILRI 144	9.2	1.3	10.5
Centrosema macrocarpum	ILRI 12146	6.0	4.0	10.0
Centrosema pubescens	CIAT 15160	14.9	8.0	22.9
Chamaecrista rotundifolia	ILRI 9288	20.2	8.4	28.6
Desmodium heterocarpon	CIAT 13651	7.6	6.1	13.7
Macroptilium atropurpureum	ILRI 12391	9.7	2.0	11.7
Stylosanthes guianensis	CIAT 184	42.9	16.0	58.9
Stylosanthes guianensis	CIAT 11844	22.1	10.9	33.0
		$P < 0.001$	$P < 0.001$	

had experimented with intercropping of centro in an existing napier fodder bank. The dry season reminded everyone of the need of having forages which could tolerate drought. Severe forage shortage existed at Umoja group. A few forages from the experimental plots remained green.

There had been no systematic evaluation for drought tolerance. In March, a tour was conducted among all plots and pictures were taken of all sub-plots. After comparing the digital photos, drought resistance of the species and varieties was ranked. The following ranks were made:

1. Stylo (both accessions)
2. Mulato
3. Toledo
4. Chamaecrista
5. *Centrosema pubescens*
6. *Desmodium heterocarpon*
7. all others

When the first rains hit the ground at the end of March, farmers were surprised to see that the forages which were at a bad stage of drying up all regenerated fully and within a very short time.

With the help of facilitators, shorter and easier names were given to the forage species and varieties (Table 63). This greatly enhanced communication and comparison of forage performances.

Monitoring of the forage experiment had been integrated in the general PME plans. One important indicator for learning from the experiment was added to the plan: the number of visitors, their purpose, and their opinion about the forages shown.

Harvesting of seeds remained a problem. An opportunity arose during an interaction with scientists from a nearby institute, the Livestock Health Research Institute. The Director was interested in forage experimentation and some collaboration took off. One of the benefits for the groups in Tororo was that the institute would also try to produce seeds of the most preferred forages.

Planning. Farmers were expecting a better rainy season. Fourteen farmers were planning to expand 2 or 3 of the following species integrated on their farms: stylo 184, Toledo, Mulato, Calliandra, Chamaecrista, Desmodium, and Panicum. They were planning on using vegetative materials collected from the experimental plots to expand the new forage options. Some Desmodium seeds were still available from the original planting, and would be given to the groups. Seedlings of Calliandra would be bought from nurseries in Tororo.

In order to facilitate a second data collection on fodder biomass production, all plots would be slashed to remove dead and dry material. The weighing of this dry material was not considered relevant, because animals had been browsing on the plots during the drought, and weights of the materials left was considered to bear little relation to real biomass production during the dry season.

Fifth cycle, April – October 2005

Mole rats continued to cause severe damage in some plots. Two factors probably play a role: (1) the plants are perennial and provide food for the mole rats when the other crops have been cleared from the land after harvest, and (2) the plants have been selected for their palatability to livestock, with a high probability that they are also palatable to mole rats.

The artificial insemination (AI) service in Tororo District had collapsed more than 2 years ago. Farmers depend on an unreliable and expensive AI service from Mbale, some 50 km away. As a result, cows have remained without a calf and without milk for up to 2 years. Whether cows are being milked or not, they need to be sprayed weekly with acaricides to keep them free of ticks. Farmers had relaxed on the treatments due to money constraints and lack of income from sales of milk. As a result, most cows were affected by tick born diseases, especially East Coast Fever, and only one cow in the whole group has survived.

It was observed that the expansion of forages into the farms at the Katamata group had stagnated. We hypothesised that the problems with the lack of AI and the mortality of cows were the cause of the reduced enthusiasm for improved forages, and we decided to test this with the farmer group. The question was raised why forages were no longer adopted in the farms and a candid discussion revealed the reasons in order of importance:

1. Farmers had other priorities, commitments, or thought the planting of forages was too much work.
2. Although it had been iterated at the beginning that there would be no dispersal of animals implicated with the forage evaluation project, expectations on the contrary were hard to die out. When it became clear that no animal dispersal was taking place, enthusiasm for forages dropped.
3. Loss of animals.

At the Umoja group most cattle had survived, and expansion of forage in is progress. The group still struggles with lack of leadership, which is seriously affecting the social capital. It is difficult to bring members of the group together for a meeting.

One farmer has been able to produce and collect a small amount (about 30 g) of Chamaecrista seeds. Chamaecrista produces large amounts of seeds under Tororo farm conditions, but most is left on the ground. Compared to Stylo, it is relatively easy to harvest the dry pods of Chamaecrista and thresh the seeds.

In the second season of 2005, A2N has started to scale out forages to 11 other groups. Members were selected who had dairy cows or improved goats. Mulato, Toledo, Chamaecrista and Lablab are now grown in fodder banks on-farm. Lack of seeds has prevented the scaling out of Stylo. A new initiative is started to bring research partners in Uganda (NARO, CGIAR, CIRAD, Makarere University), development partners (MAAIF, NGOs, NAADS, Local Governments), farmer organisations, and private seed companies together to analyse the national forage seed system and explore new partnerships which will enhance the availability of priority forage species, varieties and hybrids.

Lessons learned

After two years of evaluation with farmer participation of new forage options the following lessons were learned:

1. The value of the new forages for farmers tested was related to availability of green forage during the dry season and not on total forage yield. For this reason, the Brachiaria cultivars tested in this project are a welcome addition to the napier grass that some farmers are already using. Napier normally stays green during the dry season, but stops growing and becomes stemmy. Brachiaria has the potential to continue growing during at least part of the dry season, and remains a high leaf:stem ratio. The dry matter production of the two Brachiarias obtained from this experiment was 55 – 56 tonnes fresh weight over a year, equivalent to 13.9 – 14.1 tonnes dry matter (DM) per year. This compares favourably to expected yield of unfertilised napier which is normally in the range of 2 – 10 t DM/yr under similar rainfall conditions (Mwangi et al., 1998; SoFT 2005).

2. Replacement of napier by Brachiaria cv. Mulato or Toledo is seen as a way to deal with a mycoplasma causing the 'stunt' syndrome affecting napier grass in East Africa. The diseases is transmitted by plant hoppers. Ninety-nine percent of all farmers' napier plots across the country are affected, and the disease causes an average of 60 % decline in forage yield (Kabirizi, pers. com).

3. Although grasses normally out-yield herbaceous legumes under similar conditions, biomass production of *Stylosanthes guianensis* CIAT 184 was comparable to the highest yielding grasses in this experiment, (i.e. the two Brachiarias). The advantages of Stylosanthes over all other grasses is that it has a higher crude protein content which remains stable during the dry season. Stylosanthes can be used as a protein supplement to balance protein deficient forages such as maize stover and grasses during the dry season.

4. If seeds were available of Stylo, dairy farmers in Tororo District would plant it. Stylo does produce seeds, but they mature unevenly, scatter on the ground, and are too small to pick up by hand. Technologies exist for seed collection from the ground, involving either plastic sheets or progressive sieving of particles, soil and seed. We recommend that some of these technologies are tested with farmers, and that links with commercial seed companies are made to add monetary incentives to seed production and processing. Adoption of Chamaecrista, Centrosema, Mulato and Toledo would also be enhanced through availability of seeds.

5. An alternative way of spreading Mulato and Toledo among farmers is through root splits. One tuft of grass can produce up to 50 splits. In Indonesia this method has been instrumental in spreading improved *Brachiaria spp*. to thousands of farmers. The Forages for Smallholders Project initially subsidised the production of root splits by farmers, but soon after the production and sale started running without subsidies (CIAT Forage AR2004). Projects might want to continue to facilitate through providing information to producers about where the demands for planting materials are, so that more smallholder farmers are able to increase their incomes through the business of forage planting material production.

6. Adoption of forages in East Africa is highly correlated to intensification processes and market success of livestock enterprises. In the case of smallholder dairy systems, many factors contribute to its market success, such as adequate AI service, veterinary service, input and output systems, and dairy management expertise. The Katamata experience shows that when one factor breaks down, in this case the AI service, the whole system breaks down. The lesson learned is that when improved forages are introduced into a smallholder dairy system, the whole dairy innovation system should be analysed, and an action plan made to strengthen its weak linkages.

If the introduction of improved forages is associated with a livestock dispersal program, the ones likely to adopt forages are the farmers who have received an animal. The dispersal program enhances adoption of forages among those who receive animal, but discourages others who don't benefit from the dispersal. This limits the scale of adoption of forages. In locations without a dispersal program, but where other factors stimulate intensification of livestock production, the scope for scaling out improved forages is less limited. Many examples of this have been described by the Forages for Smallholders Project (CIAT Forage AR2004).

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

Highlights

- The Forages and Livestock Systems Project (FLSP) in Laos, funded by the Australian Agency for International Development (AusAID) was completed in June 2005. The project achieved its targets of developing and disseminating forage technologies to smallholder farmers, resulting in significant household impacts. More than 1300 farmers in 106 villages (covering 5 districts in 2 provinces) had adopted planted forages for livestock feeding. A total of 900 farmers were benefiting from significant impacts such as labor saving, improved animal production and increased household income. More than 150 farmers report they have been able to reduce or stop shifting cultivation as a direct result of intensifying their livestock production. More than 200 farmers report that intensifying their livestock production systems has allowed their children to attend school. The technologies deployed by this project and the approaches of working with farmers to achieve adoption has attracted considerable interest by large development projects, NGOs and the donor community in Laos, and have been incorporated into several project as a major component.

- The Southeast Asian Regional "Livelihood and Livestock Systems Project (LLSP)", funded by the Asian Development Bank, was completed in December 2005. More than 8,000 farmers have adopted forage technologies developed and introduced through this project and its predecessor, the Forages for Smallholders Project (FSP). Impact assessment studies were carried out late in 2005 to capture household impacts of forages on major production systems. These will summarized in a working document and published as individual papers in the scientific literature in 2006.

- A study of seed production of Mulato and Mulato II confirmed the higher seed yield of Mulato II, particularly at low altitudes where seed set of Mulato was particularly low. While seed set of Mulato increased with altitudes to about 20%, this was still much lower than seed set of Mulato II and Ruzi.

4.2.1 Forages and Livestock Systems Project (FLSP), Lao PDR

Contributors: Peter Horne (CIAT), Viengsavanh Phimphachanhvongsod (NAFRI), Viengxay Photakoun (NAFES) and John Connell (CIAT)

Rationale

In 2000, the Australian Agency for International Development (AusAID) approved a 5-year project, the Forage and Livestock Systems Project (FLSP), to capitalize on the promise of earlier forage research work conducted by CIAT and CSIRO in the Forages for Smallholders Project (FSP). The FSP identified a small suite of robust, broadly adapted forage varieties that had the potential to provide significant benefits in SE Asian smallholder livestock systems.

AusAID funded the FLSP so that CIAT could demonstrate this potential by working with farmers to integrate improved forage and livestock management strategies into smallholder upland farming systems in northern Lao PDR. In the process, CIAT was able to further develop participatory approaches to action research and learn more about the opportunities and constraints of these forage varieties in smallholder farming systems. The FLSP was completed in June 2005.

Livestock are found on most farms in the Lao PDR with 89% of all farm households raising one or more livestock types. The importance of livestock to households is very high typically providing both a livelihood safety net and the majority of cash income. Traditional livestock production systems in the north of the Lao PDR are, however, characteristically extensive, low-input, low-output and opportunistic. These systems neither assist farmers to move out of shifting cultivation nor help them overcome poverty. In most cases, the major constraint to livestock keepers becoming more market-oriented is livestock disease, but there is little farmers can do about this while their livestock systems are extensive. Developing feed resources near the village is an ideal way to help farmers raise their animals closer to home, enabling better management and health. The FLSP was developed to use forage varieties and other livestock technologies to help farmers make the jump from being livestock keepers to being livestock producers.

Results and Impacts

By the end of the fourth wet season (Nov 2004), the project was supporting 26 field staff in 5 districts working with >1,300 farmers in 106 villages. Most farmers were planting grasses for cattle and buffalo and about 950 farmers were planting *Stylosanthes guianensis* to feed their pigs. By this time, 900 farmers (65% of the farmers working with the project) were benefiting from significant impacts and 790 said they were achieving at least one significant livelihood impact. More than 150 farmers report they have been able to reduce or stop shifting cultivation as a direct result of intensifying their livestock production. More than 200 farmers report that intensifying their livestock production systems has allowed their children to attend school. More than 670 farmers said that labor savings have allowed them to start other livelihood activities. These impacts have been wealth, gender and ethnicity neutral.

For farmers in northern Lao PDR to develop these kinds of impacts required significant systems change. To bring about these kinds of changes is not a trivial matter and required the development of extension approaches that would help farmers make these systems changes of their own accord, driven by the demonstrated potential for significant livelihood impacts. A participatory extension process was developed and used as the vehicle for providing intensive, on-the-job, mentored learning. In addition, the project provided 68 more-formal training events, totaling >900 individual training experiences. The main focus of this training was on improving the technical, extension and planning skills of provincial and district staff.

In the 2005 wet season (starting just before the end of the project in June 2005), the project substantially increased the spread and significance of these impacts with the number of villages increasing to at least 119 and the total number of farmers using and benefiting from forages reaching more that 2,000 households. The work continues with funding from local government, albeit at a much lower level of support.

Lessons learned

Some important lessons about forages and livestock systems development have been learnt from this project:

1. Market-oriented livestock production systems are now a proven option for poverty alleviation and reduction of shifting cultivation in the uplands of the Lao PDR

2. Forages as 'entry points', providing quick solutions to simple immediate problems, are a powerful tool in extension, especially in complex upland systems. They build confidence among farmers and encourage them into further innovation.

3. The impact-yielding forage systems developed by farmers usually result not from resolving immediate problems but from changing their livestock systems to take advantage of new opportunities.

4. Few of the impact-yielding forage systems can be 'photocopied' from one place to another. New farmers will always need to adapt the systems to their own realities.

5. A managed feed resource is the key mechanism enabling livestock systems change in the uplands. Relatively small areas of forages managed in this way can give relatively large impacts.

6. There is little likelihood of "magic bullet" solutions to the problems of animal disease in smallholder livestock systems in the uplands of the Lao PDR. Integrated solutions involving better feeding and management combined with strategic use of veterinary medicines are likely to be far more effective, achievable and sustainable.

7. There are simple ways of helping district staff develop a vision for how research and extension processes can work and then acquire the technical skills and extension tools that allow them to put this vision into practice within the context of smallholder livestock systems.

Through the demonstration of the ability of forages to delivery significant impacts to smallholder livestock keepers, the project has had a significant influence on the goals and plans of the Lao government. The FLSP demonstrated that market oriented livestock production can be a practical alternative to shifting cultivation and provide a means for farmers to work their way out of poverty. One result is that this work will continue beyond the completion of the FLSP as the Lao government, with support from the Asian Development Bank (ADB), is planning to invest US$10 million in a new project to "improve the income and livelihood of about 20,000 farming families by introducing animal health and productivity enhancement technologies, improving marketing opportunities and the regulatory environment, and encouraging the development of private livestock service providers". CIAT and the International Livestock Research Institute (ILRI) managed the design of this project for the ADB. It will build strongly on the experiences, technologies, methodologies and lessons learned in the FLSP. Other rural development projects and NGO's have also adopted the technologies developed in the FLSP as part of their activities.

Recognizing that the field staff of FLSP have important skills for such scaling-out, the ADB has also to fund a project with CIAT to start in early 2006 which aims to approximately double the number of skilled field teams, using the FLSP field staff as mentors. The context of this project will be a seamless continuation of the development process of the FLSP in the same districts. In essence it will provide a bridge between the FLSP and the subsequent loan project to ensure that the momentum is not lost. It is a measure of the abilities of the field staff that they can confidently take on such a task.

As the FLSP moved from relatively simple technical issues to dealing with impacts from forages, new issues have arisen that have significant consequences for CIAT's future forages research in Lao PDR and the wider region:

1. **systems-level technical issues**, including (i) nutrient decline in regularly cut forage plots and (ii) the need for farmers to reinvest profits in basic livestock inputs

2. **systems level technical opportunities**, including (i) new feed resources for small animals, (ii) 'smart' feeding using a range of new and traditional feed resources, (iii) better utilization of forage surpluses in the wet season for large animals, (iv) making a transition from cut & carry feeding to grazed forage plots to both reduce labor inputs and

improve nutrient cycling and (v) more rapid off-take of animals to optimize returns

3. **encouraging the development of livestock enterprises** to help livestock producers become better livestock producers

4.2.2 The Livelihood and Livestock Systems Project (LLSP) in Southeast Asia

Contributors: Werner Stür, Francisco Gabunada, Phonepaseuth Phengsavanh 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. 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.

Results and Impacts

By September 2005, more than 7,000 smallholder farmers had adopted forage technologies and were growing forages on their farms. The mean area of planted with forages per farm was 2,500 m^2 with individual forage areas ranging from 300 m^2 to 7,000m^2 in some areas. This was utilized almost exclusively as cut-and-carry feed and fed to rabbits, goats, pigs, cattle and buffaloes. Farmers with small areas were using planted forages as a supplementary feed to communally available feed resources while those with larger areas tend to use planted forages as the main feed sources. The main forage type grown by farmers is grass. Legumes were grown mainly for special purposes such as *Stylosanthes guianensis* CIAT 184 as supplementary feed for pigs (either fresh or dried and chopped, and fed as leaf meal) or as cover crop in tree plantations. The main purpose of growing planted forages by smallholder farmers can be summarized as:

- Improved cow-calf systems
- Fattening (finishing for sale) of cattle
- Forage for fish production
- Legumes for supplementation of village pigs
- Sale of fresh forage for feed
- Use of forages for convenience only (ie. saving labor)

The main benefits of growing planted forages initially were time saving as feed was conveniently located near the house or animal pen. This meant that farmers could keep their animals closer to their house and many farmers then started to expand their forage area. They started to experience productivity increases or increased their herd size to take advantage of the additional feed available. At many sites, farmers are now fattening cattle and buffalo for 2-3 months before selling the animals. This added considerable value to the animals and farmers became more aware of market opportunities. This process of increased market-orientation of livestock production is continuing at project sites.

Associated benefits for early adopters accrued from sale of vegetative planting material and seed. All farmers have more manure available and this is another source of income for farmers at some sites where manure is highly valued. Impact studies of planted forages on the main production systems were conducted late in 2005 and the results will be summarized in a working document and published as journal articles in 2006. The results of the LLSP attracted interest by local and national governments, and donor-funded projects. Many of the technologies developed are being taken up by development projects.

4.2.3 Seed Production of new *Brachiaria* hybrids on the Bolovens Plateau, Lao PDR

Contributors: Madeleen Husselman (MSc. student, Wageningen Agricultural University), and Peter Horne (CIAT)

Rationale

Seed production of the *Brachiaria* hybrids (Mulato and Mulato II) in Thailand showed that seed yield of Mulato is lower than Mulato II, and this was attributed largely to low seed set in Mulato. As seed set is controlled partially by environmental factors (mainly temperature and moisture) an experiment was designed which compared seed production of these Brachiaria hybrids (and a control species – B. ruziziensis) at varying altitudes on the Bolovens Plateau, Lao PDR.

Methodology

The experiment was conducted at three sites, comprising different agro-climatic zones on the Bolovens Plateau (latitude: 15^{o} N). At each site three varieties (Mulato, Mulato II and Ruzi) were planted in small plots of 3 m x 3 m, in a randomized block design with four replicates. Plots were 1 m apart and 3 m from outside borders. Plant spacing was 50 by 50 cm and only the inside nine plants were used for measurements. For practical reasons all the plants were sown in seed beds at Nong Hine on May 20th 2004 and transplanted to the other sites on June 23rd. During the first month of their establishment the plots were manually kept weed free. On the 17th August the plants were cut approximately 5 cm above the ground. The plots were fertilized with NPK (15-15-15) at a rate of 100kg N/ha, in split applications. Two weeks after transplanting they received a third of this amount and after the closing cut the remaining two thirds.

Seed was harvested by bundling seed heads and covering them with nylon bags, when the first seeds in a plot started to mature. The bags were emptied once a week until all the seed had been shed. The seed was dried in a shed for at least three days, then half a day in the sun. The seed was cleaned using a fan to separate empty from full spikelets. The cleaned seed was weighed and recorded per plot. Seed of each species at each site was bagged and analyzed for seed quality factors in Khon Kaen, Thailand.

Results and Discussion

Seed yield (pure live seed) of *B. ruziziensis* was higher than that of the two Mulato hybrids with higher seed yields at the two higher altitudes (Table 66). Mulato II produced its highest seed yield at the lowest altitude and its lowest seed yield at the highest altitude. This was contrary to expectations. Unfortunately, variability was high and the seed yield differences between the two Mulato hybrids were statistically not different. Nevertheless, seed yield of Mulato II was double

Table 66. Pure Live Seed Yield (kg/ha) of three Brachiaria varieties at three sites

Species/ Site	Nong Hine (1280 m asl)	Ban Itou (940 m asl)	Ban Houy Hee (200 m asl)
Mulato	191 [bc]	127 [c]	143 [c]
Mulato II	158 [c]	235 [abc]	307 [abc]
Ruzi	376 [ab]	420 [a]	209 [bc]

Values followed by a common letter are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 67. Seed set (%) of Mulato, Mulato II and Ruzi at three sites

Species/ Site	Nong Hine (1280 m asl)	Ban Itou (940 m asl)	Ban Houy Hee (200 m asl)
Mulato	22 [e]	23 [e]	6 [f]
Mulato II	54 [c]	39 [d]	68 [ab]
Ruzi	76 [a]	60 [bc]	52 [c]

Values followed by a common letter are not significantly different at the 5% level by Duncan's Multiple Range Test.

the seed yield of Mulato at the lowest altitude and the differences were smaller at the highest altitude. Seed set of Mulato was lower than that of the other two varieties at all altitudes, and extremely low at the lowest altitude (Table 67). The 6% seed set of Mulato at low altitude is similar to results reported in Thailand. It also shows that seed set of Mulato improves with altitude but the maximum percentage seed set in this experiment was still only 23%. Seed set of Mulato II and Ruzi were much higher. Seed set of Ruzi improved with altitude while seed set of Mulato II was highest at the lowest altitude.

An important aspect of seed quality for farmers is germination percentage (both maximum germination percentage and speed to reach that maximum). Germination percentages of both Mulato hybrids at all sites were very low and significantly lower than for Ruzi (Table 68) due to dormancy of this variety. Seed viability of both hybrids was, however, good at all sites except for Mulato at the medium altitude site. This experiment confirmed the low seed set of Mulato. Seed set of this variety appears to improve with altitude and higher seed yields should be achievable at higher altitude locations. The experiment also confirmed the higher seed set of Mulato II at low altitude and its potential for higher seed yields than Mulato at low altitude sites. A significant issue for future research will be whether this high percentage dormancy in the Mulato hybrids is easily overcome simply with storage time or simple treatment.

Table 68. Germination (%)after 14 days and viability (%) of Mulato, Mulato II and Ruzi seed at three sites.

	Nong Hine (1280 m asl)	Ban Itou (940 m asl)	Ban Houy Hee (200 m asl)
Germination			
Mulato	10 [c]	13 [c]	12 [c]
Mulato II	10 [c]	11 [c]	40 [b]
Ruzi	90 [a]	90 [a]	94 [a]
Viability			
Mulato	81 [b]	69 [c]	80 [b]
Mulato II	90 [a]	81 [b]	92 [a]
Ruzi	90 [a]	90 [a]	94 [a]

Values followed by a common letter are not significantly different at the 5% level by Duncan's Multiple Range Test.

4.2.4 Strategy for future activities in Southeast Asia

Contributors: Peter Horne and Werner Stür (CIAT)

The FLSP and LLSP projects were in essence "Proof of Delivery" projects that built of earlier research by CIAT on forage technologies and participatory approaches ("Proof of Concept"). Both project proved to local and national governments and donor-funded projects that forages play a pivotal role in developing more market-oriented smallholder livestock production systems. They also showed that improved livestock production based on forage technologies can increase the income of poor households dramatically and help them to escape the poverty trap of having to spend more and more time in producing food for home consumption. The labor saving achieved by planting forages gives farmers the opportunity to work more effectively and quickly realize production gains. These "Proof of Concept" projects led to

(i) New ideas and opportunities for research that would never have arisen had we not delved into a Proof of Delivery mode. Examples are the feeding of forage legumes to village pigs, an innovation that emerged from farmer experimentation and has led to a new project funded by ACIAR which will commence in 2006. Another example is the feeding of forage grasses to fish which has enabled farmers to increase fish production and is highly profitable. Both of these uses of forages are now to researchers and we are pursuing ideas for projects in these areas.

(ii) Forage technologies are adapted to local conditions, delivering significant impacts to many farmers and being taken up by farmers' groups, projects and government and non-government organizations. An example of the uptake of research outcomes from the FLSP is the development of an ADB-funded investment project, the "Participatory Livestock Development" loan project in Laos. ADB asked CIAT and ILRI to design this project and this was completed in 2006. This would not have occurred from the usual research projects but required a "proof of delivery" project.

In 2006, we will build on the outcomes of the FLSP and LLSP, and pursue funding opportunities for research on feeding of legumes for pigs and feeding forages to fish. We will also develop new 'proof of delivery' projects to continue ways of achieving more market-oriented livestock smallholder production, and form alliances with development partners to scale out forage technologies in the region. Finally, we would like to pursue the development of a knowledge network on forages and livestock technologies to make innovations in livestock research available to the development sector.

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

Highlights

- Species selected and criteria used by farmers in hillsides of Colombia to select grasses and legumes were similar to those used by farmers in hillsides of Central America.
- Showed that grain yields of cowpea in hillsides (marginal areas for coffee) were depedent on genotype and on altitude.
- *B. brizantha* cv. Toledo continues to show good adaptation in the llanos piedmont, where soils have high levels of moisture in the wet season.
- Results with *Brachiaria* hybrid cv. Mulato in Central America continue to show that its main benefit relative to other grasses is higher animal productivity per unit area.
- Improved forage species were introduced in 60 collaborative farms in Central America to monitor impact on beef and milk production.

4.3.1 On-farm evaluation of forage options in Norte del Valle del Cauca, Colombia

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

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 we aim to define and adapt forage technologies suitable to smallholder production systems to improve livelihoods of farmers.

Material and Methods

Forage technologies developed with farmers include germplasm options and forage conservation technologies. A participatory process is followed facilitating adaptation, innovation and adoption by farmers. The main collaborators in the process are the farmer group 'la Ondina', the Universidad Nacional de Palmira, the Instituto Técnico de Roldanillo (INTEP), the Secretaría de Agricultura y Pesca del Valle del Cauca. Initially, in 2004, the main beneficiaries of this work were a group of farmers (30) from the municipality of Roldanillo; currently the work has been expanded to 5 groups in 5 municipalities in the Norte del Valle del Cauca (Roldanillo, Bolívar, El Dovio, Versalles and Sevilla) reaching directly a total of 200 farmers. Altitudes in the 5 municipalities range from 1000 to 2000 m.a.s.l., representative of the variable environments in the region. From the onset, a participatory approach was employed, in order to understand farmers demands and livestock systems, with the aim to select and co-develop different forage alternatives suitable to the prevalent farming systems. In each of the 5 municipalities a participatory diagnosis was carried out to identify opportunities and constraints of livestock holders. The methodology employed used a group brainstorming approach, with farmers further stratifying and prioritizing opportunities and constraints through an individual votation process. Farmer cross visits and visits to on-station trials further supported the process through exposure to new technologies and sharing of experiences with technicians and farmers.

Eight experiments were established in five municipalities, representing different climatic (altitudes between 1000 and 2000 m) and edaphic niches. At each site 16 multipurpose forages were sown. These experiments were used for the participatory selection of forage technologies and lead to further on-farm testing. The innovation and adoption process is accompanied by training in pasture establishment and management as well as on the utilization of hay and silages. The training is supported by extension type publications.

Results and Discussion

Participatory cross visits. The cross visits were very effective to facilitate the interchange between farmers and farmers and technicians/ researchers and served also as an opportunity for farmers to familiarize themselves with forage technologies available (Photo 29). Farms with established pastures of *Brachiaria* hybrid

Photo 29. Participatory process of farmers at "Norte del Valle" and *Leucaena* with *Brachiaria* hybrid cv. Mulato

cv. Mulato in Zarzal and *Brachiaria brizantha* cv. Toledo in Pereira were visited as well as the Cenicafe farm 'La Romelia' in Chinchiná; these visits allowed to see many forage options under utilization by farmers as well as observing the persistence of some forage options as in Romelia associations of Leucaena and Arachis with *Brachiaria decumbens* and *Cynodon persist* for 23 years under hillside conditions. At the CIAT station in Quilichao multipurpose forage germplasm adapted to different climates and acid low fertility soils such as *Cratylia, Flemingia, Desmodium, Canavalia, Lablab* and *Vigna* (Caupi) and animal nutrition trials including work on hay and silages were visited by farmers.

Experiments. While grasses showed a wide range of adaptation establishing well across sites, performance of herbaceous legumes was more site specific. As with grasses, the shrub species were well adapted across sites. A participatory evaluation was carried out in each of the sites to assess farmer preferences and selection criteria and to observe adaptation of the different forage options to farm conditions. In Table 69 farmer preferences for the different forage options are presented. The most important criteria for the farmer selection of forages were:

- Palatability
- Color
- Forage on offer
- Dry season performance
- Tolerance to ants
- Cover (aggressiveness)
- Rooting capacity
- Persistence in pasture
- Adaptation to soil fertility gradients

The criteria selected are very similar to results obtained in evaluations with farmers in Central America, further confirming the validity of the participatory approach taken.

As a result farmers are now sowing larger areas (0.5 to 7.5 ha per farm) of selected materials e.g. *Brachiaria* hybrids cv. Mulato, Mulato II, *Brachiaria brizantha* cv. Toledo, *Cratylia argentea*, *Leucaena leucocephala*, *Vigna unguiculata* and *Lablab purpureus*, to be utilized for further on-farm testing, adaptation and expansion. In total it is estimated that by February 2006, 40 ha of improved forages will be sown in the Norte del Valle.

Table 69. Ranking of different forage technologies by farmers in the 'Norte del Valle', Colombia.

Ranking	Grasses	Shrub legumes	Herbaceous legumes
1	*Brachiaria brizantha* cv. Toledo	*Cratylia argentea* cv. Veranera	*Canavalia brasiliensis*
2	*B.* hybrid Mulato	*Leucaena diversifolia*	*Centrosema molle*
3	*B.* hybrid Mulato II	*Leucaena leucocephala*	*Arachis pintoi*
4	*Panicum maximum* Guinea	*Flemingia macrophylla*	*Desmodium heterocarpon cv. Maquenque*
5	*Brachiaria dictyoneura*	*Desmodium velutinum*	*Lablab purpureus*

4.3.2 Exploring opportunities for alternative forage crops in Hillsides: Spatial genotype x environment and economic analysis for Cowpeas in Hillsides of Cauca

Contributors: K. Atzmanstorfer, T. Blaschke (University of Salzburg), D. White, T. Oberthür, G. Escobar, L.H. Franco, M. Peters and G. Ramirez (CIAT)

Rationale

One of the most widely grown legumes in tropical and subtropical regions, is Cowpea, *Vigna unguiculata* (L.) Walp. This annual legume is of major importance to the livelihoods of millions of poor people, especially in West Africa and China. It is grown usually as a companion or relay crop with major cereals. Development of new disease and insect resistant varieties with shorter harvest cycles have contributed to its increased cultivation over the last decade. Apart from providing inexpensive and nutritious food (grain, pods), this annual multi-purpose legume, gives excellent forage (grain concentrate, leaves and haulm) and could be used for making hay and silage. Farmers can obtain additional agronomic and environmental benefits to their farmlands using cowpea as green manure. The plant improves soil quality by fixing soil nitrogen; it is drought and heat resistant, and prevents erosion given that it is a fast growing ground cover plant.

Forage seed and leaf meals obtained from cowpea may be a promising economic alternative for many smallholders in marginal coffee growing areas in the tropical hillsides at an altitude. Coffee cultivated in suboptimal altitudes normally cannot compete with coffee produced in higher areas in terms of quality, and therefore farmers rely on the highly volatile markets for volume coffees. Currently cowpea is not widely grown in most of Colombia or other tropical hillsides. Very scarce evidence exists of its use as a forage plant in Latin America and the Caribbean and less regarding its use as an input to commercial feed concentrates and its production potential. Moreover its performance in the hillside eco-region is not yet fully understood.

The objectives of this research effort are: to (a) examine effect of environmental conditions on cowpea production, (b) identify optimal growing areas and (c) estimate financial viability of cowpea as component of animal feed concentrates. We used a hillside site in southern Colombia as case study area, in which we carry out the following research sequence:

a) As a first step, a genotype by environment performance analysis is conducted, relating performance of cowpea lines to specific environmental characteristics such as topography, soil and climate. The data is generated in semi commercial field trials (2100 m^2 each – areas big enough to get economically valid and farm size agronomic data) located in contrasted landscape positions in the Cauca Province.

b) Secondly, GIS is used for (i) describing the environments in which the trials are conducted as well as for (ii) identifying areas in marginal coffee growing regions of Colombia with similar environmental conditions to those of the trial sites. This data is required to conduct an extrapolation as to how much area and therefore how much yield the animal feed industry can potentially count on. GIS-based prediction models for environmental niche identification such as CaNaSTA (Crop Niche Selection Tool for Tropical Agriculture) or Homologue are used for these analyses.

c) A complementary financial analysis will be carried out to determine yield-price-profit thresholds using the agronomic trial data. Results will enable farmers and farmers and the feed concentrate industry to determine the financial feasibility for commercial use of cowpea as an animal feed. For large-scale production, cowpea needs to be competitive with alternative feeds such as imported soybeans. Nevertheless, the production of cowpea may be attractive to farmers during the fallow period of coffee plots. Both financial benefits of cowpea and its effect on coffee systems will be estimated.

Materials and Methods

Three cowpea accessions (DICTA 9611, IITA 5234 and IITA 1088-4) were established at five different sites in the department of Cauca: Mondomo, Suarez, but complete data was only available for three sites - El Tablón, CIAN and Mr. Manuel Trujillo (Photo 30). The plot size was approximately 500 m^2 in average, simulating commercial cultivations and the planting distances were 10 cm between plants and 0.5 m between rows. The plots were fertilized with 50 kg/ha of P_2O_5, 50 kg of K_2O, 20 kg of S and 20 kg of Mg. Plant emergence, plant vigor, cover, and incident of pest and diseases and dry matter yields were measured to 8 weeks after planting. The harvest of grain was carried out at 13 weeks.

A

B

Photo 30. Grain yield production of cowpea in two sites: (A) CIAN and (B) El Tablón.

Results and Discussion

Due to a severe attack of insects and problems with one collaborating farmer, complete data was only available for three sites. The highest grain yields were achieved on the relatively low altitude trial sites of El Tablón (1138m) and CIAN (1109 m) with a mean grain yield over all accessions of 1388 kg/ha and 599 kg/ha, respectively (Photo 30). The trial site of Mr. Manuel Trujillo (1558 m), characterized by higher altitude, more rainfall, lower temperature and less fertile soils, showed distinctly less grain yield (481 kg/ha).

The best performing accession in terms of grain yield in the three sites analyzed was IITA 5234 (1047 kg/ha) followed by DICTA 9611 (865 kg/ ha[1]), and IITA 1088-4 (557 kg/ha) (Figure 65). The highest grain yield was achieved by DICTA 9611 (1735 kg/ha) followed by IITA 5234 (1453 kg/ha) in the 'El Tablón' site.

For financial analysis, production costs were examined for each trial site. Assuming that cowpea is sold at the soybean meal market price of 0.19-0.23 US$/kilo (USDA-soybean meal price forecast for 2005/06), calculations showed that the maximum revenue would be around 217 and 261 US$$ per ha cultivated cowpea for the best performing trial site, El Tablón. (Calculated for the mean grain yield over all accessions). A second round of field trials is being performed at different sites with different grain-type accessions in order to gain more information on genotype x environment interactions as well as on economical figures. Work will be completed by March 2006.

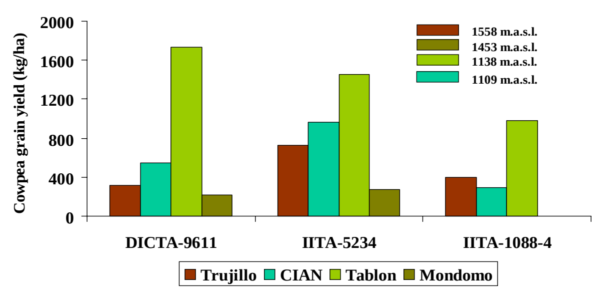

Figure 65. Cowpea grain yield of different accessions in contrasting sites in hillsides of Cauca, Colombia

4.3.3 On-farm evaluation of new forage options for pasture rehabilitation in the Llanos of Colombia

Contributors: C. Plazas, D. Vergara, J. W. 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 6-7 years we have been monitoring the reclaimed pastures in commercial farms and under the management of the farmers.

Results and Discussion

Legumes

Legumes introduction in farms of the Piedmont: In a farm (San Pedro) a pasture of *A. pintoi* - *B. humidicola* (10 ha) was established in an area that was degraded and invaded by *Homolepis aturensis*, a low quality grass. After 7 years, the legume content varies from 30 to 40% (Figure 66). The weed *H. aturensis* has practically disappeared while the content of *B. humidicola* has stabilized at 60-70% .

The pasture has been fertilized only once (2004) with P (250 kg /ha of rock phosphate) and Ca (250 kg/ha of lime). In spite of the low fertilization applied to the pasture, the carrying capacity has increased over time. Currently 40 steers with an average initial LW of 250 Kg are maintained in the pasture for 10-15 days with a rest period of 15 days.

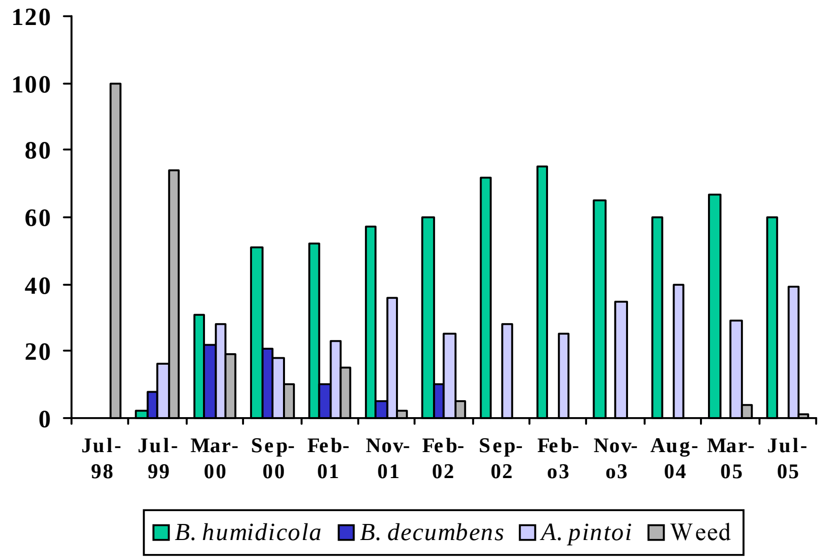

Figure 66. Botanical composition (%) in a pasture of *Brachiaria humidicola* associated with *Arachis pintoi* after 7 years of establishment at the farm San Pedro in Piedmont of the Llanos of Colombia.

Woody legumes under grazing in the piedmont: Between 2001 and 2003 we carried out a project to validate the utility of *Cratylia argentea* as feed resource for milking cows in smallholder systems in the piedmont. A total of 14 farms were selected to establish Cratylia for different uses (cut/carry, direct grazing and seed production) with farmer participation. We continued to monitor the stands of Cratylia under different management and to see to what extent farmers had made any innovations on the utilization of this legume. In 11 farms Cratylia is being used as a protein bank with direct and controlled (1 to 3 hours/day) grazing by cows in both the dry and wet seasons. In 2 farms the legume is being used to produce silage for dry season feeding and in only one farm the legume is used in a cut/carry system. In the initial conversations with farmers we had recommended that the legume be used in a cut/carry system. However, it is evident that farmers preferred to use direct grazing in order to save money and time. Labor is not always available and when it is available the cost is high.

We have been monitoring the performance of *Cratylia* under grazing and after 4-5 years it is evident that the productivity of the stands has declined from 2 tons of DM/ha to 500 kg of DM/ ha. Plant mortality has also been high (30%) as opposed to almost no mortality in farms where the legume has been managed under cutting. Thus it would seem that Cratylia when managed under grazing should be replanted at least every 4-5 years.

Grasses

Performance of *B. brizantha* cv. Toledo in the piedemont 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 13-15 steers with average LW of 320 kg grazed the pasture this year with an occupation period of 8-10 days and 25- 30 days of rest. Forage availability in this pasture has varied between 3,5 and 6,3 t/ha of DM with a content of CP between 7,5% and 11% (Table 70).

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 *B. brizantha* cv Toledo as an alternative for the llanos piedmont continue to be high carrying capacity and adaptation to poorly drained soils.

Table 70. 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	10	4.9	4
March/05	6.3		Burnt	
July/05	5.5		2.7	

a Farm San Pedro.
b Farm El Porvenir.

In 2000, at the farm El Porvenir in a well -drained savanna with acid infertile soils, a pasture (3, 5 ha) was established with *B. brizantha* cv. Toledo. Results after 5 years indicated that forage availability varied between 1, 3 and 6, 8 t/ ha of DM, with relative low CP content (3 % and 5%) in the absence of N fertilization (Table 71). The pasture has been 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 with limited maintenance fertilization. In 5 years the pasture has only been fertilized once with 50 kg/ ha of 15-15-15 and 50 kg/ha of KCl.

Performance of different accessions of *B. brizantha* in well-drained savannas. 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. Production of DM with *B. brizantha* CIAT 26124 has been low (between 2,0 and 0,4 t/ha of DM) due to its excellent palatability and heavy grazing system used (Table 71). 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%).

In general results indicate that after 5 years of evaluation of the different *Brachiaria brizantha* accessions it continues to be evident that each accession should be managed in a different manner. 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 is used with good results with cows with 5 days of occupation and 30 days of rest. The accession CIAT 26124 has practically

Table 71. Forage availability and crude protein (CP) content of accessions of *Brachiaria brizantha* at the farm El Porvenir in the Altillanura of the Llanos of Colombia.

Sampling Date	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			
March/05	Burnt	Burnt	Burnt			
July/05	4.6	2.8				

disappeared due to high palatability and limited maintenance fertilization. In 5 years the three pastures has only received 42 kg of N, 8 kg of P and 33 kg of K per hectare.

Performance of *Brachiaria* Hybrid cv. Mulato. This hybrid with multiple positive attributes (i.e. rapid establishment, excellent forage quality and drought resistance) continues to be evaluated with 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 7, 5 ha of Mulato were established in July 2001 in a plot of *B. decumbens* in advanced stage of degradation. At the beginning of the evaluation process 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, milking cows were introduced in a rotational grazing system in five plots of 0, 75 ha and 3 days of occupation. With this system 12 milking cows (3, 2 cows/ha) were maintained during a complete cycle of 15 days. Cows in pastures of *B. decumbens* produced on average 5 liters of milk in the morning milking and 4 liters in the afternoon milking. In the Mulato pasture, the same cows produced daily 6.5 liters in morning milking and 5 liters in the afternoon milking, which represented 23 liters of additional milk per day.

One major problem of Mulato in La Isla farm has been plant mortalility due to poor soil drainage in parts of the pasture and as result Mulato has been replaced by *Homolepis aturensis*. However, measurements carried out after 4 years of establishment showed that the availability of Mulato in the well drained areas is 3 and 3.5 tons of DM/ha in the dry and wet seasons, respectively in spite of heavy grazing and no fertilization.

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 in 2001 we established Mulato (15 ha) in association with maize. Grain yield after 138 days of sowing the maize was 3, 7 tons /ha, while *Brachiaria* hybrid cv. Mulato produced 4,2 tons of DM /ha. Due to N deficiency, in June 2004 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 nutrient deficiency indicating that it requires frequent fertilization when sown in low fertility soils. Currently in approximately 10 (plot 3) to 25% (plot 1) of the grazing area, the proportion of Mulato decreased due to poor drainage and plants were replaced with native vegetation. However, the pasture in well drained plots remains productive and as a result support 2.5 animals/ ha with a grazing frequency of 15-20 days and rest a period of 30-40 days.

4.3.4 On-farm evaluation of *Brachiaria* hybrid cv. Mulato

Contributors: A. Mendoza and C. Burgos (DICTA), H. (CIAT), B. Pinzón, E. Santamaría and J. Girón (IDIAP), and H. Cuadrado (CORPOICA)

Rationale

On-farm validation of new promising forage species complements the results reported from on-station research sites. This has more relevance if considering that farmers have their own preferences and management practices that influence productivity and performance of pastures, and in all cases they adapt the use of new forage options to their particular needs. Under this consideration the *Brachiaria* hybrid cv. Mulato has been monitored during the last three years in dual purpose cattle farms of Central and South American tropics, and the results continue to confirm that this grass offers an important alternative for dual purpose farmers compared with some traditional grasses, both for the high quality and high forage production reported that allows more stocking rate per unit area.

Materials and Methods

As mentioned in Project 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. Animal liveweights gains have also been measured on research stations in Panamá (IDIAP's research station in Gualaca), and in Colombia (Corpoica's research station in Cereté). In both sites a rotational grazing system was used (3/21 occupation/rest in Panamá and 2/22 occupation rest during the wet period and 3/33 during the dry season in Colombia). In Panamá the soils are acid of Inceptisol type and were fertilized annually with 80-30-20 kg/ha of N, P_20_5 and K_20 respectively, meanwhile the site in Colombia has alluvial soils and the paddocks were not fertilized during the 525 days that the experiment lasted.

Results and Discussion

On-farm monitoring: Honduras continues to be the country where *Brachiaria* hybrid cv. Mulato has been more closely monitored in dual purpose cattle farms (see IP-5 Annual Report 2004). Colleagues from the national institution (DICTA) have carried out important field work in this regards along the Atlantic coast, the north-west and the central part of the country. In Table 72 we show that from January to May 2005, covering practically the whole dry period in this country, the major effect of cv. Mulato was on higher stocking rates and not on individual milk production per cow, therefore contributing to more milk produced per unit area as was reported last year with a set of different farms. It is interesting to note that a large variation in

Table 72. Area planted, stocking rate and milk production per animal and per hectare of dual purpose cows grazing *Brachiaria* hybrid cv. Mulato and other grasses during January-May 2005 in different farms of Honduras. (Information supplied Conrado Burgos and Alejandro Mendoza of DICTA).

Farm/ Grasses	Area planted (ha)	Stocking rate (cows/ha)	Milk (kg/cow/day)	Total milk (kg/ha/day)
1. Mulato*	7.0	7.5	3.5	25.9
Swazi	11.2	3.7	3.2	14.7
2. Mulato	4.2	5.6	4.4	24.1
Swazi	11.2	2.1	3.6	7.8
3. Mulato	7.0	0.9	4.8	6.8
Swazi	14.0	1.3	4.9	3.4
4. Mulato	9.8	4.8	6.0	28.4
Swazi	14.0	3.3	5.9	19.5
5. Mulato	2.1	4.0	4.3	20.6
Basilisk	6.0	2.4	5.1	12.2

* Mulato (*Brachiaria* hybrid), Swazi (*Digitaria swazilandensis*), Basilisk (*B. decumbens*).

stocking rate exists between farms with the same type of pastures, an indication of the effect of site and the type of animal the farmers have. Both milk and beef on-farm monitoring continues in selected farms of Costa Rica, Nicaragua, Honduras and Guatemala.

Controlled grazing trial: The grazing trials ended during 2005 after 525 and 638 days in locations of Colombia and Panamá, respectively. In Table 73 we show the estimated stocking rates and the daily animal liveweight gains at both sites. In Cereté, Colombia cv. Mulato significantly out-yielded *B. decumbens* cv. Basilisk (P<0.05) in both stocking rate and total animal liveweight per ha per year.

The stocking rates for cv. Mulato were similar in Cereté and Gualaca; however animal liveweights were slightly higher at the latter site. At this locality the animals used were cross-bred young zebu steers, meanwhile that at Cereté the animals used were zebu steers and F1 cross-bred zebu x romo sinuano, a local race known by the adaptation to warm humid conditions.

Table 73. Stocking rates and animal livewights in grazing trials of cv. Mulato and *B. decumbens* (Basilisk) in Gualaca (Panamá) and Cereté (Colombia). (Information supplied by Bolívar Pinzón and Eliut Santamaría of IDIAP (Panamá) and Hugo Cuadrado of Corpoica (Colombia)).

Site	Pastures	Stocking rates (AU/ha)	Animal Liveweights (g/day)	Animal Liveweights (kg/ha/yr)
Gualaca	Mulato	3.4	544	879
Cereté	Mulato	3.5 a *	503 a	796 a
	Basilisk	2.0 b	532 a	580 b

* P<0.05

4.3.5 On-farm evaluation of different forage alternatives in Central América

Contributors: C. Burgos and A. Mendoza (DICTA, Honduras), E. Fajardo and J. Quiñones (ICTA, Guatemala), E. Benavente, O. Fargas, E. Miranda, A. Corea (IDR, Nicaragua), J. Chaves, A. Aguero and A. Barbosa (CGUS, Costa Rica) and E. Pérez (ILRI)

Rationale

Low animal productivity is the standard in beef and dual purpose production systems in Central América, despite that during the last decade there has been an increasing demand for improved pastures. The forage species are dominated by *Brachiaria* cultivars followed by *Panicum* species; few forage legumes are in the list. Both farmers and technicians are nevertheless aware that improved pasture technologies, including the use of legumes, are viable options that need more promotion and on-farm demonstration to increase adoption. Therefore, presently there are regional projects that develop forage alternatives with the participation of private companies, national institutions and farmer organizations; some results are presented.

Results and Discussions

Technological components based on improved grasses and legumes

The Tropical Forage Project of CIAT carried out activities in the ILRI/CFC Project 'Enhancing Beef Productivity, Quality, Safety and Trade in Central America'. During 2005 the establishment of improved forage components in 60 selected farms of Honduras, Guatemala, Nicaragua and Costa Rica was completed. Monitoring of animal and pasture production, as well as persistence of introduced grasses and legumes was also initiated, mainly in Honduras. However, in all participating countries some pasture components needed replanting, and in some farms additional grass-legume plantings were contemplated. For these reasons more seed was distributed during the first semester of 2005, as shown in Table 74.

Table 74. Forage species procured and distributed to each of the collaborating country of the ILRI-CFC Project in Central America during the period January-June 2005.

Species/Cultivar	Countries				Total
	Guatemala	Honduras	Nicaragua	Costa Rica	
	(kg)				
Brachiaria brizantha cv. Marandú	8	-	15	-	23
B. brizantha cv. Toledo	-	-	125	-	125
B. decumbens cv. Basilisk	8	-	26	34	68
B. humidicola (ex-*B. dictyoneura*) cv. Llanero	-	-	-	5	5
B. hybrid cv. Mulato	50	-	22	218	290
B. hybrid cv. Mulato II	-	18	8.5	28	54.5
Paspalum atratum cv. Pojuca	-	-	3	-	3
Panicum maximum cv. Mombasa	-	-	-	11	11
Arachis pintoi cv. Porvenir	53	-	10	52	115
Cratylia argentea cv. Veraniega	9	-	6	-	15.5
Leucaena leucocephala CIAT 17263	3	-	3.5	-	6.5
Stylosanthes guianensis AFT 3308	3	3.5	-	9	15.5
Pueraria phaesoloides cv. Kudzú tropical	-	-	-	22	22
Total	**134**	**21.5**	**193.5**	**379**	**754.5**

A total of 754.5 kg of pasture seed has been procured and distributed during 2005. The grasses cultivars dominate the deliveries (579.5 kg), which is an indication of farmer preferences. Honduras was the country that received less forage seed (21.5 kg), and showed adequate pasture establishment in the collaborating farms during the 2004 planting season. Costa Rica received the largest amount of seed (379 kg), particularly for the high request of *Brachiaria* hybrid cv. Mulato (290 kg), which is an improved grass of high quality that farmers begin to appreciate as important forage component for their farms. This grass has also been planted successfully in other collaborating countries particularly Honduras, and the impact on animal production, particularly the increase in milk yields in dual purpose cattle is now well documented. (See activity 4.1.4). Another country where forage components were established successfully was Guatemala. The proper forage plantings is attributed to the fact that most of the small and medium size collaborating farmers combine both annual crops and cattle in their farms, therefore they use the same crop practices to establish forage components that without doubt leads to excellent forage establishment.

In Table 75 we show grass cultivars and area planted in 8 collaborating farms distributed along the localities of El Reposo, Coatepeque, Nueva Concepción and Cuyuta in Guatemala. A total of

Table 75. Area and forage components established in collaborating farms of the ILRI/CFC Project in Guatemala during 2004/2005.

Species/Cultivar	Area (ha) planted as: Pure grass	Mixed with *A. pintoi*
B. brizantha cv. Toledo	4.7	-
Brachiaria hybrid cv. Mulato	15.5	1.7
Brachiaria hybrid cv. Mulato II	3.8	1.4
B. brizantha cv. Marandú + *B. decumbens* cv. Basilisk	4.2	1.5
B. brizantha cv. Marandú	-	3.0
Cynodon nlemfuensis cv. Estrella	-	1.4
Digitaria eriantha cv. Pangola	-	0.4
Total	**28.2**	**9.4**

38.6 ha of new pastures are now ready to be monitored during the present growing season; although we received news that the hurricane Stand caused considerable damage in both pastures and crops in the sites in Guatemala.

Again, the grass cv. Mulato dominates the areas planted, followed by cv. Toledo and the mixture of the grasses cvv. Marandú and Basilisk. The perennial peanut *Arachis pintoi* cv. Porvenir was the only forage legume used in this case, but for the present planting season other legumes such as *Stylosanthes guianensis* and *Leucaena leucocephala* will be planted as well.

4.4 Adaptation of forage conservation technologies to smallholder systems

Highlights

- Demand for forage conservation technologies and reasons for low adoption by small farmers in a region of Honduras were identified.
- The benefit of silage on milk production was estimated to be greater for small scale farmers than for large scale farmers in Central America.
- In the study area in Honduras (Yoro) a sharp increase in silo use was found mainly due to farmer training and field days. The number of farms using silage increased 90% and silage volume increased by 120% in one year.
- Plastic bag silage offers a low cost opportunity for small scale farmers, but the non-availability and high cost of suitable bags in Honduras are seen as constraints for further uptake.
- Feeding silage or hay to milking cows seems profitable. However, farmers in Honduras fed more hay than silage, while in Costa Rica the reverse was true.

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4.4.1 Stimulating innovation among small farmers of forage conservation technologies

Contributors: C. Reiber and R. Schultze-Kraft (U. of Hohenheim), M. Peters, C. E. Lascano and H. Cruz (CIAT), C. Burgos (DICTA), A. Schmidt, L. H. Franco and P. Lentes (CIAT)

Rationale

Feed shortage during the five to six months dry season in many areas of Central America severely limits livestock production and farm income. Alternative strategies to level milk and meat production include hay and silage preparation for the dry season. However, adoption of forage conservation methods by small-scale farmers so far has been low. Reasons include technologies not suitable to smallholder conditions that require high investments (e.g. machinery and/or large bunker silos) and lack of knowledge about appropriate low cost alternatives such as heap silo, earth silo, wrapped silage and little bag silage (LBS). The research carried out in Honduras aims to define criteria and pathways to enable small-scale farmers to adapt forage conservation technologies to local conditions through facilitation of innovation. Alternative forage-based products for ruminants will be validated as dry season feed and potential income-generating options.

The specific research objectives are:

1) To determine the effect, costs and benefit of hay and silage supplementation from different forage legumes (*Vigna unguiculata*, *Lablab purpureus* and *Cratylia argentea*) and improved grasses (*Brachiaria brizantha* cv. Toledo and *Brachiaria* hybrid cv. Mulato) on milk production and productivity.
2) To determine constraints for adoption, conservation technologies and to determine ways to overcome such constraints through innovation processes.

Target areas and farmer groups. Based on a diagnosis ("Forage Technologies to Alleviate Dry Season Feed Shortages - A Diagnosis of Honduras and Nicaragua") in 2004 carried out by CIAT and partners (see Annual Report 2004) with the collaboration of national and local organizations (DICTA, SERTEDESO and FHIPA, Fundación Hondureña de Investigación Participativa Agrícola), two main target areas in Honduras were selected (Yoro and El Paraíso) for the study on innovation of forage conservation for dry season feeding. Additionally, in Olancho and Intibuca two farmer groups were selected (Table 76). The areas are characterized by a long dry season (up to seven months), no or little use of conserved forages, grazing mainly on naturalized pasture (*Hyparrhenia rufa*), little use of improved pasture such as *Brachiaria* spp. and low milk production in the dry season.

The results presented in this report give an overview on the potential and constraints for adoption of forage conservation technologies in the target areas.

Table 76. Farmer groups in Honduras involved in forage conservation research.

Departments	Zones	Groups
Olancho	Catacamas	Group San Pedro de Catacamas
Yoro	Sulaco,	AGASUL
	Victoria,	EMPRASEFOR, CREL and individuals
	Yorito,	CREL
	Yoro	CREL
	La Savanna	Non-livestock farmer group
Danli	Alauca,	Independent farmers
	Jamastrán	Independent farmers
Intibuca	Jesús de Otoro	CIAL-group

Adaptation of forage conservation technologies

Two contrasting extension strategies (promotion of adoption and promotion of innovation) are compared with groups of small-scale farmers in the project areas. Each strategy represents a different approach to technology development and transfer, with differences evaluated in terms of adoption, benefit-costs of both the technology and the strategy of R&D and extension.

Promotion of adoption. In 2003 and 2004, DICTA (Dirección de Ciencia y Tecnología Agropecuaria), the main National Agricultural Research and Extension Institution, promoted little bag silage technology during field days in Choluteca, Olancho, El Paraíso and Comayagua where the theory of making silage was explained, little bag silage demonstrated and plastic bags distributed to farmers. Some farmers were visited again by DICTA to further promote the standarized technology.

Farmers at the beginning of 2006 participated in these meetings as well as farmers who received plastic bags will be visited in order to investigate the adoption processes as well as reasons for non-adoption of silage technologies.

Promotion of Innovation. Innovation, adaptation and diffusion processes are facilitated to different farmer groups through an interactive (including farmer to farmer) and experimental learning process involving selection, and modification of best-bet technology options. We focus on innovative farmers who adapt forage conservation technologies to their local conditions and then the innovation and adaptation processes are documented. The other group we focus is on non-livestock farmers who could have as an objective the marketing of dry season forage alternatives like legume hay, legume based concentrates and little bag silage.

Farmer training events. Improved forage grasses (*Brachiaria brizantha* cv. Toledo and *Brachiaria* hybrid cv. Mulato), herbaceous (*Vigna unguiculata*, and *Lablab purpureus*) and shrub (*Cratylia argentea*) legumes as well as their conservation in form of hay and silage (e.g. little bag silage were offered to farmers during farmer trainings in events).

A) Theoretical training. In June 2005, with the help of local farmers, DICTA and the NGO SERTEDESO (Servicio Técnico de Desarollo Sostenible), farmers were invited to participate in training courses on "efficient use of forages and their conservation". During the meetings, basic farm data (e.g. farm size, number of cattle and milk production in the dry and rainy season) of the participants were gathered using a structured interview. Furthermore, participatory methods were applied to obtain diagnostic data (e.g. problems in the dry and rainy season and feeding strategies in the dry season) which served as rising awareness of problems and introduction to the topic. The program of the first meetings was:

- Introduction and presentation of the project.
- Participatory diagnosis on farmers' interest, problems in the dry and rainy season and feeding strategy in the dry season.
- Theoretical part: Background of forage conservation (problems, definition, objectives, advantages and disadvantages), technical aspects of silage and hay making (optimal cutting time, important steps, forages to conserve, additives, characteristics of a good silage/hay, different silo types) and its use.
- Participatory part: Sourcing interest in hay and silage, market for hay and silage including price evaluation and interest in different kind of silos.
- Open discussion and questions.
- Distribution of information sheets and small quantities of seeds (e.g. *B. brizantha* cv. Toledo, *B.* hybrid cv. Mulato, *Vigna unguiculata*, *Lablab purpureus* and *Cratylia argentea*).

B) Field days (practical training). In September 2005, more training events directed to farmers were carried out in prototype farms. The training centered on a revision of the theoretical aspects of forage conservation (since there were some new participants) and a practical part in which little bag silage and hay was prepared. Different silage bags were evaluated afterwards.

In November and December 2005, at the beginning of the dry season, different grass and legume hays and silages (see above for the species) were elaborated in order to carry out on-farm experiments (researcher-led) with milking cows supplemented with materials during the dry season 2005/2006.

In 2004 and 2005, in the departments of Yoro (Yoro, Yorito, Sulaco and Victoria), El Paraíso (Alauca and Jamastran), Olancho (San Pedro de Catacamas) and Intibuca (Jesus de Otoro) several farmer trainings (theory and practice) and field days were conducted (Table 77).

Table 77. Training events related to forage conservation and participants in different regions of Honduras.

Region	Event	Participants
Yorito	Farmer training (theory)	22 CREL members + 1 non-CREL
Sulaco	Farmer training (theory)	23 participants (10 pupils, 7 AGASUL and 6 more individual farmers)
Victoria	Farmer training (theory)	14 participants (7 from EMPRASEFOR)
	Two field days, one about RTM* including silage use (DICTA) and one about LBS	RTM: 15 participants Silage: 23 participants from Victoria, Sulaco, Yoro.
Yoro	Field day (practice) LBS	14 participants
Alauca	1 Farmer training (theory)	14 participants
	2 Field days	About 20 participants
Jamastran	3 Farmer trainings (RTM+LBS) Including theory and practice	RTM: 27 LBS: 13
Catacamas	1 Farmer training (theory)	35 (12 students)
Jesús de Otoro	Farmer training (theory)	Group of 10 farmers

RTM= Ración Total Mezclada

In Yorito, except one person, the participants (23) were members of the milk affiliation "CREL" (Centro de Recolección y Enfriamiento de Leche). Five of the farmers already had a silo. In Sulaco, 23 persons participated of which 10 were interested young students invited by their teacher, seven farmers were from the AGASUL-group of which three farmers have already a silo, two from another nearby village (La Albardilla) and 3 more individual farmers. In Las Vegas near Victoria a farmer training event was carried out with 14 participants of whom 7 were members of the forage seed enterprise EMPRASEFOR (Empresa de Producción Artesanal de Semilla Forrajera). Two field days were carried out: (a) in Victoria in an innovators' farm where little bag silage (LBS) was elaborated and a heap silo was demonstrated and (b) in Yoro where LBS technology was demonstrated.

In Alauca, two farms were selected to introduce forage innovations. Beside several visits and field days in 2004 and 2005 with demonstration of LBS technology and hay making a farmer training event with 14 participants was carried out including theory on forage conservation. In collaboration with DICTA, 3 farmer training events were carried out in a prototype farm in Jamastran that used conserved forages. A total of 35 farmers participated in the event in San Pedro de Catacamas of which 12 were students from the college and 23 were farmers. Three farmers had already experience in silage making but ceased it due to failure. Another farmer training was held with the farmer group of Jesus de Otoro.

Characterization of farmer groups. Farmers participating in the training events on forage conservation were grouped in categories according to the number of livestock they own. As Figure 67 illustrates most of the participants can be grouped into the categories of small and medium.

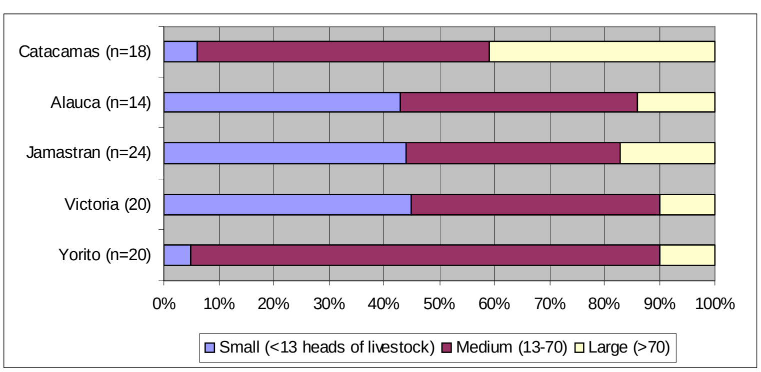


Figure 67. Share of small, medium and large scale farmers in different groups included in surveys in Honduras.

4.4.2 Survey with farmer groups to estimate current and potential use of forage conservation technologies

Contributors: C. Reiber and R. Schultze-Kraft (U. of Hohenheim), M. Peters, C. E. Lascano (CIAT), H.Cruz (CIAT-DICTA), C. Burgos (DICTA), A. Schmidt, L. H. Franco and P. Lentes (CIAT)

In the section that follows we report the main results of a survey carried out with farmers (N=101) selected to participate directly or indirectly in the research. Detailed information on how the surveys were carried out is presented in Section 4.5 of this report.

Milk production in the dry and rainy season. Considering all farm size categories over all regions (101 farmers), on average milk production in the dry season drops about 0.7 liters/cow (from 4.92 in the rainy season to 4.25 liters) in the dry season. In Alauca, the difference in milk production between the dry and rainy season was highest (2.44 liters/cow) (Table 78). In general, milk yield difference between the rainy season and dry season seems to be higher in small (<13 heads) farms (1.12 liters/cow) than in medium and large scale farms (0.51 and 0.75 liters/cow respectively) (Table 79). This can be explained by the fact that farmers grouped in categories medium and large are more specialized in milk production and invest more capital concentrates and silos than small scale farmers in order to take advantage of the higher milk price paid in the dry season.

Problems faced by farmers with milking cows in the dry and rainy seasons. During the meetings farmers were asked about their most important problems in the rainy and dry seasons.

a) Problems in the rainy season

In the rainy season problems most mentioned were:

- Low price for milk with a minimum of 2 Lempira/litre (about 0.11 US$/litre) in the rainy season compared to about 5.5 Lempira/litre in the dry season (about 0.30 US$/litre).
- Lack of marketing possibilities for dairy products.
- Pests (flies and external bloodsucking parasites, ticks) and diseases (estomatitis) diarrhea of calves, fungal diseases in the hoof.
- Weeds in the grazing areas.
- Inundation and mud (that are breeding places for pests that transmit diseases) during the rainy season.
- Lack of financial resources, land and technical assistance and non-availability of improved pasture in their farms.

b) Problems in the dry season

In all regions the most severe problem in the dry season was feed shortage (in average 86% of all farmers) followed by water shortage (50%). Other problems mentioned were “little or less milk production” (14%), “diseases”, “bad management”, “high prices for concentrates”, loss of weight” and “cattle mortality”, “pests”, “lack of money”, “bad pasture quality” and “lack of knowledge on forage conservation”.

Feeding strategies used by farmers in the dry season. Farmers use a wide range of feeding alternatives to overcome dry season feed shortages of which the most common is the utilization of forage sugar cane (caña forrajera/filipina), followed by feeding crop residues like

Table 78. Milk production (liters/cow) in the rainy season (wer) and dry season (dry) of different farmer categories in different regions.

			Farm category			
Department	Region		Small (20)	Medium (64)	Large (17)	Average
El Paraiso	Jamastran (20)	Dry	4	5.29	4.82	4.75
		Wet	5.14	5.84	4.65	5.36
		Diff	1.14(7)	0.55(9)	-0.17(4)	0.61
	Alauca (10)	Dry	2.33	2.53	5.79	3.39
		Wet	2.66	4.02	10.47	5.83
		Diff	0.33(2)	1.49(6)	4.68(2)	2.44
Olancho	Becerra (19)	Dry	4.3	5.22	3.59	4.78
		Wet	4.53	5.35	5.01	5.19
		Diff	0.23(2)	0.13(13)	1.42(4)	0.41
	SF de la Paz (17)	Dry	4.39	4.16	4.5	4.28
		Wet	5.65	4.01	3.67	4.18
		Diff	1.26(3)	-0.15(11)	-0.83(3)	-0.02
Yoro	Yorito (20)	Dry	6.67	3.57	5.22	3.89
		Wet	10	4.59	5.18	4.92
		Diff	3.33(1)	1.02(17)	-0.04(2)	1.03
	Victoria (15)	Dry	4.11	4.02	4.41	4.11
		Wet	5.31	4.24	4.85	4.62
		Diff	1.2(5)	0.2(8)	0.44(2)	0.51
Average			**1.12**	**0.51**	**0.75**	**0.67**

Small (<13 heads of livestock); Medium (13-70 heads); Big (>70 heads); (x) = number of farmers; Ver = dry season, Inv = rainy season, Diff = difference

maize and sorghum straw and corn husk (tuza), concentrate, cut and carry grasses like "Camerun" or King grass (*Pennisetum purpureum*) and renting land for grazing. Other mentioned strategies are grazing improved grasses like *Brachiaria* hybrid cv. Mulato and *Brachiaria brizantha* cv Toledo, use of molasses, gallinaza (chicken manure) and urea.

Silage. Of all participants 14% already used silage (mainly of maize and/or sorghum), and 5% used hay. There are only two cases of silage marketing in the study area. One is in Sulaco where a farmer sold maize silage (from a big silo) at a price of 25 Lempira (1.3 US$) in bags of 70 pounds (about 0.04 US$ per kg silage). In Yorito, SERTEDESO (a local NGO) sold silage in 2003: The silo had a dimension of about 8 x 4 x 2 m and a capacity of about 30 tons of silage. They sold the whole silo to a price of about 6,500 Lempira (about 350 US$) equivalent to about 0.01 US$ per kg fresh material. Other farmers stated a price of 0.05-0.08 US$/kg FM when asked to what price they would sell silage.

Table 79. Milk production in the dry and wet season.

	Dry	Wet	Diff
Small (20)	4.09	5.29	1.12
Medium (64)	4.21	4.71	0.51
Large (17)	4.59	5.44	0.75
Average	4.25	4.92	0.67

Straw and hay. In Alauca, farmers usually rent a piece of land with maize straw for a price of 115 US$ per ha or the maize straw can be bought at a price of 5 Lempira/10 pounds (0.06 US$/kg). A big bale of hay (600 pounds) costs 1,200 Lempira (0.24 US$/kg).

In Yorito, farmers stated a price of 2.7 US$ per head for 2 month rent of piece of land with maize straw.

In Jamastran sorghum straw is sold at a price of 1.33 US$ per 16 kg bale (0.08 US$/kg).

In Catacamas, farmers told us that the supply is higher than the demand for hay, and as a result people won't buy it. One bale of hay costs 11-15 Lempira/20 pounds (0.065-0.09 US$/kg).

In Victoria, a bale of Estrella (*Cynodon plectostachyus*) or Suazi (*Digitaria swazilandensis*, *D. didactyla*) hay (15 libras) costs 10 Lempira (0.08 US$) with a production cost of 0.04 US$/kg.

In Sulaco, farmers mentioned 0.07 US$/kg of hay, in Yorito about 0.1 US$/kg. Another dry season feeding option is "tuza" which is the dried husk of maize and is sold at a price of 0.04–0.06 US$ per kg. In Sulaco, a 32 kg bag of sugar cane costs 25 Lempira (0.04 US$/kg).

Another alternative is the pod of the legume tree "Espino" which costs 0.02 US$ in Sulaco and 0.03 US$ in Victoria. Other edible pods are from the tree "Cablote" ("tapa culo") with a price of 20 Lempira/100 pounds (0.02 US$ per kg) and Guanacaste.

Costs for different silo types and silage costs. In Table 80 we show initial investment costs, depreciated annual costs and the cost per kg of silage (DM) made in different silos.

Initial investment costs for different silos including plastic costs differ from up to 820 US$ for a brick silo with roof to about 50 US$ for an earth silo with the same capacity. The initial investment and annual costs for 800-1200 plastic bags that are necessary to ensile the same amount of silage (36 tons) would be very high. However, this value is very theoretical since the purpose of plastic bag is to ensile little amounts of high quality forage. Nevertheless, the cost per kg of maize silage does not differ much for all silos (0,04-0,05 US$) except for LBS which is 0.05-0.07 US$, since it requires a proportional higher amount of plastic bags per unit of silage compared to other silo types. However, for small-scale farmers who can not afford high initial investments and whose objective is to ensile little amounts, LBS is an economic alternative. Furthermore, LBS does not necessarily require extra labour costs since employees paid on day basis can additionally fill some bags every day. Other advantages of LBS are presented below.

Table 80. Initial investments, annual cost (depreciated) and silage cost/kg of different silo types (US$).

Type of silo	Initial investment (+ plastic)	Annual cost (+ plastic)	Cost/kg DM maize silage[2]
Bunker silo (30 years use)	500-800 (+20)	17.5-27 (+20)	0.04-0.05
Plastic bag silage[1] (2 years use)	0 (+ 168-400 for 800-1200 bags)	112-200	0.05-0.07
Earth silo (5-10 years)	30 (hole) (+20)	3-6 (+20)	0.04-0.05
Heap silo (with earth filled bags)	51 (324 bags) (+30)	15 (bags) (+30)	0.04-0.05
Heap silo (without bags)	0 (+ 65)	0 (+ 32.5)	0.04-0.05

Size of silo: 8*4*2 m (for ca. 36 t)

[1] Cost for bag: 0.14 $ (30kg/bolsa) - 0.5 $ (45 kg/bag)

[2] The silage cost is based on a maize production cost of 0.04 US$/kg DM

Priority of farmers for investment. Farmers were asked in what they would like to invest in order to improve there farm if they had financial resources available. The objective was to evaluate farmer priorities and detect differences between small, medium and large scale farmers in order to estimate the potential of forage conservation technologies.

Most farmers mentioned that priority on investments were‘: (a) improved pasture, (b) purchase of cows, (c) installations (stable, trough), (d) silo and (e) improve herd composition (breed) (Figure 68). The order of importance of the intended farm improvements for small, medium and large scale farmers are shown in Table 81.

Small scale farmers would like to increase the number of livestock (40%) and improve pasture (37%) before investing in barns (29%), silo (14%) and fences (12%). The priority of medium scale farmers' is to improve the feed base (pasture, 56%) for their herd before investing in breed improvement (16%) followed by silo and irrigation (both 11%) and buying cows (10%).

Large scale (as well as medium scale) farmers' priority is to improve pasture (32%) followed by breed improvement and irrigation system (both 23%), buying cows, milking machine and silo (all 18%). They intend to intensify their farm through high cost investments like irrigation system, milking machines, wells (14%) and machinery (9%).

In summary the sequence of most important investments to improve farms of small and large scale Honduran farmers are: 1. Improve pasture and increase number of livestock, 2. Construct/ improve barns, 3. Silo and improve breeds, 4. Fencing and 5. Irrigation.

This reveals that farmers are not only aware of silage technology but it is already an important component in the planning of their projected farm improvements.

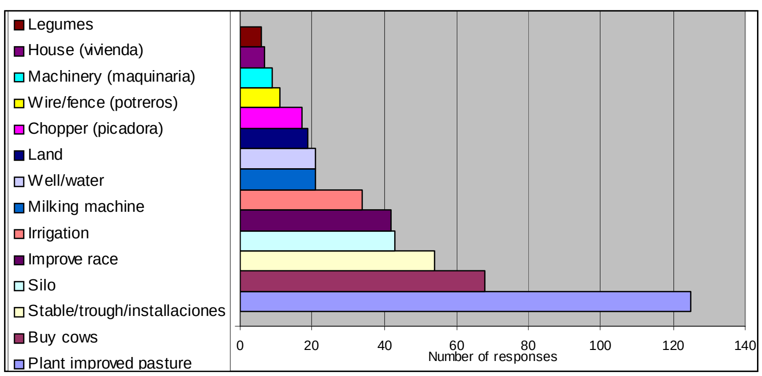


Figure 68. Preferences of farmers for farm improvement

Table 81. Order of importance of farm improvements for small, medium and large scale farmers:

	1. place	2. place	3. place	4. place	5. place
Small (n=35)	Buy cows (40%)	Pasture (37%)	Stable/trough (29%)	Silo (14%)	Wire/fence (12%)
Medium (n=61)	Pasture (56%)	Stable/trough (20%)	Improve herd composition (16%)	Silo (11%), Irrigation (11%)	Buy cows (10%)
Large (n=22)	Pasture (32%)	Improve herd composition (23%), Irrigation (23%)	Buy cows (18%), Milking machine (18%), Silo (18%)	Well (14%)	Machinery (9%)

Demand for forage conservation technologies by farmers. Farmers were asked about their motivation for participating in training events in order to define their interest and demand for forage conservation. In Yorito, 84% of the group mentioned to be interested in forage conservation, 77% in Sulaco, in Las Vegas all farmers (100%) and in Jamastran 85%. In Jesus de Otoro and Catacamas farmers' main interest was to learn about improved pasture species and their management whereas only 18% and 12% respectively voted for forage conservation.

A reason for farmers' preference in Jesus de Otoro and Catacamas might be that in these areas in comparison to the areas in Yoro improved forages like *Brachiarias* were not yet promoted and there is still little use of these. Thus it would seem that the first priority of farmers is to improve their pastures before investing in forage conservation technologies. Another question concerning interest of farmers in different forage conservation possibilities revealed that hay making, LBS as well as trench silo were the most favoured (Table 82).

Table 82. Number of farmers interested in hay production and different silo types.

Item	Ala	Jam	Yor	Sul	Cat	LV	Total
Hay	n.d.	3	4	n.d.	n.d.	8	15
Little bag silage	6	2	0	5	2	4	19
Trench silo	1	0	4	13	0	3	21
Heap silo	3	1	0	3	2	0	9
Bunker silo	1	0	7	0	0	2	11

n.d. = no data

The fact that the most severe problems in the dry season mentioned by farmers is feed shortage and their interest in forage conservation for the dry season, clearly illustrate the demand for feed alternatives like hay and silage.

Comparison of milk production in farms with and without silage. Milk production in the dry and rainy season of farms with silo was compared to milk production in farms without silo in order to estimate benefits of forage conservation in the form of silage (Table 83). In general, farms having silo compared to farms without silo not only produce 56% more milk in the dry season (difference of 2.13 liters/cow) but also 34% more in the rainy season (difference of 1.53 liters/cow). This milk yield difference between dry and rainy season is smaller for farms having silo (0.14 liters/cow) than for those without silo (0.74 liters/cow) and highest for small scale farmers without silo (1.56 liters/cow).

Level of milk production is not exclusively dependent on the season of the year or the use of silage. The higher milk yield in the rainy season of farmers having silo (34%) reflects improved and intensified livestock production systems characterized by the use of improved pasture, breeds more appropriate for milk production, use of concentrate, and/or better management (e.g. pasture rotation, milking frequency).

Assuming that small scale farmers without silo fed silage in the dry season and that the ratio of milk production in the dry and rainy season is equal to the ratio of dry and rainy season found in farms with silo, the potential milk yield is 4.41 liters/cow which is 1.12 liters (or 34%) more than presently being collected. Thus the effect of

Table 83. Milk production (liters/cow) of farms with silo compared to farms without silo.

With silo (n=49)				Without silo (n=139)				Diff2 - Diff1
	Dry season	Rainy season	Diff1		Dry season	Rainy season	Diff 2	
Small (2%)	5.71	6.25	0.54	Small (19%)	3.29	4.85	1.56	1.02
Medium (45%)	5.98	5.59	-0.39	Medium (59%)	3.96	4.39	0.43	0.82
Large (53%)	5.92	6.48	0.56	Large (22%)	3.87	4.73	0.86	0.30
Average	5.94	6.08	0.14	Average	3.81	4.55	0.74	0.60

Small (<13 heads of livestock); Medium (14-70 heads); Large (>70 heads)

Table 84. Estimated average milk yield increases if silo was utilized in farms without silo.

Farm size	% milk yield in dry season of milk yield in the rainy season (with silo)	% milk yield in dry season of milk yield in the rainy season (without silo)	Farms without silo: Potential yield in dry season if used silo (liters/cow)[a]	Farms without silo: Potential milk yield increase if used silo (liters/cow)[b]	% milk yield increase if used silo (estimated effect)
Small	91	68	4.41	1.12	34%
Medium	107	90	4.70	0.74	19%
Large	91	82	4.30	0.43	11%
Average	98	84	4.46	0.65	17%

a = (Liters rainy season without silo) • (% milk yield in dry season (with silo)
b = Potential yield dry season - actual yield dry season of farms without silo

using silage can be greater for small scale farms (1.12 liters or 34%), followed by medium scale and large scale farms (Table 84). These calculations do not take into account the variability of the data within categories and assumes that milk yield difference in the rainy season between silo and non-silo farms is mainly the effect of breed differences.

Cost-benefit of using silage. Assuming an increase of 1.5 liters/cow if cows were fed with silage, a price of 0.3 US$/liter, a silage cost of 0.015 US$/kg FM and an intake of silage of 20 kg/cow/day, the benefit of feeding silage can be calculated (the following only considers the benefit from milk production) using the following:

Milk price • milk yield increase – cost of silage/kg • silage intake = benefit.
Using this formula a farmer with 10 cows would have a benefit of 1.5 US$/day (0.3 US$/liter • 1.5 liters – 0.015 US$/kg • 20 kg/cow = 0.45 US$ – 0.3 US$ = 0.15 US$ per cow/day.

Calculation of break even point (income = costs) only considering milk production:
0.3 US$/litre • x liters = 0.3 US$. The break even point is 1 liter/cow which means in this case that a cow should increase milk production by more than 1 liter if supplemented with 20 kg of silage in order to produce a profit.

The benefit of feeding silage on milk production is highly dependent on the breed, silage quality and quantity. In order to evaluate the overall benefit of feeding silage, these factors and effects on reproduction and live-weight as well as effects on stocking rate have to be considered. More detailed economic assessments are under way.

Reasons for non-adoption of silage technology by small scale farmers. Out of 49 farmers with silo, only one (2%) was a small scale farmer.

Some reasons for the little use of silage by small scale farmers are the following:

- The investments required for (renting) machinery and/or for constructing a silo are high.
- Non availability of a forage chopper ("picadora").
- Lack of knowledge and/or experience on silage technology in general and/or alternative low cost silo technologies.
- Preference of investing in cows, improved pasture, land or barns before constructing a silo.
- Have breeds of low milk production potential and the milk produced is used for household consumption.
- Lack of infrastructure (e.g. roads, milk associations (CRELs).
- Unsatisfactory experiences leading to bad reputation of silage.
- Aversion to innovation and risk.
- Traditional extensive farming systems.
- Lack of planning and motivation.

Nevertheless, about 13 small scale farmers with 3 to 7 milking cows are presently beginning with silage preparation after its socialization in the field days.

Acceptance of plastic bag silage by farmers. Comments made by farmers reveal that LBS is an attractive technology for its low costs, easy handling, low labor requirement and efficient use of labor, reduced risk of losses due to rapid filling and small size, adaptability of bag size and marketing possibilities. Furthermore, LBS was mentioned to be an alternative to ensile high quality forages of smaller plots whose amount would not be sufficient to fill a large silo (Photo 31).

The main criteria used by farmers for selecting plastic bags were: (1) market availability, (2) cost, (3) resistance and (4) size (handling). After the evaluations, farmers voted for their preferred plastic bags. Small bags were preferred i.e. a green self made bag elaborated from a plastic in tube form and the double layer concentrate bag-plastic bag (calibers 2 and 3). For the big bags, farmers preferred the bag of the same raw plastic material as the self made small bag (caliber 6).

The evaluations revealed that farmers preferred plastic bags of at least 4 caliber and low elasticity (low density) or a concentrate bag in order to facilitate the compaction and reduce the risk of damages and consequent silage losses.

In Table 85 we summarize the main advantages and disadvantages as viewed by farmers of different plastic bags for making LBS.

Photo 31. Different bag types elaborated and evaluated during field days. (a) Manual adaptation: Plastic tube is cut to appropriate size and sealed using a hot machete; (b) Evaluation of different silage bags; (c), (d), and (e) use of barrels, garbage cans or (used) particularly thick animal feed concentrate bags in order to facilitate filling, compaction and reduce risk of perforation of plastic bags

Table 85. Advantages and disadvantages of different bag types.

Bag type	Advantages	Disadvantages
Transparent bag (Calibre 3)	- More resistant than rubbish bag - Easy handling - More docile	- Not available in the market - fragile
Little rubbish bag (Calibre 2)	- Available in the market - Cheap - More docile than the bluish one	- Very fragile
Two-layer resistant concentrate bag – plastic bag	- Better than blue transparent bag - More resistant - Double protected - More practical for compaction,	- Higher costs but we can save the concentrate bags
Green small bag self-made (Calibre 6)	- Available in the market - Adaptable in size and form - Better for compaction and air removement - Easy handling	- Higher costs - More time requirement for elaboration of bag
Green big tube bag with barrel (Calibre 6)	- Available in the market - Resistant - The size can be adapted - Safer for compaction - Greater capacity - Less plastic requirement (less costs)	- More air in the sides and ex-tremes (sealing at two extremes) - Too big and heavy (need 2 persons to carry)
Big black rubbish bag (Calibre 4)	- Available in the market - Greater capacity - The bigger the cheaper per kg of silage	- More expensive - Less resistant than green bag - Need for 2-3 persons

4.4.3 Case study: Adoption of silo technologies in the area of Yoro, Honduras

Contributors: C. Reiber and R. Schultze-Kraft (U. of Hohenheim), M. Peters and C. E. Lascano (CIAT), H. Cruz (CIAT-DICTA), C. Burgos (DICTA), A. Schmidt, L. H. Franco and P. Lentes (CIAT)

Rationale

In many parts of Honduras, silage preparation for dry season feeding is a strategy rarely employed by smallholder farmers. Nevertheless there are regions where some farmers have adopted the silo technology but its diffusion is slow. Reasons include high initial investments for the most common large bunker silo inaccessible to smallholder farmers, lack of know-how on silage production and lack of knowledge of appropriate low cost silo alternatives such as heap silo, earth silo and little bag silage (LBS).

In this section we present a successful case of adoption of forage conservation in the forma of silage in Yoro, Honduras and the conditions that favoured diffusion and adoption of silage technology.

Materials and Methods

In 2002, CIAT and its partners identified the need and demand for silo conservation technologies by farmers in the area of Yoro (a reference site for forage related R and D led by CIAT). Silo types such as heap and earth silos and especially little bag silage were offered during farmer trainings and field days in order to catalyze innovation, adoption and dissemination processes of forage conservation technologies with and by small-scale farmers. In this case study we analyze the most relevant factors of the diffusion process at the social system level. An informal expert interview and structured farmer interviews were conducted in order to document this process. Further research will be carried out on the diffusion and the individual adaptation and adoption process of forage conservation technologies influenced by farmer socio-economic conditions.

Results

Factors influencing the spread of silage innovations were among others, promotion of silage technology (farmer training and field days), extension and interaction among farmers, demand and market price of milk in the dry season, presence of milk associations, and key farmers with innovative ideas.

Farmer trainings and field days. CIAT and DICTA have been promoting forage conservation (maize and sorghum) in form of silage and its use since 2002 when a field day including theory and practice about silage making (earth silo) and a feeding demonstration was held in a prototype farm in Victoria. A total of 17 farmers from Victoria, Sulaco and Yorito participated in this event. Additionally, individual farmers visited this farm at the time when the innovator elaborated his silo. In 2003, there was only one silage field day event with about 20 farmers and 10 students from Yoro, Victoria and Sulaco. The following year, CIAT and DICTA carried out further field days in prototype farms addressing topics such as improved pasture, its use and conservation. In subsequent years (2004-2005) courses on forage conservation were carried out in the Yoro area (Yorito, Yoro, Sulaco and Victoria) with special focus on plastic bag silage. For more details on the events and their results see section 4.2.1 of this report.

Development of silage use in the Yoro area (regions of Yoro, Yorito, Sulaco and Victoria). In Figure 69 we illustrate the increase of farms using silos in the different regions around Yoro over time. The diffusion process began in Sulaco and Victoria in 2002, originating from 11 farms with silo of which four were "fincas prototipo", i.e. farms where new forage technologies are introduced, monitored, evaluated and scaled out. Since then, the adoption rate has followed a linear increase. In Yorito and Yoro this process started two years later with a sharp increase of the number of farms using silo.

The curve in Figure 70 represents the aggregated number of farms making silo in the Yoro area. There is not only an increasing number of silo farms (190% in the last year) and total silage production (220% in the last year), but also an

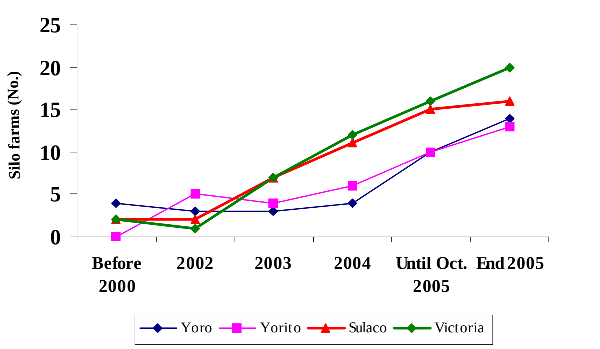


Figure 69. Number of silo farms in different regions of Yoro.

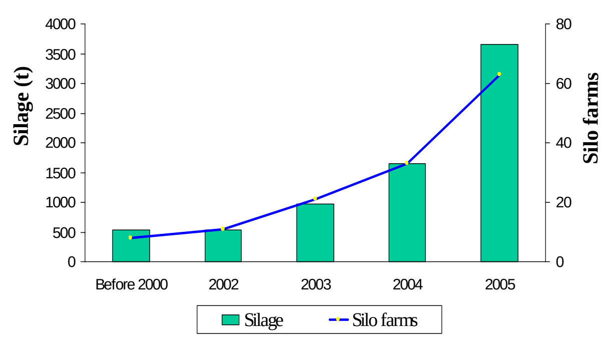


Figure 70 Start up phase of silo diffusion process in the Yoro area: number of silo farms and silage produced.

increase in silage production per farm over the last years (e.g. from 46 t in 2003 to 58 t per farm in 2005). Some innovators even tripled their silage production since 2003.

In 2003 and 2004, there were only medium and large scale farmers using silo. Currently, 13 small scale farmers in the region with 3 to 7 milking cows are starting to use mainly heap and earth silo as well as little bag silage. Since 2005, farmers also started to ensile improved forages such as *B. brizantha* (cv. Toledo) and *Brachiaria* hybrid (cv. Mulato) as well as the shrub legume *Cratylia argentea*.

Presently, there are 14 farmers in Yoro, 13 in Yorito, 16 in Sulaco and 20 in Victoria who integrated silage technology as part of their dry season feeding strategy. About 3.700 t from about 130 ha of mainly maize and sorghum are ensiled in the area as feed for more than 1000 heads of cattle over a 6 months dry period (assuming a consumption of 20 kg/head/day).

(a) Bunker silo **(b) Heap silo**

(c) Earth silo **(d) Little bag silos**

Photo 32. Different silo types: (a) Common silo type, and alternatives (b, c, and d).

Silo types. The most common silo type used in the area is a bunker silo constructed of bricks and/ or concrete with a size of 8 x 4 x 2 m (capacity of about 35 tons of ensiled forage) and an opening at the front side. In Yorito and Sulaco, some of these silos are with roof to protect the silage from water and direct sunlight (Photo 32). In 2003, this silo type was still used by 92% (24 out of 26) of the farmers compared to 50% in 2005. As illustrated in Figure 71, the use of alternative silo types such as little bag silage (LBS), earth and heap silos has increased in the last two years with a present share of 11%, 22% and 17%, respectively.

Silo farmers and CREL (Centro de Recolección y Enfriamiento de Leche)**.** In Yoro, Yorito and Victoria some livestock farmers (20, 25 and 21 respectively) are affiliated to milk associations (CRELs). Milk is stored and cooled in these centres and subsequently delivered to a milk processing enterprise ("SULA").

By the end of 2001, farmers in these regions got together and started the process of organization, legalization and training. In Yoro, the CREL group has been delivering milk to SULA since June 2003, in Yorito and Victoria since February 2004. Farmers associated to CRELs can deliver every amount of milk at a fixed and steady price for both the dry and rainy season, which in 2005 was 0.32 $US (5.93 Lempiras) per liter for Yorito and Victoria and 0.34 $US per liter for Yoro.

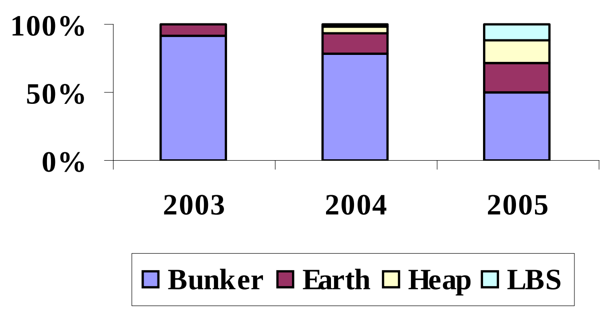


Figure 71. Percentage of different silo types over years

In Victoria and Yorito about 40% and in Yoro about 63% of the farmers in the CREL group have a silo. In total, about half of the farmers (47%) who are affiliated to a CREL group feed silage in the dry season 2005/2006 (first column in Figure 72). Considering all farmers in the Yoro area who have a silo, 53% are affiliated to a CREL (second column in Figure 72). In Victoria and Yoro, about 45% and in Yorito 67% of CREL farmers have a silo. In Sulaco, about 15 farmers are affiliated to a group called AGASUL (Asociación de Ganaderos y Agricultores de Sulaco, founded in the 80s). Milk is sold at the local market at a price of about 0.22 $US (4 Lempiras) per litre in the rainy and about 0.30 $US (5.50 Lempiras) in the dry season. About two thirds of the group have a silo.

Discussion

Promotion of Innovation. It is evident from the Yoro case study that activities like farmer training and field days have an accelerating effect on the diffusion of silage technology. Many farmers mention that there is a lack of know-how concerning silage making. Awareness creation on dry season forage scarcity, its consequence on animal productivity (e.g. milk production, liveweight gain and fertility), the transfer of silage technology as well as the demonstration on how to elaborate silage are very important for the adoption of the technology. Subsequently, farmers can adapt the silo type to their specific situation. The most frequently used bunker silo was first adapted by an innovative farmer (Oscar Nuñez) who participated in a field day where an earth silo was demonstrated. He wanted to construct it with concrete walls and an extended roof at one side to have a feeding place for his livestock. Although this silo type was not promoted specifically (since it requires high investment) farmers nearby adopted it.

In 2004 and 2005, alternative silo types like plastic bag silage, earth and heap silos were offered and this had an immediate effect on the number of farmers who got interested in making silage.

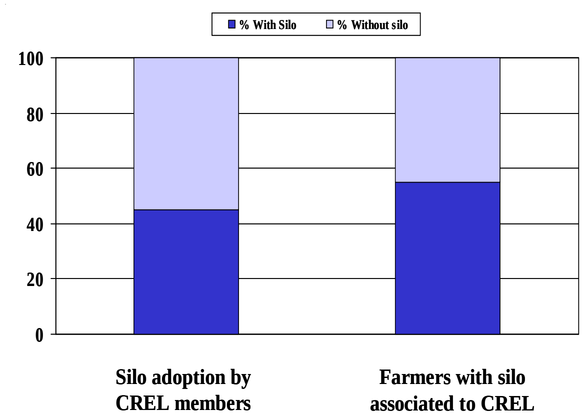


Figure 72. Relation of silo adoption to CREL affiliation in the Yoro area

Interaction and communication. Some argue that the speed of the diffusion process of a successful innovation of a technology is mainly determined by the extent of the interaction between the farmers who have already adopted and potential adopters. Livestock farmers in Honduras affiliated to milk associations like the CRELs as well as other farmers in these regions have permanent contact with each other and most of them exchange their experiences, especially those concerning improved production systems, almost every day.

Although there appears to be a relation between the existence of CREL (and the secured purchase of milk at a fixed and higher market price) and silage use, this may not have been the decisive factor as a similar diffusion process can be observed in Sulaco where no CREL exists. Furthermore, in Victoria and Yorito the CRELs deliver milk since February 2004 but the silo diffusion process in Victoria already started two years before. Another argument is that in the CREL group there are as many farmers using silo as there are without silo. Nevertheless, only considering Yorito and Yoro, there is a coincidence of the existence of CRELs and the diffusion of silage technology.

Key persons. According to some authors it is important for the speed of diffusion of a given technology whether the innovators are at the same time respected communicators. One of the pioneer innovators in the region whose farm is one of the prototype farms in Victoria is additionally working with CIAT and DICTA since 1996 in the forage area as technical and scientific assistant and extensionist. He is well known in the region and is regarded more as a farmer than a technician. He visits farms and farmers come to him in order to pick up information, advice and recommendations. He undoubtedly can be regarded as an innovator, key communicator and influential at the same time not only within the social system group and community but also at higher system levels connecting the regions and groups through communication and exchange. But this is not the only case. Other farmers like e.g. Oscar Nuñez, another "prototype" farmer, fulfil these conditions for the social system level group (CREL) and community (Yorito).

Projected adoption of silage technology. The curve shown in Figure 69 illustrates a slow initial adoption of silage technology but a subsequent steep increase indicating the beginning of a diffusion process. Considering that silo technology starts to be transferred from farmer to farmer and that an estimated 10-20% of the livestock farmers in the regions of Yorito, Sulaco, Victoria and Yoro will have a silo by the end of 2005, it can be hypothesized that silo diffusion will continue independently from any further interference. However, results need to be further validated since there are 30 farmers implementing silage technology for the first time in 2005/2006 and the outcome and acceptance first have to be confirmed, especially for the small scale farmers using alternative silo types.

The projected adoption of little bag silage technology for small scale as well as for medium scale farmers depends on the success with the technology in at least some cases. Success will be determined by: (1) the elaboration process (e.g. type and humidity of the forage used, type of bag, additives used, compaction, sealing) which will have consequences for the quality of the silage (e.g. smell, presence of moulds and acceptance by the animal), and (2) the storage management (e.g. in a closed room) in order to protect the bags from rodents, insects and sunlight. Successful cases with plastic bag silage could then be used for the further dissemination of the technology by a guided interaction between first adopters and those who have not yet adopted (farmer to farmer transfer of technology).

In general, based on comparison with the literature and the observed situation in the Yoro area, it can be concluded that:

- Farmers' participation in the meetings, their interest in forage conservation as well as the annual silo adoption rate demonstrate the demand for silo technology.
- Earth and heap silos as well as plastic bag silage seem to be appropriate for adoption by small scale farmers.
- Adoption, adaptation and innovation of alternative silo types by smallholders are likely to continue and expand in the next years.
- Silo technology requires precise instruction either by technicians or by experienced farmers in order to reduce the risk of failure and subsequent discouragement.
- Research and/or development projects can initiate and accelerate the diffusion process of silage technology by e.g. farmer trainings and field days with multi-actor exchanges.
- After a certain level of adoption the diffusion process is likely to continue independently from any outside interference.
- Farmer associations like CREL foster farmer exchanges and transfer of technology but are no prerequisite for the diffusion of forage conservation adoption or innovations.
- Key persons like innovators who have an influence on the decision making of other farmers can accelerate the innovation, adoption and diffusion process.

4.4.4 Case study: Innovation of the bag silage technology by farmers

Contributors: C. Reiber and R. Schultze-Kraft (U. of Hohenheim), M. Peters, C. E. Lascano (CIAT), H. Cruz (CIAT-DICTA), C. Burgos (DICTA), A. Schmidt, L. H. Franco and P. Lentes (CIAT)

Case study-Ignacio Sanchez, Olancho: Earlier, the farmer fed maize silage produced in earth and heap silos, but he discontinued the use of silage and is now feeding Mulato hay. He argued that it is more comfortable, practical and cheaper to make hay (elaborated with machinery). A neighbour told us that this farmer was the silo pioneer in the region, but he discontinued its use it because his silo had fungi and some cows died feeding on it.

In 2004, he had 1000 bales of hay and with this he maintained his milk production and his cows. The cost to elaborate the hay is about 0.6US$ per bale and the market price is about 1.5US$/bale.

In 2003, in collaboration with DICTA Mr. Sánchez elaborated 25 bags of Cratylia silage of which two were ruined in the end and were not fed. The others had fungi on the top layer (2.5 kg) that was still fed after sun drying. He prepared most of the bags without molasses with one day of dehydration and preferred them to those with molasses ("helps to compact, works better"). The cost was estimated to 25-30 Lempiras/bag (1.2-1.6 US$).

Presently and motivated by CIAT and DICTA, he is elaborating plastic bag silage again (Photo 33) which will serve for a milk production experiment and additionally he wants to sell some bags.He is ensiling Cratylia and not corn or sorghum as most farmers. For him, the advantages of the Cratylia silage bags are the time flexibility in its elaboration and its feeding to calves and weak cows.

Case study-Rigoberto Nolasco, Juscarán: The owner of another prototype farm (DICTA) began feeding silage in the 80's. He filled a large bunker silo and later a heap silo every year. In 2004, he was told about the little bag silage technology and experienced a successful case in another region which convinced him. Presently and for the first time, he is elaborating big bag silage and invented the use of a barrel which eases the compaction and protects the plastic bag from perforation.

The silage consists of a mixture of various species of cut and carry grasses like *Pennisetum purpureum* cultivars Camerun and King Grass, *Panicum maximum* (Mombaza) and the legume *Cratylia argentea*. Salt and citrus fruits (orange and/or lemon) cut in half are added as preservatives in layers (Photo 34). Molasses which was said to be only available for a short period after the harvest of sugar cane is not added. Presently, 100 bags of about 100 kg each are elaborated and another 200 bags will follow.

Problems with the large silos he used to make were the long time requirement to fill (one week), high costs, high labour requirement in times of labor scarcity, effort, bad smell, silage drainage problems and the soiling of the silage caused by muddy water coming from the slope above. He mentioned that he does not have these problems

Photo 33. Silage bags of Cratylia in 2004

Photo 34. Silage of different species and mixture with fruits.

with the bags. Furthermore, he does not have extra costs for labor; the workers who are paid on day basis can additionally fill some bags. Another advantage of the bags mentioned is that once opened a bag, the silage is used immediately and because of that there are less losses due to prolonged exposure to air and the consequent spoilage than with a large silo. A disadvantage of the bag silage was the high cost of the bag (0.46 US$) and the higher cost per kg of silage compared to a big silo.

Case study-Antonio Polanco, Yoro. A farmer who had participated in a field day in Yoro in September 2005 prepared on his own initiative the first 15 plastic bag silage. These bags were small and he said that the forage ensiled (*Pennisetum purpureum*) had a high water content so that liquid leaked out of the bags. After the second field day, he prepared 20 larger bags of about 60 kg and dehydrated the material for some hours. He mentioned as an advantage that the dehydrated silage does not weigh that much. The silage was prepared without any additives except for one bag in which he added ground maize as an experiment (Photo 35). The plastic tube used is very resistant, adaptable in size and locally available to a price of 10 Lempira (about 0.5 US$) per yard. Compaction is done with a wooden stake and at the margins carefully by hand in order to prevent damage of the plastic. On each bag the date of production is noted down in order to control the smell and the acceptance by the cows after a specific time. The first feeding experience revealed acceptance of the silage by the cows. He noted that the effort and cost is only worth it if high quality forage is used.

The smell of the silage of an opened bag was slightly acetic. Thus, we suggested adding some molasses or other sugar-containing products in order to improve fermentation and agreed on an experiment of different additives: dissolved sugar, cut sugar cane, orange pulp and ground maize.

Constraints for the adoption of the bag silage technology

Initial results reveal the following constraints expressed by farmers for the use of bag silage:

1. Bags are susceptible to infestations by rodents, ants, worms, and insects that damage the bags and lead to growth of fungi and consequent losses of silage in quantity and quality (Photo 36).

Photo 35. Silage of different species and mixture with maize.

Photo 36. Worms and fungi in LBS

2. Plant stems can perforate the bags and the holes have to be sealed by an adhesive tape.
3. Little availability of adequate bags in the rural areas.
4. Suitable resistant plastic bags are expensive.
5. Compaction, sealing and transport have to be done with great care in order not to damage the bags.
6. Higher cost per unit of silage.
7. Proportional quality losses are usually greater than in large silos due to proportionally greater margin area per unit of silage and insufficient compaction at the sides.

Experience and innovation with hay

In November 2004, 1 kg of *Brachiaria* hybrid cv. Mulato was planted in a selected plot (about 875 m^2). Two months later, the farmer transplanted Mulato for the first time, another 6 weeks later for the second time. The area was about 2400 m^2 (total area of 3275 m^2) and was irrigated in 5 days interval during the dry season. The cost of transplanting was 700 Lempira (about 38 US$). The farmer was trained on hay making including technical aspects on cutting, drying (including turning) and elaboration of bunches (5-10 kg). In March 2005, the farmer elaborated the first hay from the area which was planted with the grass (Photo 37). He dehydrated the material in the sun for 2 days before feeding it to the cows and calves. We recommended cutting the grass at 10-15 cm since it was cut too low affecting its sprouting potential. In August, he reported that he had to fertilize the field twice since plants appeared yellowish. After two applications of about 240 kg of urea fertilizer, Mulato grew vigorously.

In the rainy season, the grass was cut at 4 week intervals and carried to an unused pig barn for final drying, since excessive rain did not allow proper sun-drying. The grass was spread on wooden sticks bend over the divisions of the pig stable. When the farmer considered the material as dry, he bound it in bunches and put it into the small storing room in the same pig stable building.

However, part of the stored hay was considered to be not dry enough in the centre of some bunches. Thus the grass had to be removed and

(a)

(b)

(c)

Photo 37. (a) Mulato established; (b) hay of Mulato (c) bunches of Mulato spread outside in the sun for one more day. It was recommended to cut early in the morning of days with less probability of rainfall and to cut only the amount that could be dried and managed in time. Furthermore, it was pointed out that although the material may appear dry, residual moisture may remain inside the thick stalks damaging the stored hay. It was demonstrated how to estimate the dry matter content by a wring probe.

A constraint to manual hay making of Mulato is that farmers do not like handling the material due to the pricking characteristic of the fine hairs which cause burning skin irritations. In addition in the rainy season 2005, it was very difficult to make hay since rainfall was abundant, and Mulato requires at least two days of sunshine for proper drying. In case of daily precipitation, silage seems to be the more appropriate alternative for conservation.

In summary, based on the case studies and interviews to farmers, the following points can be drawn:

- The main problem in the dry season stated by farmers is forage scarcity leading to low(er) milk production.
- Farmers are interested in and demand for forage conservation technologies.
- For small scale farmers, the estimated milk yield increase if supplemented with silage would be about 1.1-1.9 liters/cow/day (34-74%).
- In spite of constraints of bag silage technology, it is an attractive alternative for small as well as for medium scale farmers. It is adaptable to local conditions and its advantages (like for example the flexibility, low labour requirement and low investment cost) favour its adoption at a larger scale.
- Favouring conditions for the adoption of bag silage technology are, beside others, the availability of a chopper, improved forages and milk races, adequate promotion, the availability of appropriate plastic bags and the existence of innovators.

4.4.5 Economical benefits of feeding hay and silage during the dry season on commercial dual-purpose farms in Central America

Collaborators: D. Schoonhoven (U. of Wageningen), F. Holmann (CIAT-ILRI), P. Argel (CIAT), E. Perez (ILRI), J. C. Ordoñez (DICTA), and J. Chavez (CORFOGA)

The objectives of this study were to (a) estimate and compare the increase in milk and beef production due to feeding hay and silage during the dry season, (b) estimate and compare the production costs of making silage and hay, and (c) estimate and compare the net benefits as a result of feeding silage and hay.

In Honduras thirteen farmers were personally interviewed: seven farmers who produced silage and six farmers who produced hay. All surveyed farms were located in Yoro and its surroundings, a region with a prolonged dry period. In Costa Rica nine farmers were interviewed: seven who produced silage and two who produced hay. Two farmers were selected in the Esparza-Puntarenas region and seven farmers in the Nicoya Peninsula, both regions on the Pacific Coast with a prolonged dry season.

General information on the silage and hay

In Tables 86 and 87 we present general information on farms using silage and hay in both countries. Farmers in Yoro had to deal with a longer dry season and therefore, the use of conserved feedstuffs was desired for a longer period. Hence, as can be seen in Table 86, farmers in this part of Honduras compared with farmers in Costa Rica, allocated more land to

Table 86. General information on silage.

	Honduras (n=7)	Costa Rica (n=7)
Used forage (% of farms)		
Silage made of corn	42.9	71.4
Silage made of (corn and) *Cratylia*	14.2	28.6
Silage made of corn and other forages	42.9	0
Used type of silo (% of farms)		
Little bag silage	0	14.3
Monton silage	14.3	85.7
Bunker silage	85.7	0
Amount of land allocated to produce silage (ha)	3.9	1.1
Yield (mt/ha)	23.9	16
Yield as DM (mt/ha)	8.4	5.6
Size of silo (m^3)	134.1	24.3*
Construction costs (US$/$m^3$)	19.08	0
Waste (%)	4.5	2.7
Duration of silage in store (months)	6	3
Years producers have been feeding silage	6	7
Producers in neighbourhood using silage (%)	16.3	6.3

*n = 6

make silage (i.e. 3.9 ha vs. 1.1 ha) and fed it for a longer period (i.e. 6 mo vs. 3 mo). Likewise, Table 87 shows that farmers in Honduras compared with farmers in Costa Rica, allocated more land to produce hay (i.e. 6.4 ha vs. 3.5 ha) and fed this for a longer period (i.e. 6 mo vs. 5 mo).

Results in Table 86 indicate that in Honduras the yield of silage was higher than in Costa Rica (i.e. 24 mt/ha vs. 16 mt/ha). This could be explained by the use of a combination of maize and sugarcane and/or sorghum by 43% of farmers in Honduras. A study executed in Honduras and Nicaragua revealed that sugarcane had a yield 80 mt/ha, while maize had 33 mt/ha. Sorghum had a yield of 45-50 mt/ha. Table 87 shows that in Costa Rica the yield of hay was higher than in Honduras (i.e. 10.5 mt/ha vs. 8.2 mt/ha). In Costa Rica and Honduras, on average, the resting period before harvesting the pasture was 90 and 37 days, respectively. The longer resting period in Costa Rica resulted in a higher yield.

The results of this study suggest that in Honduras the adoption rate of silage was higher than of hay, while in Costa Rica the adoption rate of hay was higher. In Honduras, the interviewed farmers mentioned that 16% of the farms in their vicinity utilised silage and 6% utilised hay, while this percentages in Costa Rica were 2% and 20%, respectively (Tables 86 and 87). As can be seen in Table 86, farmers in Honduras chose to construct an expensive and durable type of silo; 86% of farmers used bunker silo compared to 14% who used a monton silo. Contrarily, 86% of farmers in Costa Rica used a monton silo. On the other hand, farmers in Costa Rica constructed larger and more expensive stores to stockpile their hay than farmers in Honduras despite the fact that farmers in Costa Rica produced less of it.

Costs of hay and silage

In Tables 88 and 89 we present the costs of silage and hay. The costs of making silage were subdivided in labour costs (costs for clearing and preparing the land, applying fertilizer, planting, controlling weed and harvesting), machinery costs, and other costs (ie., herbicide, seed, fertilizer, additives, and plastic). The costs of making hay were subdivided in labour costs (although labour costs most of the time were included in the rental costs of machinery), machinery, and other costs (ie., fertilizer).

Table 87. General information on hay.

	Honduras (n=6)	Costa Rica (n=2)
Used forage (% of farms)		
Hay made of improved grass	66.7	100
Hay made of (improved grass and) corn	33.3	0
Amount of land allocated to produce hay (ha)	6.4	3.5
Yield (mt/ha)	8.2	10.5
Yield as DM (mt/ha)	7.2	9.2
Size of storing facility (m^3)	298*	480
Construction costs of storage facility (US$/$m^2$)	15.62	25.89
Resting period before harvesting hay (days)	37*	90
Duration of hay in store (months)	6	5
Price of hay (US$/mt)	46.55*	93.96
Years producer has been feeding hay	5	10
Producers in neighbourhood using hay (%)	2.0	20

*n = 5

Silage. In Table 88 we show the costs of making silage in Honduras and Cost Rica (i.e. $16/mt and $46/mt, respectively). The production costs of silage was significantly lower in Honduras than in Costa Rica, mainly explained by the lower labour cost. The higher labour costs in Costa Rica were due to more expensive labour (the salary of a worker was $8.47/day, compared with $2.57/day in Honduras) and an higher amount of labour per hectare (i.e. 32 man-days/ ha vs.18 man-days/ha in Honduras). In Costa Rica more labour was involved in land clearing (i.e. 20 man-days/ha vs. 2 man-days/ha in Honduras). This could be explained by the fact that three smallholders produced silage for the first time, and therefore had to clear the land thoroughly. In Costa Rica also more labour was allocated to planting (i.e. 7 man-days/ha vs. 2 in Honduras) because of the higher amounts of seed used. In addition, in Costa Rica more labour was engaged in harvesting, transporting and filling the silo, although the yield (mt/ha) was lower compared with Honduras (i.e. 16 mt/ha and 24 mt/ha, respectively, see Table 88).

Machinery costs were also lower in Honduras than in Costa Rica. This was because the rental costs of a tractor or cutter were lower and because of the use of oxen instead of tractors by about half of the farmers in Honduras.

Furthermore, silage-using farmers in Costa Rica used more expensive management practices than farmers in Honduras: (a) almost every interviewed farmer in Costa Rica used herbicides, while in Honduras just about half of farmers applied it, (b) farmers in Costa Rica applied more seed (24 kg/ha vs. 19 kg/ha) and (c) farmers in Costa Rica used higher amounts of fertilizers per hectare (386 kg/ha vs. 226 kg/ha in Honduras). In addition, the yield (mt/ha) of silage was lower in Costa Rica (Table 86). Therefore, the costs, which were independent of the quantity of silage (like costs of cleaning the land) were more expensive than in Honduras.

Table 88. Costs of silage.

	Honduras (n=7)	Costa Rica (n=7)
Costs of making silage		
Labour costs ($/mt)	6.32	23.57
Machinery costs ($/mt)	3.73	7.82
Other costs ($/mt)	6.43	14.24
Total costs ($/mt)	16.48	45.63
Total costs as DM ($/mt)	47.08	130.37
Costs of feeding silage ($/head/day)	0.21	0.33
Costs of feeding silage ($/farm/year)	511.56	565.19

All costs are expressed in US dollars.

Hay. In Table 89 we show the costs of making hay in Honduras and Costa Rica ($20/mt and 39/mt, respectively). The higher cost of producing hay in Costa Rica was due to the high machinery costs. The rent of machinery for baling (with labour costs included) was more expensive in this country. Two farmers in Honduras did not bale the hay, but stored it as a heap, which was a cheaper option than baling. Comparing the costs of silage and hay, it appeared that in the case of hay the machinery costs were much higher. This was because labour costs were (in almost all cases) included in the rental costs of machinery. On the other hand, other costs were lower for hay production. This could be explained by the use of improved pastures. Farmers didn't need to buy seed and didn't use herbicides, which were necessary for silage.

Comparing figures in Tables 88 and 89 revealed that in Honduras the cost of producing silage was higher than the cost of producing hay (i.e. $47/mt DM vs. $23/mt DM). The feeding costs were lower when hay was fed (i.e. $0.19/cow/day vs. $0.21/cow/day), although the amount fed was higher (i.e. 6.2 kg DM/cow/day vs. 4.1 kg DM/cow/day). In Costa Rica, the cost of producing hay was lower than the cost of producing silage (i.e. $44/mt DM vs. $130/mt DM). The feeding costs were lower when hay was fed (i.e. $0.19/cow/day vs. $0.33/cow/day), although the amount fed was higher (i.e. 4.4 kg DM/cow/day vs. 2.7 kg DM/cow/day). Thus, these data demonstrated that, both in Honduras and Costa Rica, feeding hay was cheaper than feeding silage.

Benefits from feeding hay and silage

Based on the increased milk production or the maintained body weight and the prices of milk or beef, the net income and net benefit due to feeding hay and silage were calculated. In Tables 90 and 91 these benefits are given. As described before, due to higher amounts of silage fed in Honduras, farmers obtained a higher increase in milk yield. Additionally, profits from milk were higher in Honduras due to higher milk prices (i.e. $0.29/lt vs. $0.24/lt in Costa Rica). Therefore, as shown in Table 90, the net income due to feeding silage was higher in Honduras than in Costa Rica (i.e. $0.93/cow/day vs. $0.52/cow/day). The same was true for hay (Table 91). Farmers in Honduras fed more hay and therefore, obtained a higher increase in milk yield. Consequently, the net income due to feeding hay was also higher in Honduras than in Costa Rica (i.e. $1.16/cow/day vs. $0.35/cow/day), although it has to be mentioned that the net income due to feeding hay

Table 89. Costs of hay.

	Honduras (n=6)	Costa Rica (n=2)
Costs of making hay		
Labour costs ($/mt)	13.67*	NA
Machinery costs ($/mt)	13.05	34.6
Other costs ($/mt)	5.01	4.37
Total costs ($/mt)	20.34	38.94
Total costs as DM ($/mt)	23.11	44.25
Costs of feeding hay ($/cow/day)	0.19**	0.19
Costs of feeding hay ($/calf/day)	0.03**	
Costs of feeding hay ($/farm/year); cows	447.69**	990.65
Costs of feeding hay ($/farm/year); calfs	61.99**	

All costs are expressed in US dollars.

*n = 1

**n = 3

NA = Not Available. Labour costs are included in the rental cost of machinery

Table 90. Benefits from feeding silage.

	Honduras (n=7)	Costa Rica (n=7)
Milk		
Price of milk in dry season ($/lt)	0.29	0.24
Income from milk without silage ($/cow/day)	1.83	0.36*
Income from milk with silage ($/cow/day)	2.76	0.88*
Net income due to feeding silage ($/cow/day)	0.93	0.52*
Net income due to feeding silage ($/farm/year)	3318.30	725.93*
Income:cost-ratio	6.1	1.6
Net benefit due to feeding silage ($/cow/day)	0.72	0.20*
Net benefit due to feeding silage ($/farm/year)	2806.74	512.03*
Beef		
Price of cow meat ($/kg)	1.14?	0.9??
Price of calf meat ($/kg)	1.2?	0.94??
Income loss due to not feeding silage ($/head/day)		0.68**
Net income due to feeding silage ($/head/day)		0.68**
Net income due to feeding silage ($/farm/year)		1485**
Benefit:cost-ratio		2
Net benefit due to feeding silage ($/head/day)		0.45**
Net benefit due to feeding silage ($/farm/year)		1052.07**

All costs are expressed in US dollars.
*n = 5
**n = 2

in Costa Rica was based on just one farmer, therefore, this number was may not be representative.

Farmers in Honduras fed more hay to their milking cows than silage. Therefore, farmers realised a higher increase in milk yield and, as Tables 90 and 91 show, a higher income due to feeding hay (i.e. $1.16/cow/day vs. $0.93/cow/day). In Costa Rica the silage-using farms achieved higher increases in milk yield than the hay-using farmer, which resulted in a higher income (i.e. $0.52/cow/day and $0.32/cow/day, respectively).

As shown in Table 90, the income-cost ratio of feeding silage [net income ($/cow/day) divided by total costs ($/cow/day)] of farms with milking cows was positive in both countries; 6.1 and 1.6 respectively. Also the net benefit due to feeding silage [net income ($/cow/day) minus costs ($/cow/day)] of farms with milking cows was positive in both countries; $0.72/cow/day and 0.20/cow/day, respectively. This indicated that feeding silage to milking cows was profitable in both countries. In Honduras, the lower production cost and the higher net income explained the higher income-cost ratio and net benefit on farms with milking cows compared with Costa Rica. In addition, due to the higher amount of milking cows fed during more months, the net annual benefit due to silage was much higher in Honduras than in Costa Rica ($2,807/farm/year and $512/farm/year, respectively). This same scenario was true for the case of hay in both countries (Table 91). Comparing Tables 90 and 91 revealed that in Honduras the income-cost ratio of hay was higher than of silage (i.e. 9.1 vs. 6.1). Also the net benefit due to feeding hay was higher (i.e. $0.97/cow/day vs. $0.72/cow/day). Therefore, the annual net benefit from feeding hay (i.e. $6,885/farm/year) was higher than from silage (i.e. $2,807/farm/year) and appeared therefore to be more profitable. Thus, the low adoption rate of the use of hay in Honduras, as described before (2% vs. 16% of silage, Table 86), seemed not logical.

Table 91. Benefits from feeding hay.

	Honduras (n=6)	Costa Rica (n=2)
Milk		
Price of milk in the dry season ($/lt)	0.29	0.24
Income from milk without hay ($/cow/day)	2.06**	0.75*
Income from milk with hay ($/cow/day)	3.22**	1.10*
Net income due to feeding hay ($/cow/day)	1.16**	0.35*
Net income due to feeding hay ($/farm/year)	7684.80**	945*
Income:cost-ratio	9.1**	1.9*
Net benefit due to feeding hay ($/cow/day)	0.97**	0.17*
Net benefit due to feeding hay ($/farm/year)	6884.90**	419.85*
Beef		
Price of cow meat ($/kg)	1.14?	0.9??
Price of calf meat ($/kg)	1.2?	0.94??
Income loss due to not feeding hay ($/head/day)	0.28**	0.45*
Net income due to feeding hay ($/head/day)	0.28**	0.45*
Net income due to feeding hay ($/farm/year)	1220.40**	3240*
Benefit:cost-ratio	16.59	2.2*
Net benefit due to feeding hay ($/head/day)	0.25**	0.24*
Net benefit due to feeding hay ($/farm/year)	1158.41**	1751.76*

All costs are expressed in US dollars.
*n = 1
**n = 3

A comparison within Costa Rica revealed that the income-cost ratio of hay was higher than of silage (i.e. 1.9 and 1.6, respectively), although the net benefit due to feeding silage was higher (i.e. $0.20/cow/day vs. $0.17/cow/day) due to the fact that the interviewed silage-using farms in Costa Rica were all low-milk yielding farms, while the hay-using farmer realised a higher milk production. Because silage-using farmers fed this feedstuff to more cows, their net benefit ($/farm/year) was higher than the net benefit ($/farm/year) of hay-using farmers ($512 and $420/farm/year, respectively). Again, it has to be mentioned that the net benefit due to feeding hay in Costa Rica was based on just one farmer; therefore, this number may not be representative.

In the case of beef production, in Honduras, the net income and net benefit due to feeding hay were $0.28/calf/day and $0.25/calf/day. The income-cost ratio was 16.6. In Costa Rica the net income and net benefit due to feeding silage were $0.68/cow/day and $0.38/cow/day and due to feeding hay were $0.45/cow/day and $0.24/cow/day. The income-cost ratio was 2 in the case of silage and 2.2 in the case of hay. These results indicate that feeding silage in Honduras and hay or silage in Costa Rica to young and mature non-milking animals was profitable.

Market potential

Hay. All interviewed farmers in Honduras and Costa Rica suspected that other producers were willing to buy the surplus of hay. Except for one farmer in Honduras, all farmers knew the selling price. On average, this was more than twice the price of producing it; $47/mt in Honduras and $94/mt in Costa Rica. This indicates that farmers were aware of the market value or their hay. In Costa Rica, actually, the two interviewed farmers sold hay to neighbours. In Honduras, the adoption rate of hay was low. However, the income-cost ratio and net benefit due to feeding hay was higher than silage, which possibly will bring along a increased demand, higher adoption rate and the development of a market. However, at this moment, just informal sales on very small scale occurred.

In Costa Rica, the adoption rate of hay, compared with silage, was high. Since many years, bales of hay mostly from rice straw or from "Transvala"grass (ie., *Digitaria decumbens*) had been marketed. In most cases, the demand, and not the quality and price, played an important role.

The ministry of Agriculture and Livestock of Costa Rica developed, in cooperation with agriculture organisations, a program to stimulate the production and sale of high quality hay. Possibly, due to this program, the hay market will expand in Costa Rica. Currently, the development of a national market for hay is also part of a project of the Instituto Nacional de Innovación y Transferencia de Tecnología Agropecuaria (INTA). The development of this market is based on auctions, where hay with different prices, which reflect different qualities, is auctioned and sold to the higher bidder. In April 2005, the Asociación de Productores Agroindustriales de Bagaces (APAIB) held the first auction in Costa Rica, where six farmers sold hay (between 150 and 250 bales per farmer). The hay was classified in three different qualities with prices ranging from $0.11/kg for the highest quality (i.e. 9% CP and 55% DIVMS) to $0.08/kg for the lowest quality (i.e. 4% CP and 35% DIVMS). The APAIB intends to have another auction in February 2006, with 5 different types of qualities and corresponding prices and with a higher amount of hay.

Silage. All farmers in Honduras and Costa Rica assumed they could sell an excess of silage to other producers. However, farmers didn't have a surplus and therefore didn't sell it. Most of the silage-producing farmers didn't know the selling price. It appeared that neither in Honduras nor in Costa Rica existed a market for silage. This was possibly due to the fact that it is cumbersome to transport, which makes it difficult to market. Introducing the little bag silage technology seems promisory as this constraint can be solved.

In Honduras the adoption rate of silage was higher than hay. However, the income-costs ratio and net benefits due to feeding hay were higher. This meant that the use of hay was more profitable. Therefore, the adoption rate and demand for hay may increase in the future at the expense of silage.

In Costa Rica, although the use of silage was profitable, its adoption rate was low. Opposite to the efforts which are made to develop a market for hay, no attempts are made to develop a market for silage.

4.5 Adoption of forages-based technologies in Central America

Highlights

- Documented that in positive deviance farms (successful adopters) included in a survey it is posible to maintain or even increase milk yield in the dry season with proper feeding strategies.

- To assist in the extrapolation of results the interrelation of spatial factors with pathways of decision-making among farmers is being analyzed along an altitudinal gradient in Olancho, Honduras.

- The adoption of cowpea in a reference site in Honduras has been low, mainly due to lack of seed and lack of market for the grain and fodder.

- The prototype EMPRASEFOR former-led seed company in Honduras expanded the seed plots by 70% as a result of an alliance with a large seed company who will purchase the seed at an agreed price.

- The farmer group EMPRASEFOR has joined its formal enterprise.
- Baseline data for farming systems analysis available for most tipical climatic zones of Olancho.

4.5.1 Potential for adoption of forage-based technologies in representative climatic zones of Honduras: Base line study

Collaborators: P. Lentes, M. Peters, D. White (CIAT), F. Holmann (CIAT-ILRI), and C. Burgos (DICTA)

Rationale

Farmers in Honduras located in areas with a prolonged dry season face severe animal nutrition problems. The length of the dry season, up to 8 months in the driest parts of the country, is roughly equivalent with the period of forage shortage in the typical Honduran farm. Thus, in many small and medium size farms, milk production ceases during most of the dry season. Livestock malnutrition increases risk of animal losses and diseases and decreases performance in meat production and in reproduction.

Despite widespread awareness among farmers concerning dry season forage shortage and low livestock productivity, few farmers have adopted multipurpose forage-based technologies. By adopting one or several options out of the available range such as drought tolerant germplasm or forage conservation technologies, farmers can overcome fodder shortages period and eliminate forage shortage in the long term in a sustainable way. Initial adoption may start on a small scale e.g. by dedicating a small investment to plant an improved grass and a shrub legume. The benefit gained from this can be used for a stepwise increase of the area of improved grasses. Once improved grasses are available, their conservation as hay or silage could be the next step to eliminate forage shortage.

The underlying reasons for the decision to adopt improved forages can be many: the socio-economic situation of the farms, and non-economic reasons of decision-making, such as traditions, different ways of seeing the problem and potential solutions. The assessment and comparative socio-economic analysis of bottlenecks and opportunities for adoption of improved forage will give an insight on principles and pathways to introduce feeding systems into smallholder farms.

In the analysis, a ‘typical farmer’ and the early or successful adopters (positive deviances from normality) are considered in two separate groups to enable researcher to potentially identify enabling conditions and actions required for the adoption of forage technologies.

Materials and Methods

The potential for adoption of multiple purpose forage-based technologies in representative climatic zones of Honduras is being assessed by means of a financial farming systems analysis. A comprehensive socio-economic data collection must take into account the diverse structures of farms and how livestock holders use wide a range of feeding strategies. A holistic farming systems approach is most suitable to assess decision making of farmers and to assess possibilities for adoption of multi purpose forage options.

In some farms, feeding strategies may include native pasture and crop-residue grazing, silage, hay, cut-and-carry forages, and purchased inputs. Other farms may only rely on native pasture. In addition, farmer’s decision making usually depends on more factors than livestock and livestock feeding alone, such as for example availability of resources like land, labor, cash and food security. To define which areas of the farming systems had to be included in the data collection, a contextual analysis was carried out in which we looked at dry season problems and areas of the farm are important for income generation.

In order to develop a feasible and cost-effective survey instrument, the contextual analysis used participatory methods in areas with a prolonged dry season of Yoro, Olancho and Danli where small and medium farms prevail. For socio-economic data collection, a standardized questionnaire and database structure was developed, adapting and extending existing material to the requirements of this survey. After the pre-testing phase, the questionnaire was improved with field results and the database was constructed. Sampling was done in two distinct stages following the objective of a comparative analysis between adopters and the typical conditions found in each of the zones. Two separately selected samples were chosen:

a) Through randomized data collection in several sub study areas, the typical socio-economic situation of the farmers in the area is assessed and
b) A separate sample is selected, using expert knowledge in order to find successful examples of adopters and reasons for adoption.

To assess the economic conditions of the representative livestock holder, the sampling was done in a randomized way. In several sub study areas, spread over Olancho, the farmers were selected randomly from the total population of farmers. After the elaboration and testing of the survey instrument, detailed sampling activities were started in Olancho in two blocks: a) Collection of representative data in 5 sub study areas representing altitudinal and ecological change, as well as a distance gradient from the province capital. b) assessment of positive deviances by means of targeted sampling.

Targeted sampling is done employing expert knowledge from partner institutions, like DICTA (Dirección de Ciencia y Tecnología Agropecuaria). Additional farms were identified asking farmers whom they know that was already using forage conservation or another forage technology in the area. This was in order to effectively search for farms that already have adopted one or several of the improved feeding strategies for milking cows.

The data were checked for their correctness and formula were developed for the calculation of parameters. Results were analyzed statistically, using non parametric tests.

Results and Discussion

Being a recently initiated activity (running since May 2005), many of the result presented indicate tendencies rather than final results.

In the frame of the contextual analysis information was collected informally (in the provinces of Yoro, El Paraiso and Olancho) to gain a basic understanding of the how farming systems work in different areas and which problems farmers perceive as most important. Much of this work was done in conjunction and complementary with other activities such as participatory assessment of problems and objectives with farmer groups, taking advantage of group trainings on dry season forage conservation techniques (hay and silage). An important objective of this investigation was to obtain detailed knowledge about dry season-problems on the farms, as perceived in the different regions by the livestock producers. In the view of farmers, the key problems in all zones is feed shortage, water shortage, drought and low milk production. More explicit results of this activity are presented in Section 4.2 of this report.

Semi-structured interviews with individual farmers revealed, that livestock production is one of many components in income generation. With the priority of family food security and risk management, small and medium size cattle farms rely on the production of basic grain (maize and beans) for home consumption and to cash income generation. Thus both, the livestock and cropping system components of the farming system needed to be included in the survey. Further, characteristics of the family and institutional aspects were parts of the structured survey. Farm decisions are made based on the whole situation of the family and thus each activity can be influence the allocation of resources in the farm. The same holds for the capability to invest in new forage options.

The survey in Olancho covered 66 randomly selected farms in 5 different zones of the province and was complemented with targeted sampling of 5 successful adopters of improved forage based technologies. There is a wide range of livestock herd sizes and production strategies found within the five zones. To facilitate the comparative analysis of livestock production, the farms were classified according to farm size. In this case, the approach of Fujisaka et. al (2005) was employed for the classification of farm sizes using the number of cattle heads for differentiation: small (1-12 head of cattle), medium (13-70), and large (>70).

To get an initial insight, the analysis focused on differences in milk production between the dry and the wet seasons and between farm sizes (Table 92). Out of 66 interviewed farmers, 12 do not produce milk in the dry season. This is distributed as follows: Of the medium producers, 8 farmers (22 %) did not produce milk in the dry season, of the small producers, 3 farmers (20 %) cease milk production and of the large producers only one case (6.6 %) did not produce milk in the dry season, respectively.

The reasons to stop milk production in the dry season as indicated by the farmers are the lack of pasture and conserved forage. Two farms did not produce milk in the wet season. Asked for the reason, they said there would not be enough forage available in pastures even during this time. One farm did not produce milk at all, although 5 milking cows were available. In this case, the milk was used to feed the calves.

Results on milk yield per cow in the dry and wet season between the different farm sizes indicate that there is no large difference in the intensity of milk production between small and the medium producers. Also the difference in milk yield per cow was found not to differ significantly between the small and large producers.

The hypothesis of farm size having no effect on milk yield is rejected (with a probability of >95 % according to Mann-Whitney test) when dry season milk yield of medium size and large size

Table 92. Daily milk production for the dry and wet season in conventional farms of different sizes, Olancho (2005).

Herd size		Livestock head	Dry season, Cows in milk	Wet season, Cows in milk	Dry season, milk per cow (l)	Wet Season, milk per cow (l)
Small 1-12 head 22.70%	Mean	7.1	1.9	2.6	3.6	5.3
Total n = 15	SD	2.4	1.4	1.1	2.3	3.1
Medium 13 - 70 head 54.50%	Mean	32.5	7.4	9.4	3.9	4.6
Total n= 36	SD	17.8	6.5	5.5	1.5	1.7
Large > 70 head 22.70%	Mean	182.5	37.4	37.5	2.8	4.7
Total n = 15	SD	102.8	22.1	20.5	1.4	1.9
Total 100%	Mean	60.8	13.0	14.4	3.6	4.8
Total n = 66	SD	83.5	17.6	16.9	1.7	2.2

farms is compared. Average milk production per cow in large size farms is 1.1 liters lower than in medium size farms, although it is nearly the same in the wet season. Mean wet season milk production of small producers is highest, but the high variability observed in the sample for this parameter did not allow to pick up statistical difference with the other the groups. These differences show that the importance of production per animal declines as the herd size increases.

In the dry season, the milk prices only differ (probability > 95 % according to Mann-Whitney test) between the small and the large farms. This is due to a higher milk price obtained by the small farmers, who often market their milk directly in the village without intermediaries. For the large producers, the comparatively lower milk price obtained in the dry season and the slightly higher milk price in the wet season reflects the smaller amplitude in milk prices for this group during the year. Some of them possess long-term contracts with the milk processing industry, which are usually available for members associations called CREL. The wet season milk price of the medium size farms is significantly lower than the price of the small farms (probability of >94%) and the price from large farms lower (probability of > 90 %) than that from the other two groups.

In Table 93 we present figures for gross revenue from milk as affected by farm size and season of the year. It should be noted that these figures do not represent net income, because they were calculated without consideration of production cost. Detailed income analysis is forthcoming. Nevertheless some comparisons are given here in order to identify tendencies.

Large and medium size farms showed differences in monthly revenue per cow between dry and wet seasons (probability of >96%). While the dry season revenue of the medium size farms was higher than in large farms, the situation is contrary during the wet season. Small farms have the highest mean revenue per cow in the wet season, but with a high variability within the group.

Table 93. Dry and wet season milk revenue and prices for conventional farms of different sizes, Olancho (2005).

Herd size		Dry season, monthly revenue/cow	Wet season, monthly revenue /cow	Dry season milk price	Wet season milk price	Improved pastures
		Lps	Lps	Lps/l	Lps/l	% of farm area
Small 1-12 head 22.70%	Mean	552.5	614.2	5.1	3.9	41.7
Total n = 15	SD	349.0	377.0	0.4	0.9	41.4
Medium 13 - 70 head 54.50%	Mean	584.6	443.2	4.9	3.4	55.7
Total N= 36	SD	229.2	205.4	0.4	0.6	37.0
Large > 70 head 22.70%	Mean	401.8	503.6	4.7	3.7	67.2
Total N = 15	SD	209.8	175.3	0.5	0.6	30.4
Total 100%	Mean	532.5	498.3	4.9	3.5	55.1
Total N = 66	SD	262.7	256.3	0.4	0.7	37.2

Note: Monetary units in Lempira (Lps); 1 USD is approximately 19 Lps.

On average, small and large farms experience income losses during the dry season, which was not observed on the average medium farms, but the variability in this group is high. Differences in the availability of improved pastures between the groups contribute to a high variability in the sample, although the use of improved pastures increases with farm size. For a complete analysis of pasture use, data on the areas of each variety were collected and will be analyzed further on.

The analysis of farms included in the positive deviances is based on a very small sample size, thus results in Tables 94 and 95 need to be interpreted with care. Of the five sampled farms, 2 are medium size and 3 are large. The number of milking cows differs only slightly between the seasons for the whole group, a feature that reflects better dry season forage availability. The share of improved pastures is high in this innovative group (82 %), as compared with the conventional farms (37 %).

In the conventional farms the dry season milk production is generally lower than in the wet season. The reduction in milk yield due to the dry season is 1.7, 0.7 and 1.9 l/day for small, medium and large farms respectively. In the non-conventional (positive deviance) farms, an average increase of milk production of 1.4 l could be found between dry and wet season.

The increase of milk production in the dry season relative to the well season in the positive deviances farms (Table 94) shows the potential impact dry season forage management can bring to farmers.

This difference is likely due to a better dry season forage management. So the first lesson learned from the positive deviances is that it is possible to maintain or even increase milk production in the dry season. This is potentially interesting from the financial point of view, because of the current differences in the milk price between seasons.

In the dry season, the monthly revenue per cow in the positive deviances farms is nearly 2.5 times greater than the one of conventional farmers. Differences were also observed with daily milk yield per cow, which is 2.6 times higher in the dry season and about 1.5 times higher in the rainy season than revenues obtained in the typical farm.

The decrease in income from milk was very variable among conventional farms. The small farms lose about 10 % of their revenue in the dry season (Table 93). Although production of the medium size farms drops by 0.7 l per cow in the dry season and the number of cows milked is lower in the dry season, their revenue rises by 31 % as compared to the wet season. The large farms experience the highest percent losses of revenue from milk in the dry season (20 %). A striking difference could be found for the positive deviances.

These farms prepare themselves for the long dry season and have about 80 % more revenue in the dry than in the wet season. The monthly revenue per cow in the dry season is 590 lps (about 31 US$) higher than in the rainy season in the case of the farms in the positive deviances group.

Table 94. Daily dry and wet season milk production in farms included in the positive deviances analysis, Olancho (2005).

Positive deviances N = 5	Livestock head	Dry season, milking cows	Wet season, milking cows	Dry season, milk per cow (l)	Wet Season, milk per cow (l)
Mean	99.6	24.8	25.6	8.5	7.1
Standard desviation	60.0	16.6	15.7	4.0	3.9

Table 95. Dry and wet season milk revenue and prices of positive deviances, Olancho (2005).

Positive deviances N = 5	Dry season, monthly revenue/cow	Wet season, monthly revenue / cow	Dry season milk price	Wet season milk price	Improved pastures
	Lps	Lps	Lps/l	Lps/l	% of farm area
Mean	1326.1	735.3	5.2	3.4	81.7
Standard desviation	655.2	421.8	0.3	0.4	26.1

Note: Monetary units in Lempira (Lps), 1 USD is approximately 19 Lps

4.5.2 Socio-economic factors associated with livestock/forage farming systems in Honduras: spatial variation

Collaborators: P. Lentes, M. Peters, D. White, T. Oberthur (CIAT), F. Holmann (CIAT-ILRI), and C. Burgos (DICTA)

Rationale

Within the on-going project led by CIAT entitled "Understanding and Catalyzing Learning-Selection Processes of Multi-Purpose Forage based Technologies in Central-America" in collaboration with DICTA (Dirección de Ciencia y Tecnología Agropecuaria), numerous socio-economic and non-economic factors change along spatial gradients. Such gradients may describe differences in farm types in two directions: (a) from the valley bottom to the top of the mountain, and (b) from areas with good infrastructure to remote areas. Another possibility of a gradient could be the description of gradual change of environmental characteristics between zones of farm types and land use.

Gradients generally can serve for the regionalization and scaling of socio-economic data that are usually collected for specific locations. The characteristics of farms and conditions for farming usually do not change abruptly but follow a continuum of change e.g. market distance or climatic conditions. Reasons of decision making in the farms and possibilities for adoption of multi purpose forage options are different between regions. This variation limits scaling of results from surveys that do not consider geographic factors in sampling. Since farming systems are to a great extent dependent on geographical site conditions, gradients are in this case used to establish relations between socio-economic conditions in the area and spatial factors.

The gradient or transect approach is used to consider the geographic characteristics of the study areas. Thus the plan is to scale results from other areas of investigation (socio-economics and learning selection). In doing so, social and spatial sciences provide means to detect similarities between regions. The knowledge gained in one region may then be transferred to a similar region. Using GIS as a tool to detect congruent features between regions, information can be extrapolated, constructing and using specific regionalization models. This enables a wider coverage of the information gained from socio-economic surveys, which have to be more or less punctual. Extrapolation of socio-economic factors to areas where no survey was done have the advantage of lower cost and workload. Regionalization models allow the estimation of future development on regional scale, considering both, spatial and socio-economic aspects.

Material and Methods

A focal area of our investigation in CA is to assess the interrelation of spatial factors with the pathways of decision-making processes among farmers from a geographical point of view. Along a transect line, principal zones are defined. Within these zones socio-economic interviews are conducted, using random sampling to cover the typical conditions of farmers for each zone. The exact location of each surveyed farm is measured using GPS. In order to scale this information of individual farms to the area of the village, interviews with key persons or village and communal level statistical data are required. GIS data are used to define the spatial parameters for the linkage of the empirical data with regionalization models.

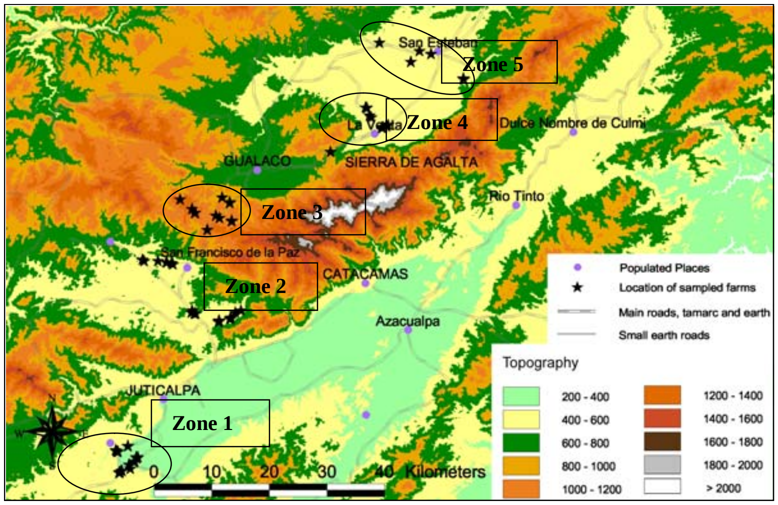
From June to September 2005 socio-economic surveys were conducted, using a transect approach at the same time. In Olancho, data collection covered 66 farms from 5 different zones along an altitudinal gradient that was selected to cover as much as possible the ecological conditions prevailing in the region. The survey includes small, medium and large-scale animal holders. Amongst them there are adopters of new technologies as well as non-adopters. Economic parameters (e.g. income, gross margins and milk production parameters) were calculated in order to compare groups and to identify and understand driving forces and main determining variables for the adoption process.

In the section 4.5.1 of this report the data were interpreted according to herd sizes. Information obtained from conventional farmers and those who already adopted multi purpose forage options was compared. In this section, the results are interpreted according to geographical zones. Field visits to the zones of interest were carried out to define interesting and representative areas for data collection and to define the course of the transect in the main study areas. In order to obtain a representative cut through Olancho, the characteristics of each major climatic zone were discussed with experts from the collaborating institution DICTA, using a map to localize the areas. From their experience, similar regions were defined and for each of this regions a parallel region was selected along the transect. Criteria for the definition of regions were the length of the dry season, the prevailing farm sizes and similar altitudinal and slope conditions. Some compromises were necessary in order to avoid dangerous areas and to keep work feasible, the area east of Catacamas, where the dry season is comparatively short, was excluded.
In Olancho, the transect line follows an altitudinal gradient, that begins in the valley around Juticalpa (zone 1). To leave the valley of Guayape river, a side road between Juticalpa and Catacamas was selected and interviews were conducted along the course of the road and following side roads. The transect takes course up the mountain through the municipality of San Francisco de la Paz (zone 2), that covers the intermediate area around 500 to 550 m.a.s.l. and further up to the municipality of Gualaco (zone 3), crossing a pass of about 1200 m.a.s.l.. The transect goes down to an intermediate zone (4) again. At about 94 km from the crossing at the main road from Juticalpa to Catacamas, the dirt road reaches San Esteban (zone 5) with its large-scale cattle farms again in a waste plain (Map 1).

Results and Discussion

In Table 96 we present the differences in the dry season length and the periods of forage shortage for the selected zones. Along with the altitudinal gradient goes a moisture gradient. Several factors more, including the adoption of dry season forage options and soil properties influence the length of the forage shortage period.

To assess the effect of feed shortages on livestock production, milk yields were estimated for each of the zones (Table 97). The number of animals per farm is higher in the two zones far away from the main road (probability > 95 % according to Mann-Whitney test). While the valley around Juticalpa (zone 1) and the intermediate area around San Francisco de la Paz (zone 2) have comparable farm sizes. Zone 3 shows the lowest number of animal heads. This is due to the more diverse structure of farms in the area on the mountain, where coffee is grown and generates additional cash income. In the zones 4 and 5, where the land price drops, as compared to zone 1, the farms are larger in area and possess more livestock.



Map 1. Zones of principal investigation, Olancho
Data sources: CIAT (1999): Atlas de Honduras- Datos Mitch, (Versión Beta – Enero 1999) , CGIAR - Consortium for Spatial Information (CGIAR-CSI) (2004)

Table 96. Farmer´s perception of dry season and forage shortage length in Transect zones, Olancho (2005).

Zone	Months of dry season	Months of forage shortage
1	5.5	3.5
2	5.3	3.9
3	2.7	1.5
4	4.6	3.1
5	5.0	3.7

On the top of the mountain the shorter dry season and the favorable conditions of forage availability result in a better milk yield per cow in the dry season. Zone 3 clearly exceeds milk yield as compared to the other areas (probabilities > 90 % for zones 1, 2 and 4). The intermediate type zone 4, where herd size is comparatively large shows the lowest milk production per cow in the rainy season (probability > 95 % for zones 1 and 3). The difference in milk prices also shows a spatial trend. In the dry season, the milk price is higher in zones 1, 2 (probability > 95 %) and 3

Table 97. Milk production and milk prices in the dry and wet season in the zones along Transect, Olancho (2005).

Region		Livestock head	Dry season, milk per cow	Wet season, milk per cow	Dry season milk price	Wet season milk price	Improved pastures
			l	l	Lps/l	Lps/l	% of farm area
Zone 1	Mean	42.57	3.52	5.01	4.98	3.39	46.44
	SD	57.55	1.69	2.20	0.29	0.46	37.39
Zone 2	Mean	50.21	3.54	4.72	5.06	3.50	38.73
	SD	71.50	1.11	1.63	0.38	0.82	34.57
Zone 3	Mean	30.33	4.98	5.99	4.94	3.78	63.32
	SD	28.43	1.85	3.06	0.58	0.94	36.59
Zone 4	Mean	93.00	3.06	3.42	4.83	3.36	88.31
	SD	104.94	1.96	1.05	0.50	0.54	20.44
Zone 5	Mean	162.50	3.01	4.71	4.38	4.17	78.15
	SD	144.52	2.02	2.39	0.33	0.08	23.99
Total	Mean	60.88	3.62	4.82	4.92	3.54	55.11
	SD	83.52	1.74	2.15	0.43	0.68	37.16

(probability > 90 %), as compared to zone 5. The wet season milk prices also differ between the same areas (probability > 95%). But in the wet season the milk price in zone 5 is higher. This can be explained by the presence of CRELS in zone 5. These associations offer long-term contracts with stable milk prices between the seasons, an advantage that is also felt in zone 5 and 4, where herd sizes are greater.

4.5.3 Learning selection processes on the use of different forage based options

Collaborators: P. Lentes, M. Peters, D. White, B. Douthwaite (CIAT), and C. Burgos (DICTA)

Rationale

As mentioned in the section 4.5.2 of this Report, learning selection, socio-economics and spatial conditions are interrelated. The research we are carrying out adopts the learning selection view of innovation (Douthwaithe 2003) in which "people engaging in an innovation process experiment and generate novelties (i.e., adaptations) through experimental learning. They make sense of these novelties by internal reflection and talking to colleagues, neighbors and friends. They then choose to continue to use the novelty, or not. At the same time they will influence others who are going through their own learning selection cycles. The net result is a continual process of novelty generation, selection and promulgation that improves the "fitness" or adoptability of the technology. As the adoptability improves more people adopt.

Four phases in the innovation process can be used in the context of multi purpose dry season forage options: (a) Development phase, (b) Start-up phase, (c) Adaptation phase and (d) Expansion phase. The combination of learning selection with socio-economics and thus the use of different methodologies makes it possible to assess the decision making of farmers from the economic point of view and simultaneously consider non-economic factors. This combination is believed to be of great value in the case of small scale and often mixed farming systems in zones with prolonged dry season forage shortage in Honduras. Usually small-scale farmers are constrained by low availability of resources and low levels of education and training for the utilization of multi purpose forage options.

Another main point of interest is the assessment of a learning selection processes to get to know farmers' pathways to get out of dry season forage shortage and to learn more about bottlenecks of adoption of forage-based technologies as a response to these constraints in Honduras.

The identification of bottlenecks and chances for adoption of multipurpose dry season forage, options for first time users and for advanced users has to be analyzed in order to define which difficulties can be eliminated. The bottlenecks of adoption differ between the replication cycles of learning. A range of typical bottlenecks of first time users can be defined for each technology option and by a process of adaptation. By adapting first time users farmers improve the technology and make it more viable for others.

Materials and Methods

Two approaches are being used to analyze the learning selection processes:

a) New farmers: initiation of contacts and introduction of specific best bet technologies (hay, silage, improved grasses, forage legumes) through training events.

b) Positive deviances farmers: group of farmers already applying multipurpose forage options are identified. These farms also serve for the assessment of technology spread from early adopters to more farms.

Among both groups of farmers, we will analyze how adoption takes place, which phases of adoption can be distinguished and how adaptation of technology works. Research questions like the following are to be answered.

Questions:

- What are the benefits of the technology from the point of view of the adopters?
- Which stages of the learning process can be distinguished in the regions covered by the study (Yoro, Olancho El Paraiso)?
- What are the characteristics of the adopters?
- Can there be principles derived from these characteristics?
- What were the circumstances under which the positive deviances adopted?

The following hypothesis will be tested during the course of the study:

- When farmers start adopting one of the multi purpose forage options, the chances are high that they continue adopting other options in the future or increase the use of the first option.
- A good entry point for the introduction of the whole package can be one specific forage option that is easy to start with.

Results and Discussion

During field training on forage conservation technologies, which served for the collection of socio-economic information, first contacts with farmers were established in Olancho. Farmers were instructed on how the information they provide was going to be used and that the possibility of training on e.g. hay, silage and improved grasses and legumes was available from CIAT and DICTA. This procedure served as a good starting point for the establishment of good working relations with farmers.

The intensive contact during the interviews created an interest and awareness among the farmers. Many of persons interviewed expressed their interest in training, they knew what all the questions were about. At the end of the interviews, an open discussion was usually conducted with the farmers, in which they asked questions back. At a later stage, these farmers were invited for training on hay and silage preparation. The introduction of more technology options is planned with these groups. Follow up visits with individual farmers and the facilitation of experience exchange in the form of group discussions will bring insight on adoption and adaptation processes. This is necessary to facilitate and enhance the application of technology and to get to know which obstacles farmers face and what they actually do with the introduced technologies. Since the socio-economic situation of the farmers trained was already assessed in base line surveys, it will be assessed for interrelations between adoption and socio-economic factors.

In Olancho, two training events were organized for focus groups defined by the sample of the socio-economic survey: (a) one for the group from the valley area around Juticalpa (27 participants) and (b) one for the group of farmers from the area of San Francisco de la Paz (25 participants) (Photo 38). Farmers were invited personally with a flyer that addressed the problem, objective, and the topics of the training. The possibility to invite more interested farmers was offered to each person. The training was conducted at a prototype farm, where improved grasses and forage legumes are cultivated.
In the group of the valley, some farmers already had experience with GOs and NGOs that offer training, while the second group did not have this experience. Many families in the valley receive remittances from their children that migrated to the US. This creates a dependency on money transfers, which may reduce motivation to change dry season feeding strategies. Young and middle age farmers were more interested in the training events. A possible explanation could be that older farmers are less motivated in trying out new options. In general, the group from San Francisco de la Paz was more interested and curious. This was already noticed during data collection.

(a) (b)

Photo 38. Farmer during events (a) hay production and (b) silage production using plastic bags.

For the training, a DICTA (Dirección de Ciencia y Tecnología Agropecuaria) prototype farmer was ready to host the groups for the two days. This farm was selected because it offered the possibility to include practical examples in forage conservation. The content of the training events carried out was designed to give the farmers an overview on several options that were identified as their points of interest during the survey when they were first contacted. These included:

1. Welcome and introduction of the objectives of the workshop
2. Presentation of results from farming systems survey in Olancho
3. Improved pastures as a forage crop, requirements on soils and climate, advantages and disadvantages
4. Forage legumes as sources of high quality feed (annuals and perennials)
5. Establishment, disease and pest management of forage grasses and legumes
6. Farmers experience with multipurpose forage options. (3 farmers that have a good dry season forage management reported their experiences)
7. Visit of Pasture plots (Brachiaria hybrid (Mulato), Mulatto associated with Arachis pintoi, *Cratylia argentea*
8. Presentation of the theory on hay and silage as alternative for dry season feeding.
9. Practical training hay drying (turning was done 2 times in the course of the day) and making of hay bunches.
10. Elaboration of little bag silage, using Craylia and Sugarcane
11. Discussion and evaluation of different forms and sizes of hay bunches
12. Discussion and evaluation of different sizes of little bag silage

The farmers gave good feedback on the presentations and they actively participated in discussions and the evaluations of hay and silage preparation. Participants also appreciated that the events had practical training and that the location offered the possibility to see much of the forage options mentioned in the training event. The involvement of positive deviances farmers (i.e. farmers having had successful experiences with improved forage technologies) in the training was also positive for the credibility and establishment of a trusty environment. Participants took advantage of the presence of these farmers who readily shared their experience.

At the end of the workshop, small samples of seed of *Cratylia argentea* (about 23 lb to 35 farmers for both workshops) were distributed to farmers who were interested to seed directly (seed value per farmer was about 2.50 US $). For the distribution of Vigna *unguiculata* the quantity of 10 lb was distributed to interested farmers. These farmers were ready to plant half a manzana (0,35 ha) with cowpea accessions IITA 9611 (8 farmers), IITA 284/2 (2 farmers) and CIDICCO 4 (2 farmers). With these farmers and also with others that expressed their intention to make hay or silage on their farms, follow up is scheduled. Once the technology is introduced, the farmers can be observed to monitor success, adaptation, spread of technology and the adoption process during the whole project period.

In summary, with the two farmers groups in Olancho, new forage-based technology was introduced and the next step is to observe and follow up what each participant is going to do with the knowledge gained in the training. For each case, it is now possible to survey the farmers individually or in groups on what they do and which constraints they have in their specific cases.

More training events will be organized in the future in other focal areas of the project to allow comparison between regions with different climatic and socio-economic conditions.
Cases of more experienced farmers, which have already passed a few replication cycles will be used to observe the adaptation and innovation process. Another activity will be to monitor the dissemination of technology from farmer to farmer where prototype farmers will play an important role. The results achieved with these activities will be integrated into the spatial context and will be used in spatial analysis.

4.5.4 Case study: Adoption of cowpea in Hillsides of Honduras

Contributors: C. Reiber, S. Biller and R. Schultze-Kraft (U. of Hohenheim), M. Peters and P. Lentes (CIAT)

Rationale

Research on the opportunities and constraints of different cowpea accessions for integration into smallholder farming systems was carried out in the Yorito area during 2003. A total of 57 farmers had experimented with cowpea on small plots, mainly with the objective to use cowpea for human nutrition and soil improvement. The results revealed a high acceptance of cowpea by farmers who employed grain and biomass yield, drought tolerance, low disease infestation and taste as the main criteria of selection. It was concluded that cowpea had a high potential of being adopted at a larger scale. Since 2003, the farmers did not get any more seeds and assistance. A follow-up study was carried out in September 2005 to examine process related for non-adoption of cowpea, and farmers assessment on price and potential uses of cowpea.

Materials and Methods

Structured interviews with 18 farmers were performed in 10 different communities. As farmers in the communities who have experience with cowpea are in contact frequently and live close to each other, this sample was considered to be sufficient to investigate who had continued cultivating or still had seed of cowpea. A standardized questionnaire with both quantitative and qualitative questions was used. The study only considered farmers who planted cowpea in 2003.

Results

Cowpea adoption. Since 2003, the number of cowpea planters decreased from 57 to an estimated 13 in the second cropping season (“postrera”) of 2003 (Figure 72). In 2004, only four farmers grew cowpea. In 2005, there were 5 cowpea growers and a total of 6 farmers still had seeds.

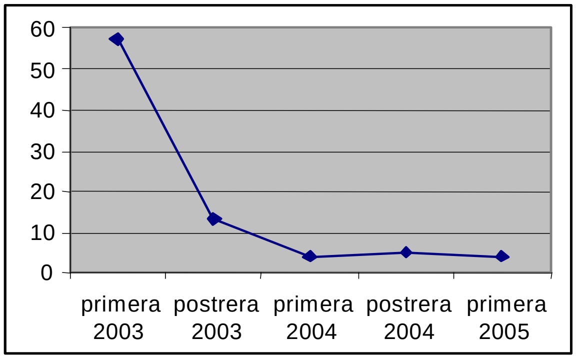


Figure 72. Number of cowpea planters in different seasons during a two year period.

Reasons for not growing cowpea. When farmers were asked for the reasons why they ceased planting cowpea, their main response was that they did not have any seeds left. The causes for the loss of seeds varied. On the one hand, seed production was limited due to climatic constraints (drought or too much rain), pest problems (rabbits and leaf cutter ants) and the use of plant biomass for green manure. On the other hand, seeds were damaged during storage due to pest attacks, were consumed, fed to chicken or distributed to others.

Process of innovation. The following briefly describes four cases of cowpea users as a result of promotion in 2002 and 2003.

1. A group of young people (CIAL-youth) was supported with additional cowpea grains in order to raise young pigs. The piglets had an age of 2 months and a weight of about 17 kg when cowpea supplementation started. The first week, 500 g of crude cowpea were mixed with 500 g of concentrate in order to adapt the piglets to the new feed. Then, cowpea was fed alone (2 kg per day and pig) for a period of 68 days before they were slaughtered. The pigs reached a final live-weight of 94 and 81 kg respectively which means that the average live-weight gain for this period was about 1 kg per pig/day.

2. During the survey in 2003, a farmer already used pre-cooked cowpea grain to feed fish (Tilapia) in his pond. Presently, he prepares fish concentrate composed of ground grains from legumes such as Cowpea, Mucuna, "Cablote" (*Guazuma ulmifolia* Lam.) and if available soybean grains as well as salt. He mentioned that he had given some cowpea seeds for grain production to another farmer nearby who was interested in his fish concentrate idea. This farmer, also having a fish pond, then copied his idea and is presently also elaborating his own fish concentrate.

3. A woman who was not included in the survey in 2003 produces cowpea to sell bundles of green pods in the streets of Yorito for 5 Lempira/bundle.

4. A farmer planted 3 cowpea accessions in association with maize. Although he had problems due to drought and leaf-cutter ants he continued to produce cowpea for household consumption. Presently this farmer associates cowpea with sugar cane.

Interest and estimated market price of cowpea seeds. The farmers were asked if other people who were not reached by the 2003 promotion activities had requested seeds or information on cowpea from them. In total, there were 23 additional persons who asked 10 cowpea planters for seeds or information. Eight of the farmers gave seeds as a gift to 15 other farmers. Additionally, 3 farmers sold seeds at prices of 2.5, 3 and 5 Lempira/pound to 8 other farmers.

Farmers were asked if they would be willing to produce cowpea in case a market (demand) for cowpea existed and 16 out of the 18 farmers said that on this condition they would (of course) produce cowpea. In order to investigate the cowpea market potential, farmers were asked at what price they would sell the seed. The price range mentioned was in between 3-10 Lempira/pound: 10 farmers stated a price of 3-5 Lempira/pound and 4 farmers mentioned a price of 10 Lempira/pound which is double the price of common bean.

A total of 14 farmers (78%) mentioned that they would buy seeds if available at the local market of which 6 already tried to get some. The mostly stated price at which cowpea would be purchased was at 5 Lempira/pound (range from 3-10 Lempira).

Farmer experiences with cowpea. When farmers were asked about their experience of using cowpea to improve soil fertility, 83% replied that they had observed improvements after cowpea. Of this 50% indicated growth improvement of the succeeding crop after cowpea (in the same field). Other farmers (25%) observed a general improvement of the soil and 13% argued that subsequent crops were less susceptible to pests and diseases.

Farmers were also asked if they thought that cowpea could be used to improve the food situation in their villages. A total of 67% agreed and were then asked for their reasons. The "greater food variety", "high yields", "good taste" and "high quality" of the bean were statements of the farmers.

Other advantages mentioned:

- Cowpea can be used as a multiple purpose forage
- Vigorous and fast growth
- It can be harvested several times (undetermined maturation) leading to high grain production
- Good resistance against pests and diseases.

Promising cowpea accessions: Farmers gained experience with different accessions during the evaluation period in 2003 and two years later they were asked which of these accession(s) they preferred. FHIA, which is an early maturing accession and used for seed/grain production was mentioned 5 times. Verde Brazil, an accession with high biomass production (for soil improvement and forage) and DICTA 9611 (intermediate, erect type that adapts well to different biophysical conditions) were mentioned 4 times. In general, red seeded materials including the accessions FHIA, DICTA 9611 and CIDICCO 4 were preferred to white seeded accessions.

Farmers' selection criteria were based on the possible uses of the different accessions, in their production systems as well as their seed appearance, which is an important factor for marketing purposes.

Agronomic constraints: Based on measurements, observations and farmers' experience, cowpea did not tolerate high precipitations (especially the accession Verde Brazil) and altitudes above 1500 m.a.s.l. Furthermore, cowpea is highly vulnerable to pests such as leaf-cutter ants and rabbits that could cause partial or even complete crop failures if no pesticides are applied.

Uses of cowpea: If farmers could get seeds of cowpea, they would like to produce cowpea mainly for food purposes (13 times mentioned). Other uses mentioned were for example the sale of the grain if a market existed, for soil improvement as well as for feed purposes (for chicken and for fish).

Discussion

Some answers of farmers may have been biased as they may have answered some questions as they thought interviewer wanted to hear and in order not to lose possible fringe benefits. For example, when farmers were asked if they would produce cowpea in case of market demand, hardly anyone would say no although they might think differently. Regarding the low adoption rate and seed availability, one might assume that farmers' interest in cowpea is limited. However, the fact that seeds were lost due to unpredictable circumstances (e.g. rabbits, drought, and spoilage of stored seeds) and the non-availability of more seeds could also explain the low adoption.

Nevertheless, there are some farmers who still produce cowpea for different purposes (concentrate, green pods) and some already began to sell seeds to other interested farmers indicating its high potential demand in the region studied.

The existence of a local market for cowpea products seem to be a prerequisite for greater adoption since farmers additionally want to sell at least a part of their cowpea production. The use of cowpea as feed for ruminants as well as monogastrics could fill the niche for as alternative high quality fodder and protein grain for feeding monogastrics.

In summary, results from the survey indicate:

- Problems associated with non-adopotion are pests such as leaf-cutter ants and rabbits, low tolerance to high soil moisture content, altitudes above 1500 m.a.s.l. and no seed availability at the local market.
- Some farmers have learned how to use cowpea (food, feed and soil improvement) and are aware of its benefits.
- Farmers would produce cowpea in case of the existence of a local market.
- Most promising accessions are FHIA (for its early maturation and high seed production), Verde Brazil (for its high biomass production) and 9611 for its adaptability.

The way forward

Presently, and as part of the CIAT-project on forage alternatives for the dry season, cowpea hay and grains for the elaboration of concentrates are being produced in different cattle farms in the area in order to evaluate its effects on animal production. In addition, four farmers (of the former cowpea planters) without cattle were selected for cowpea forage production (hay). Trade linkages between cowpea and poultry pig producers and feed companies will be established in order to create the basis for possible production expansions.

4.5.5 Case study: Prototype forage seed enterprise of small farmers in Honduras

Collaborators: P. Lentes (CIAT), H. Cruz (CIAT-DICTA), M. I. Posas (SERTEDESO), M. Peters (CIAT), C. Reiber (U. of Hohenhein), C. Burgos (DICTA), P. J. Argel and C. E. Lascano (CIAT)

The adoption of forage technologies is dependent on availability of good quality seed at reasonable prices. Therefore, taking into account the current forage 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. A farmer group in Honduras working under their own label – 'EMPRASEFOR' (Empresa de Producción Artesanal de Semilla Forrajera), formerly PRASEFOR, produces seed since 2001; this farmer-led seed enterprise was established with very limited financial support (i.e. less than US$ 2000), hence the approach could easily be replicated at other regions. As shown in Table 98 in 2001, seed production in Honduras began with 286 kg of seed, produced by 11 members of EMPRASEFOR. During 2002 the 13 members of EMPRASEFOR produced a total of 720 kg of *Brachiaria brizantha* cv. Toledo on 10.4 ha, doubling the cultivated area of the year before. In 2003, the production volume and area again rose to nearly 1.5 tons, produced on 18.5 ha. The 13 members of the group nearly reached 2 tons of

Table 98. Evaluation of seed production of *B. brizantha* cv. Toledo in EMPRASEFOR.

Year	Area	Production	Production	Increased production area
	ha	kg	ha	%
2001	5.25	286	54.5	
2002	10.40	720	68.8	99.3
2003	18.50	1465	79.0	77.3
2004	21.80	1915	87.5	17.9
2005	37.40	4000 *	106.8	71.2

*Estimation of what is expected.

seed in 2004. As the production volume of *B. brizantha* cv. Toledo seed rose, the group faced the problem of a limited local market and extended its sales area to more clients in the wider region during 2004 and 2005.

In April 2005, CIAT facilitated the contact of EMPRASEFOR with a Mexican seed company (PAPALOTA), which is a partner of CIAT in the development and distribution of Brachiaria hybrids. During a workshop on seed production and marketing in Yoro, an open discussion was held among EMPRASEFOR members (about 10 people attended), SERTEDESO (the NGO collaborating with EMPRASEFOR) and PAPALOTLA on the benefits of forming an EMPRASEFOR - PAPALOTLA alliance.

The objective of this alliance was to facilitate the expansion of seed production by PRASEFOR through an assured market offered by PAPALOTLA. The underlying principle of the alliance was that both PAPALOTLA and EMPRASEFOR should see economic benefits.

In a closed door meeting, PAPALOTLA and EMPRASEFOR discussed potential agreements, i.e. the sale of the seed produced to PAPALOTLA, to access a wider market for PRASEFOR utilizing the commercialization channels of PAPALOTLA and reducing the need for import expenses (quarantine, paper work for import, shipping cost etc.) for PAPALOTLA. The final agreement reached include:

a) minimum production target of 3 t/year of *B. brizantha* cv Toledo (in high demand) seed, with well defined quality requirements,
b) a price that could compete with the price of seed imported from Brazil and
c) access by PRASEFOR farmers of needed agricultural inputs such as fertilizers, herbicides at preferred rates through the PAPALOTLA distributor in Honduras.

After the workshop the group met several times to further define points of negotiation, concerning production volume, price per kg of seed and quality parameters (purity and germination). CIAT facilitated the negotiations and communication between the two parties. Once the core points of the alliance were agreed upon, PAPALOTLA agreed to buy the seed produced by EMPRASEFOR during 2005 with minimum quality parameters.

Quality will be assessed by the neutral government organization, Servicio Nacional de Sanidad Agropecuaria (SENASA). Minimum quality requirements are purity of 90% and germination > 65 %. The price of 6.50 US$ per kg was based on a purity of 95 % and germination of 70 %. For inferior quality still in the range of the minimum requirements, a formula to apply on the price per kg was also agreed.

The commercial seed company PAPALOTLA agreed to include the EMPRASEFOR label in the form of a sticker on the seed package sent to the market. To meet the production target, the group started to extend the area of cultivation to a total of about 37.4 ha, 71% more than in 2004. PAPALOTLA financed and organized the delivery of fertilizers and agrochemicals for production through their local reseller.

In October 2005, CIAT trained the farmers once on seed production of Toledo given emphasis on establishment, management and harvest of seed multiplication plots. It was found that post harvest processing was not done in an optimal way by EMPRASEFOR. In the process of purification, a better calibration of the processing equipment would probably lead to better results in terms of volume of pure seed. In order to be able to sell the seeds in accordance with Honduran laws, EMPRASEFOR had to be certified as seed producer by a government agency in Honduras (SENASA).

CIAT established the contact and started the registration process of the group. In the course of the certification process SENASA trained the farmers on legal issues of seed production and the correct use of agrochemicals. SENASA also had to examine the plots before the official registration document was handed out to

EMPRASEFOR.

One more precondition to start business with PAPALOTLA was that EMPRASEFOR had to legalize the enterprise based on laws of Honduras. This is currently in the process. In collaboration with SERTEDESO, CIAT established the contact with MIPIME (the government organization that issues the legal constitution of the company), helped the farmers to define the objectives of the company and to collect all documents necessary to obtain the legal status of the company.

A specialized lawyer was contracted to develop a constitution act for EMPRASEFOR. The official documents of the firm foundation was expected of the end of 2005.

4.6 Analysis of current and improved livestock/forage systems in LAC from an economical perspective

Highlights

- Investment on improved forages by farmers in Central America is economically profitable, but for the investment to be viable, producers need a line of credit of several years since they do not have the cash flow necessary for the financing of the necessary investments.

- Adoption of *Brachiaria* hybrid Mulato for direct grazing during the rainy season and *Cratylia argentea* for feeding during the dry season significantly improves the productivity of milk and beef as well as stocking rate, which allows the option of expanding the herd size.

- Costa Rica's beef industry performs very unsatisfactorily. At the farm level, beef production systems generate low gross incomes if we take into account that the commercial value of beef farmland ranges between $1,000/ha and $2,000/ha. As a result, the gross income cannot recover the opportunity cost of the capital invested in the land, making the beef industry uncompetitive.

- Intensification of beef and dual-cattle systems in the Llanos of Colombia would result in dramatic increases in rural employment.

- Forestry production would be a good option in the Llanos of Colombia to the extent that the region invest in reasonable means of transportation and adequate infrastructure for the management and processing of forest products.

4.6.1 Improved forages as drivers of economic growth in Central America

Contributors: Federico Holmann (CIAT-ILRI) and Libardo Rivas (CIAT)

This study aims at the evaluation of the economic viability of new forage options in different farm sizes and production systems in Central America, within the framework of the improvement of the competitiveness of the livestock sector. It is the goal to contribute relevant economic information, that helps to improve the design of economic and technological policies that accelerate the processes of innovation and technical change in the region. The economic return and the economic viability of investments in improved forages are analyzed, in order to evaluate its economic potential in different contexts of farm sizes, production systems and internal and external constraints to producers.

Data came from a random sample of 123 farms located in Costa Rica (30), Nicaragua (32), Honduras (35), and Guatemala (26). Producers were interviewed in order to obtain information regarding herd structure, land use, milk and beef production, and input use for animal feeding. This information allowed the estimation of technical and reproductive parameters as well as labor use, both family and hired. Based on this information it was possible to define 3 farm sizes, that represent groups of producers with different orientations and economic possibilities, thus: (a) the sector of subsistence where the objective function of the producer is household consumption and its main activity agriculture; (b) the small commercial livestock producer; and (c) the livestock producer of medium size.

A multi-period, linear programming model was used to analyze and evaluate the various scenarios and calculate the profitability indicators of the alternatives under evaluation. The model evaluates each of the 3 farm sizes and includes the following scenarios: (a) The producer adopts a *Brachiaria* hybrid in the areas within the farm which are presently planted with native pastures and also adopts the dry season feeding system based on the shrub legume *Cratylia argentea.* The increase in productivity and income is estimated based on the profits from the increase in animal response with respect to the baseline; and (b) the same scenario described in (a) but assuming alternatively that the farm changes the production system from dual purpose to specialized beef production.

The results obtained indicate that the investment in improved forage is economically profitable and that it represents a good option in order to increase the well-being of producers. However, in order for the investment in improved forages to be viable, producers need a line of credit of several years (i.e., 2-7, depending on the production system and country) since they do not have the cash flow necessary for the financing of the necessary investments. The adoption of the *Brachiaria* hybrid for its utilization in direct grazing during the rainy season and that of the shrub legume *Cratylia argentea* for feeding during the dry season significantly improved the productivity of milk and beef as well as the stocking rate, which generates the possibility of expanding the herd size. The number of cows can be increased between 2.1 and 3.5 times in the dual purpose system and between 2.6 and 6 times in the specialized beef production system. Milk production per hectare can be increased up to 2.3 to 3.5 times in the dual purpose system and beef production can be increased between 3.7 to 4.5 times, in the specialized beef production system. Table 99 contains this information taking as an example the dual purpose production

Table 99. Herd inventory, milk and beef production, employment generation, net income, number of years credit is needed, and time necessary to achieve maximum herd growth in small dual purpose farms in Central America.

	Guatemala		**Honduras**		**Nicaragua**		**Costa Rica**	
	Base line	Goal	Base line	Goal	Base line	Goal	Base line	Goal
Number of mature cows	14	30	14	30	14	30	14	26
Milk production (kg/farm/day)	31	66	31	66	31	66	31	56
Beef production (kg/farm/mo)	167	352	167	352	167	352	167	305
Area under improved forages (ha)								
* *Brachiaria* hybrid	0.0	6.9	0.0	6.9	0.0	6.9	0.0	10.2
* *Cratylia argentea*	0.0	6.1	0.0	6.1	0.0	6.1	0.0	2.8
Employment generation (# full-time persons/yr)	0.9	1.9	0.9	1.9	0.9	1.9	0.9	1.4
Net income ($/farm/mo)	126	378	94	336	70	305	90	271
Number of years to pay back credit	NA	4	NA	2	NA	2	NA	3
Years needed to achieve maximum herd growth	NA	9	NA	9	NA	9	NA	7

NA = Not apply

system and the small farm size. The investment in improved forages not only brings economic benefits for the producers, but also social, since the adoption of new technologies based on improved forages increases the generation of rural employment and food availability. In the dual purpose system it is possible to increase employment between 1.5 to 4 times and in the specialized beef system between 1.8 to 3 times.

The parameter of greatest impact in terms of net income is fertility. An increase of 10% in the annual calving rate improves net income between 12-19% in subsistence farms and small, and between 14-21% in medium size farms, depending on the country and on the prevailing production system. Table 100 contains this information for all farm sizes using the dual purpose production system. The second parameter in importance with regard to net increases in income is milk productivity in dual purpose farms or beef productivity in farms with specialized beef production. A 10% increase in the current productivity per cow results in 10-13% increase in net income in subsistence farms, 12-15% in small farms, and 12-19% in medium farms. Similar improvements in other parameters such as calf mortality results in a very low response in terms of net income/farm (i.e., < 3%).

The dual purpose system turned out to be a better economic option than the specialized beef production system. (Table 101). It can be observed that the potential for generating income is strongly associated with the economic orientation of the livestock activity. Indeed, subsistence farms with dual purpose systems have the capacity to generate from 28 to 35% more income that their homologous specialized in beef. In the small farms, that proportion ranges between 68 and 84% and in the medium farms the range of increase in income is between 107

Table 100. Sensibility of net income to a change in 10% improvement of herd fertility and beef and milk productivity, and a reduction of 10% in calf mortality and price of milk and beef for different farm sizes and production systems in Central America. 1/.

Parámetro	Guatemala	Honduras	Nicaragua	Costa Rica
	(% change in net income)			
Subsistence farm size				
Herd fertility (+10%)	+ 17.9	+ 18.3	+ 17.7	+ 19.4
Milk yield (+10%)	+ 12.9	+ 12.8	+ 12.5	+ 13.1
Beef yield (+10%)	+ 5.0	+ 5.2	+ 5.1	+ 4.4
Calf mortality (-10%)	+ 1.0	+ 1.1	+.1	+ 0.8
Milk price (-10%)	- 16.4	- 19.1	- 16.4	- 13.8
Beef price (-10%)	- 12.3	- 11.4	- 12.4	- 8.9
Small farm size				
Herd fertility (+10%)	+ 16.7	+ 16.9	+ 15.7	+ 19.1
Milk yield (+10%)	+ 13.0	+ 12.9	+ 12.3	+ 15.0
Beef yield (+10%)	+ 3.9	+ 4.0	+ 3.6	+ 4.6
Calf mortality (-10%)	+ 0.5	+ 0.5	+ 0.5	+ 0.8
Milk price (-10%)	- 14.2	- 14.3	- 13.6	- 16.3
Beef price (-10%)	- 9.7	- 10.4	- 9.6	- 10.7
Medium farm size				
Herd fertility (+10%)	+ 15.5	+ 15.1	+ 14.2	+ 19.8
Milk yield (+10%)	+ 13.0	+ 12.5	+ 11.8	+ 17.9
Beef yield (+10%)	+ 2.9	+ 3.0	+ 2.8	+ 3.9
Calf mortality (-10%)	+ 0.5	+ 0.5	+ 0.5	+ 0.5
Milk price (-10%)	- 14.3	- 13.6	- 12.8	- 19.9
Beef price (-10%)	- 8.9	- 9.2	- 8.1	- 12.3

1/This is a partial analysis in the sense that when a variable changes, the others remain constant.

Table 101. Net income by farm size and production system in Central America.

Country	Production system					
	Dual purpose			Specialized beef		
	Subsistence	Small	Medium	Subsistence	Small	Medium
	(US$/cow/yr)					
Guatemala	120	152	193	112	113	118
Honduras	105	135	178	94	98	104
Nicaragua	94	123	163	87	86	93
Costa Rica	122	127	129	105	112	118

and 145% compared to specialized beef. The reduced cost shows the income that is forgone because a forage technology which is not in the optimal solution is forced to enter. The shadow price represents the quantity of money that the producer would be willing to pay for an additional unit of a given limiting factor that has been exhausted. Eliminating a hectare of the *Brachiaria* hybrid in order to replace it with a hectare of the traditional grass *B. decumbens* would generate a loss per year between $57 and $115 dollars in subsistence farms. Furthermore, replacing a hectare of *Cratylia* with one of King grass would generate a loss per year between $136 and $195 dollars, depending on the country (Table 102**).**

Table 102. Reduced cost of traditional forage alternatives and shadow prices of land, protein, and digestible energy in different farm sizes using the dual purpose production system in Central America.

Variable	Guatemala	Honduras	Nicaragua	Costa Rica
	(net imcome per annual unit)[1]			
Subsistence farm size				
Reduced cost				
Brachiaria decumbens	- 115	- 108	- 104	- 57
King grass	- 195	- 161	- 136	- 192
Shadow price				
Land	131	127	124	47
Digestible protein dry season	1.7	1.4	1.2	1.5
Digestible energy dry season	0	0	0	0
Small farm size				
Reduced cost				
Brachiaria decumbens	- 163	- 151	- 142	- 98
King grass	- 223	- 186	- 159	- 229
Shadow price				
Land	205	194	185	102
Digestible protein dry season	2.0	1.7	1.4	1.9
Digestible energy dry season	0	0	0	0
Medium farm size				
Reduced cost				
Brachiaria decumbens	- 212	- 204	- 189	- 60
King grass	- 252	- 217	- 186	-200
Shadow price				
Land	282	212	258	51
Digestible protein dry season	2.3	2.0	1.7	1.6
Digestible energy dry season	0	0	0	0

[1] In the case of *Brachiaria*, King grass and land, the unit is represented by one hectare. In the case of protein, by a kilo, and in the case of energy, by a Mcal.

The shadow price of land in farms with subsistence size ranges from $47/year in Costa Rica to $131/year in Guatemala. The shadow price of the energy nutrient is zero, which means there is an energy surplus in the ration (ie., it is exceeding) and as a result, it is not limiting. On the other hand, the shadow price of the protein ranges from $1 to $1.7 per kilogram of digestible protein, which indicates that what is being lacking in the diet during the dry season is a little more protein in order to optimize the existing excess energy in the diet. This optimization can be made by either fertilizing the bank of *Cratylia* in order to increase the quantity of biomass, or supplementing during the dry season with a low-cost protein supplement such as chicken manure. The shadow price of capital in the dual purpose system ranges from $1.38 in subsistence farms to $2.14 in medium farms. In the specialized beef system this ranges from $1.11 in subsistence farms to $1.37 in medium farms (Table 103). This means that the investment in improved forages makes it possible to pay very high interest rates.

Table 103. Shadow price of capital available for investing in improved forage technologies in livestock production systems in Central America.

Production system	Guatemala	Honduras	Nicaragua	Costa Rica
	(US dollars willing to pay for each dollar invested in forages)			
Dual purpose				
Subsistence farm size	1.41	1.38	1.51	1.48
Small farm size	1.92	1.70	1.60	1.57
Medium farm size	2.13	1.78	1.89	2.14
Beef				
Subsistence farm size	1.12	1.11	1.11	1.12
Small farm size	1.21	1.18	1.14	1.19
Medium farm size	1.37	1.26	1.16	1.25

4.6.2 Beef chain analysis in Costa Rica: Identifying critical entry points to improve the efficiency of the sector

Contributors: Federico Holmann (CIAT-ILRI), Libardo Rivas (CIAT), Edwin Pérez (ILRI), Paul Schuetz (ILRI), Cristina Castro (CORFOGA), and Diego Obando (CORFOGA)

Rationale

Costa Rica's livestock and beef industry generally performs very unsatisfactorily. The national herd has declined significantly, as has beef production. This evolution is closely associated with two forces: inefficiency in breeding and fattening, with revealing indices of an underexploited industry; and an industry that is inefficient and uncommitted to forging partnerships with the production sector to promote the production of better quality animals. Intermediaries abound, and their place in the system, together with established economic relationships, debilitates the producer's capacity to influence the distribution of the aggregate value he helps create. This translates to economic performances that do not correspond with the time and capital invested, or with the economic risks faced.

The study's overall objective is to characterize and analyze the beef chain in Costa Rica, and thus to identify and suggest lines of action that would optimize its operation and facilitate greater participation, particularly that of small-scale actors, in processes other than those of simple primary production. Such a strategy would help improve technological adoption, and the productivity and profitability of livestock production. The goal is to generate strategic information that helps public and private actors set priorities and implement lines of action that promote technological change and improve the competitiveness of the nation's livestock agribusiness. The specific objectives of the study were to:

1. Identify the articulations between links, technological levels, efficiency indicators, installed capacity (scale), and types of occupation
2. Describe the economic agents in the chain and their commercial and legal relationships
3. Characterize and estimate cost and price structures, and the generation of aggregate value in different links of the chain
4. Identify critical costs that can be modified through interventions, whether technological, policy, or other
5. Determine the biological and economic risks throughout the chain

To obtain primary, qualitative, and quantitative information (Table 104), selective samplings at different levels of the chain were taken, using structured and semi-structured surveys of different actors, including producers, intermediaries, traders, processing plants, and supermarkets.

Results and Discussion

Primary production

In Tables 105 and 106 we show the results of a survey conducted of 1074 livestock farms throughout the country during the first semester, 2005. The farms' principal activities were cow-calf, dual purpose, or fattening. The average herd size was 93 heads and of farm size 67 ha. Farms ranged from 82 heads and 55 ha in dual-purpose systems to 105 heads and 80 ha for fattening.

These production systems generate an annual animal extraction rate between 8% in dual-purpose systems and 24% in fattening systems, with a national average of 13%. In contrast, annual rate of cow replacement is very low, ranging from 5.1% in dual-purpose systems to 3.9% in fattening systems. This annual extraction rate is caused mainly by the low rate of annual calving, which ranges from 49% in fattening systems to 63% in dual-purpose systems, with a national average of barely 54%.

This low extraction rate generates an annual average of animals sold per farm of 12 heads, ranging from 7 in dual-purpose systems to 25 in fattening systems. However, the average weight of animals sold was 164 kg and 158 kg for male and female calves, respectively; 330 kg for young bulls (<2 years old); 252 kg and 440 kg for heifers and young bulls (2–3 y o), respectively; 335 kg for young cows; 582 kg for bulls; and 439 kg for cows.

This number of animals, multiplied by the average weight at sale for each category, generates very low annual sales that range from 2,260 kg in dual-purpose systems to 10,140 kg in fattening systems, with a national average of 3,980 kg. This means that annual productivity is about 60 kg beef/ha, ranging from 41 kg/ha in dual-purpose systems to 126 kg/ha in fattening systems.

In 2004, farm gate prices for beef (live weight) for steers and heifers slaughtered in abattoirs were US$1.11/kg and $0.95/kg, respectively. Auction prices for other categories were $0.82/kg and $1.02/kg for female and male calves, respectively; $0.88/kg for heifers; $0.96/kg for young bulls (<2 y o); $0.76/kg for culled cows; and $0.95/kg for bulls.

The annual sales in kilograms of beef, translated into gross income, varied from US$2,050 for the average dual-purpose farm to $10,090 for the average fattening farm, generating an annual gross income of $37/ha in the dual-purpose system to $125/ha in the fattening system. Such

Table 104. Lists of specific information to collect at different levels of the beef chain, Costa Rica.

Level in the chain					
Producer	Livestock trader or auctioneer	Slaughterhouse	Meat wholesaler	Processing plant	Supermarkets and markets
Farm size		Number of animals slaughtered	Volumes of meat and purchase and sale prices by type of meat	Volumes of meats processed	Type and volumes of meats and processed products Consumer prices
Area under pastures		Use of the capacity installed	Volumes of byproducts and purchase and sale prices	Classes of cuts and processed byproducts	Percentage of losses of meats and processed products Agents who assume them
Sales of livestock by category	Volume of purchases by category	Type of installations Technological level	Percentage of physical losses Agents who assume them Commercial arrangements with suppliers	Type of installations and technological level Use of capacity installed	Commercial arrangements with suppliers Insurance policies and risks covered
Age at sale and by category					
Average weight of animals sold by category	Travel expenses	Costs or fees for dressing		Type of products Prices at the processed meat plant	
Total inventory	Buying prices by category	Class of services Products and byproducts generated	Volumes and types of meats marketed	Percentage of losses of meats and processed products Agents who assume them	Purchase prices of meats on the carcass at the slaughterhouse Purchase prices of processed products
Farm gate price (US$/kg on the hoof) by category		Prices of slaughtered cattle Prices of byproducts	Purchase and sale prices of meats and byproducts	Commercial arrangements Insurance policies and risks covered	
Technical parameters: • birth rate (%) • mortality (%) • weight gains		Commercial arrangements Insurance policies and risks covered	Percentages of physical losses of meats and byproducts Agents who assume them	Sale conditions and agreements	
Technical and economic limitations		Percentage of losses of products and byproducts Agents who assume them	Identification of business risks as perceived by the wholesaler		
Sale conditions and agreements	Sale conditions and agreements		Sale conditions and agreements		

Table 105. Inventory of the average herd, annual animal sales, extraction rate, and average weight of animals sold during 2004, according to a 2005 survey of livestock producers who own breeding (602 farms) and dual-purpose (298 farms) production systems, Costa Rica.

	Production system											
	Breeding[a]						Dual purpose[a]					
Variable[b]	1 (n=139)	2 (n=203)	3 (n=175)	4 (n=57)	5 (n=28)	Average (n=602)	1 (n=70)	2 (n=114)	3 (n=74)	4 (n=30)	5 (n=8)	Average (n=296)
Inventory herd (no.)												
Cows	7.8	21.4	42.8	87.5	192.9	38.7	7.5	20.5	44.1	84.8	171.3	33.9
Young cows	2.1	6.6	12.7	29.4	47.0	11.4	1.5	6.1	12.3	20.5	51.3	9.2
Heifers	1.3	4.7	10.2	19.1	50.4	9.0	1.9	6.2	10.9	25.4	62.1	9.8
Female calves	2.8	7.7	15.8	27.9	87.7	14.6	3.0	7.9	17.2	23.2	71.4	12.3
Male calves	2.1	5.9	11.3	19.0	42.4	9.5	2.3	5.7	11.8	24.2	47.0	9.4
Young bulls (<2 y o)	0.6	2.8	5.8	9.1	15.2	4.5	0.1	1.4	4.2	9.0	1.8	2.9
Young bulls (2–3 y o)	1.4	0.9	3.7	5.3	27.5	3.3	1.4	0.7	2.6	11.1	7.0	2.3
Bulls	0.7	1.6	2.2	3.6	5.1	1.9	0.6	1.2	1.9	3.3	6.6	1.6
Total animals	**18.7**	**51.7**	**104.6**	**200.7**	**468.1**	**93.0**	**18.3**	**49.7**	**105.1**	**201.4**	**418.4**	**81.5**
Area (ha)	48.6	41.1	72.2	127.2	217.9	68.4	15.5	45.7	67.8	123.8	136.9	54.7
Annual calving (%)	53	52	48	53	53	51	67	64	62	54	34	63
Mortality (%)												
Calves	2	2	2	2	2	2	2	2	2	1	1	2
Adults	1	1	1	0	1	1	0	1	1	1	1	1
Annual sales (no.)												
Cows	0.5	0.7	2.6	5.1	17.9	2.5	0.7	1.6	2.8	4.3	4.3	2.0
Young cows	0.2	0.2	0.9	1.2	0.5	0.5	0.1	0.3	0.4	0	3.8	0.3
Heifers	0.1	0.3	0.7	1.9	4.1	0.7	0	0.5	0.5	0.6	0	0.4
Female calves	0.1	0.3	1.4	1.1	5.0	0.9	0.2	0.4	0.8	0.6	2.6	0.5
Male calves	0.5	1.3	4.4	2.9	10.3	2.6	0.4	1.4	3.5	2.3	3.5	1.8
Young bulls (<2 y o)	0.2	1.1	1.2	4.4	0	1.3	0.3	0.2	0.9	1.5	0	0.5
Young bulls (2–3 y o)	0.7	0.1	1.1	0.9	19.6	1.4	0.1	0	1.4	4.0	0	0.8
Bulls	0.2	0.1	0.5	0.3	0.6	0.3	0	0.1	0.4	0.5	12.5	0.5
Total animals	**2.5**	**4.1**	**12.8**	**17.8**	**58.0**	**10.2**	**1.8**	**4.5**	**10.7**	**13.8**	**26.7**	**6.8**
Extraction rate (%)	**13.4**	**7.9**	**12.2**	**8.9**	**12.4**	**11.0**	**9.8**	**9.1**	**10.2**	**6.9**	**6.4**	**8.3**
Replacement rate (%)	**3.9**	**3.7**	**5.1**	**6.4**	**8.8**	**4.7**	**5.1**	**5.1**	**6.3**	**2.3**	**3.1**	**5.1**
Weight at sale (kg)												
Cows	403	425	430	426	456	428	404	539	412	419	400	466
Young cows	301	325	354	400	405	336	338	326	250	N/A	350	320
Heifers	253	236	255	236	303	252	220	241	250	237	N/A	239
Female calves	108	157	172	175	191	164	85	159	129	168	150	136
Male calves	151	175	174	180	213	175	150	150	156	127	125	149
Young bulls (<2 y o)	293	353	328	307	N/A	330	205	269	282	250	N/A	263
Young bulls (2–3 y o)	277	542	460	580	491	470	470	385	467	378	N/A	433
Bulls	615	579	650	650	660	627	450	500	550	615	550	532
Meat sold (kg)	**768**	**1134**	**3620**	**4911**	**20225**	**3018**	**551**	**1428**	**3095**	**5097**	**10750**	**2261**
Income from meat sold (US$)[c]	**705**	**1054**	**3322**	**4370**	**19163**	**2789**	**493**	**1193**	**2870**	**4856**	**9881**	**2053**

a. Herd size: 1 = smaller than 30 heads per farm; 2 = 31–75 heads; 3 = 76–150 heads; 4 = 151–300 heads; 5 = more than 300 heads.
b. y o = years old
c. Prices in 2004: live steers slaughtered in abattoirs = $1.11/kg and females, $0.95/kg. Auction prices for other categories were $0.82/kg for female calves, $1.02/kg for male calves, $0.88/kg for heifers, $0.96/kg for young bulls (<2 y o), $0.76/kg for culled cows, and $0.95/kg for bulls.

Table 105. Inventory of the average herd, annual animal sales, extraction rate, and average weight of animals sold during 2004, according to a 2005 survey of livestock producers who own breeding (602 farms) and dual-purpose (298 farms) production systems, Costa Rica.

	Production system											
	Breeding[a]						Dual purpose[a]					
Variable[b]	1 (n=139)	2 (n=203)	3 (n=175)	4 (n=57)	5 (n=28)	Average (n=602)	1 (n=70)	2 (n=114)	3 (n=74)	4 (n=30)	5 (n=8)	Average (n=296)
Inventory herd (no.)												
Cows	7.8	21.4	42.8	87.5	192.9	38.7	7.5	20.5	44.1	84.8	171.3	33.9
Young cows	2.1	6.6	12.7	29.4	47.0	11.4	1.5	6.1	12.3	20.5	51.3	9.2
Heifers	1.3	4.7	10.2	19.1	50.4	9.0	1.9	6.2	10.9	25.4	62.1	9.8
Female calves	2.8	7.7	15.8	27.9	87.7	14.6	3.0	7.9	17.2	23.2	71.4	12.3
Male calves	2.1	5.9	11.3	19.0	42.4	9.5	2.3	5.7	11.8	24.2	47.0	9.4
Young bulls (<2 y o)	0.6	2.8	5.8	9.1	15.2	4.5	0.1	1.4	4.2	9.0	1.8	2.9
Young bulls (2–3 y o)	1.4	0.9	3.7	5.3	27.5	3.3	1.4	0.7	2.6	11.1	7.0	2.3
Bulls	0.7	1.6	2.2	3.6	5.1	1.9	0.6	1.2	1.9	3.3	6.6	1.6
Total animals	**18.7**	**51.7**	**104.6**	**200.7**	**468.1**	**93.0**	**18.3**	**49.7**	**105.1**	**201.4**	**418.4**	**81.5**
Area (ha)	48.6	41.1	72.2	127.2	217.9	68.4	15.5	45.7	67.8	123.8	136.9	54.7
Annual calving (%)	53	52	48	53	53	51	67	64	62	54	34	63
Mortality (%)												
Calves	2	2	2	2	2	2	2	2	2	1	1	2
Adults	1	1	1	0	1	1	0	1	1	1	1	1
Annual sales (no.)												
Cows	0.5	0.7	2.6	5.1	17.9	2.5	0.7	1.6	2.8	4.3	4.3	2.0
Young cows	0.2	0.2	0.9	1.2	0.5	0.5	0.1	0.3	0.4	0	3.8	0.3
Heifers	0.1	0.3	0.7	1.9	4.1	0.7	0	0.5	0.5	0.6	0	0.4
Female calves	0.1	0.3	1.4	1.1	5.0	0.9	0.2	0.4	0.8	0.6	2.6	0.5
Male calves	0.5	1.3	4.4	2.9	10.3	2.6	0.4	1.4	3.5	2.3	3.5	1.8
Young bulls (<2 y o)	0.2	1.1	1.2	4.4	0	1.3	0.3	0.2	0.9	1.5	0	0.5
Young bulls (2–3 y o)	0.7	0.1	1.1	0.9	19.6	1.4	0.1	0	1.4	4.0	0	0.8
Bulls	0.2	0.1	0.5	0.3	0.6	0.3	0	0.1	0.4	0.5	12.5	0.5
Total animals	**2.5**	**4.1**	**12.8**	**17.8**	**58.0**	**10.2**	**1.8**	**4.5**	**10.7**	**13.8**	**26.7**	**6.8**
Extraction rate (%)	**13.4**	**7.9**	**12.2**	**8.9**	**12.4**	**11.0**	**9.8**	**9.1**	**10.2**	**6.9**	**6.4**	**8.3**
Replacement rate (%)	**3.9**	**3.7**	**5.1**	**6.4**	**8.8**	**4.7**	**5.1**	**5.1**	**6.3**	**2.3**	**3.1**	**5.1**
Weight at sale (kg)												
Cows	403	425	430	426	456	428	404	539	412	419	400	466
Young cows	301	325	354	400	405	336	338	326	250	N/A	350	320
Heifers	253	236	255	236	303	252	220	241	250	237	N/A	239
Female calves	108	157	172	175	191	164	85	159	129	168	150	136
Male calves	151	175	174	180	213	175	150	150	156	127	125	149
Young bulls (<2 y o)	293	353	328	307	N/A	330	205	269	282	250	N/A	263
Young bulls (2–3 y o)	277	542	460	580	491	470	470	385	467	378	N/A	433
Bulls	615	579	650	650	660	627	450	500	550	615	550	532
Meat sold (kg)	**768**	**1134**	**3620**	**4911**	**20225**	**3018**	**551**	**1428**	**3095**	**5097**	**10750**	**2261**
Income from meat sold (US$)[c]	**705**	**1054**	**3322**	**4370**	**19163**	**2789**	**493**	**1193**	**2870**	**4856**	**9881**	**2053**

a. Herd size: 1 = smaller than 30 heads per farm; 2 = 31–75 heads; 3 = 76–150 heads; 4 = 151–300 heads; 5 = more than 300 heads.
b. y o = years old
c. Prices in 2004: live steers slaughtered in abattoirs = $1.11/kg and females, $0.95/kg. Auction prices for other categories were $0.82/kg for female calves, $1.02/kg for male calves, $0.88/kg for heifers, $0.96/kg for young bulls (<2 y o), $0.76/kg for culled cows, and $0.95/kg for bulls.

gross incomes are extremely low if we take into account that the commercial value of beef farmland ranges between $1,000/ha and $2,000/ha. As a result, the biological inefficiencies mentioned above, combined with high land costs, make it impossible to recover the opportunity cost of the capital invested in the land, making this beef activity uncompetitive.

Table 107 shows the use and cost of labor in the above-mentioned production systems, taking as value the cost of the minimum wage in the case of family labor. The value of labor represents the principal cost in these production systems, ranging from an average of 1.7 full-time people in the cow-calf operations at an annual cost of US$3,346 per farm to 2.2 people in the fattening system at $4,330 per farm.

If we compare these values with the annual gross income per beef sale in Tables 105 and 106, then this labor cost represents, on average, between 43% of sales in the fattening system (i.e., US$4,330 in Table 107 divided by $10,088 in Table 106) and 201% in the dual-purpose system (i.e., $4,133 in Table 107divided by $2,053 in Table 105). The latter is understandable as most sales come through selling milk, not beef. However, the labor cost for the cow-calf system represents, on average, 120% of beef sales. This is worrying, as it implies that this system is not profitable, with the recompense for family labor being lower than the minimum wage.

Risks of beef production

Figure 73 shows a steer's life cycle from conception to slaughter. For 1.3 years (i.e. 15.5 months), the producer does not obtain any profit, as the animal is not born. The mating period is about 6.5 months until the female becomes pregnant (i.e., 12 months × 0.54, which is the annual rate of calving). Gestation takes another 9 months.

Once the male calf is born (weighing about 35 kg and worth US$50 dollars), it starts growing through three commercial phases: (1) pre-weaning period, which lasts between 7 and 10 months, with a 5% risk of mortality, (2) development, which usually lasts another year, with a 2% risk of mortality, and (3) fattening, which takes a further year, with a 2% risk of mortality, plus a conservative 3% risk of theft for being a fat appetizing animal.

In addition, in beef production, the annual replacement of the beef-producing machinery, that is, the cow and bull, must be considered, thus adding an annual 2.4% cost for replacing the cow (i.e. the annual 4.7% is divided between the two as 50% of all births are male; Table 106), and an annual 0.1% cost for replacing the bull (assuming a ratio of 25 cows per bull). That is, to each young bull that reaches slaughter age, a 14% mortality rate must be added from birth to slaughter, 3% for rustling, and 2.5% for replacing his parents, totaling 19.5%. That is, 1.2 young bulls are needed for one to reach the slaughterhouse, or 4 out of 5 male calves born.

This risk, taken over 4.2 years (i.e., 50 months), is assumed totally by the producer. Other links of the chain, such as the slaughterhouse or supermarket, protect against risks by buying insurance policies that are then transferred to the consumer and/or producer.

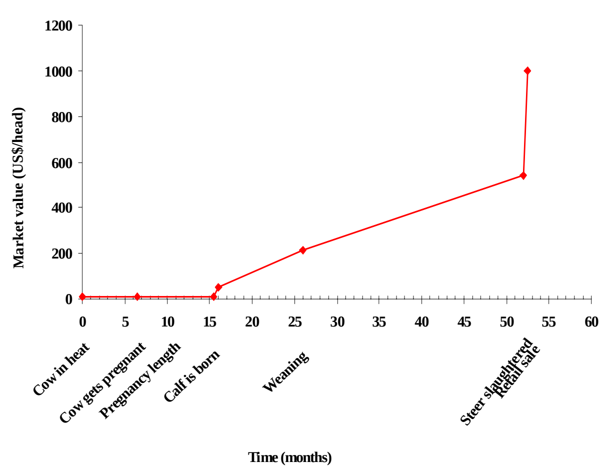


Figure 73. A young bull's life cycle from conception to slaughter, and its commercial value.

Table 107. Quantity and cost of contracted and family labor allotted to livestock activities on 1074 farms, Costa Rica, 2005.

Herd size[a]	Labor type		Dual purpose (n=296)		Breeding (n=602)		Fattening (n=176)		Total (n=1074)	
			Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
1	Contracted		0	0	0	0	0	0	0	0
	Family		0.6	1180	0.4	787	0.7	1378	0.6	1180
		Total	0.6	1180	0.4	787	0.7	1378	0.6	1180
2	Contracted		0	0	0	0	0	0	0	0
	Family		1.1	2165	0.6	1180	1.1	2165	0.9	1771
		Total	1.1	2165	0.6	1180	1.1	2165	0.9	1771
3	Contracted		0	0	0	0	0.8	1574	0.3	590
	Family		1.6	3149	1.5	2952	0.8	1574	1.3	2558
		Total	1.6	3149	1.5	2952	1.6	3148	1.6	3148
4	Contracted		1.3	2558	1.9	3739	1.7	3346	1.6	3149
	Family		1.4	2755	1.1	2165	0.8	1574	1.1	2165
		Total	2.7	5313	3.0	5904	2.5	4920	2.7	5314
5	Contracted		4.1	8069	4.0	7872	6.0	11808	4.3	8462
	Family		1.1	2165	1.0	1968	1.0	1968	1.0	1968
		Total	5.2	10224	5.0	9840	7.0	13776	5.3	10430
Avge	**Contracted**		**1.0**	**1968**	**1.0**	**1968**	**1.2**	**2362**	**1.1**	**2165**
	Family		**1.1**	**2165**	**0.7**	**1378**	**1.0**	**1968**	**0.9**	**1771**
		Total	**2.1**	**4133**	**1.7**	**3346**	**2.2**	**4330**	**2.0**	**3936**

a. Herd size: 1 = less than 30 heads per farm; 2 = 31–75 heads; 3 = 76–150 heads; 4 = 151–300 heads; 5 = more than 300 heads.

Livestock marketing

Much of the livestock trade is carried out through the country's 19 auctioneering entities, which together carry out 24 events per week. The auctioneers act as intermediaries by receiving the animals from a producer and, once having sold them, pays the seller according to the price at which each animal was sold but discounting the corresponding percentage for the commission by sale. The commission varies from auction to auction, with most collecting between 3.8% and 4%.

The producer is paid 5 to 20 minutes after the animals have been auctioned, going to the cashier's window to collect the check, which is payable in cash. On closing the books, the difference between purchases and sales should equal the percentage of the collected commissions. The sum of commissions, minus the expenses generated in developing the auction, is the profit made by the auction owner. Every auction is obliged by law to contract a veterinary to verify the health of the animals admitted into the auction. The animals enter the installations 2 hours before the auction. The event lasts as long as the number of animals admitted. An auctioneer can negotiate 110 to 125 animals per hour, with the average number of animals traded per event being 450.

The trade of live cattle is governed by the balance between supply and demand. If the auction prejudices the seller, he will then seek other means of marketing his livestock. If the buyer finds prices are too high, then he will also seek better options elsewhere. To achieve the balance, auction owners must carry out the process transparently. Base prices should reflect current market value.

For small producers, auctions are a major outlet for selling cattle. An analysis carried out by Servicios Integrados para el Desarrollo Empresarial (SIDE) showed that, during 2003, auctions traded for 2,850 sellers. Only 0.2% of these (i.e., 6 people) were large producers, 1.8% were medium-scale producers (i.e., 45 sellers), and 98.2% were small producers[1].

For most cases, the producer markets his livestock once a year and that, in 63% of cases, he sells less than 10 animals. Another 17% market their livestock at auctions two times a year, and 9% three times. Only 5% of all producers marketing livestock sell more than 40 animals. As a result, small producers find this environment a transparent and safe option for marketing their livestock.

4.6.3 New diversified livestock/agriculture/forestry production systems: An economic evaluation in the Colombian Llanos

Contributors: Libardo Rivas (CIAT), Federico Holmann (CIAT-ILRI), and James García (CIAT)

The objective of this study is to evaluate from the economic, social, and environmental optics, new models of farm that include various livestock, agricultural, and forest components for the production of food and raw materials, and in addition, generation of environmental services such as carbon sequestration. To meet the objective a multiperiodic linear programming model was used to optimize different production systems and to evaluate environmental externalities. For this analysis, the progressive incorporation of new technological components into the current livestock production systems are simulated, constructing various sequential technological scenarios. The starting point is a livestock farm with an extensive production system based on native sabanas in monoculture. In the following phase, the model adds a component of pasture

[1] According to the classification of producers developed by the Consejo Nacional de Producción de Costa Rica. This established that producers who obtain a gross income of up to US$25,000 per year are small producers; from $25,000 to $70,000 as medium-scale producers, and more than $70,000 as large producers.

rotations and crops, in a process oriented to improve the soil conditions through the construction of arable layers. The incorporation of forest and the sale of environmental services, in the form of carbon sequestration represent the following stage in the path of transformation of the productive systems.

For the animal feeding component the forage sources considered are: 1) Pastures in monoculture: a) native savanna, b) improved *Brachiaria brizantha* (cv. Toledo) and c) a mixed pasture of grass and legume (*B. decumbens* + *D. ovalifolium*); and 2) Forage from the rotations of grasses and crops. It is assumed that the improved pastures in addition to providing forage also fix carbon into the soil.

The evaluation period is 19 years. The semiannual crops that enter in the rotation scenarios are rice, corn, and soybeans. Three pasture rotations are considered. Rotation 1 is composed of three segments. The initial segment is a native pasture that remains in production during 7 years, followed by a cycle of 4 years of semiannual crops: rice–soybeans and corn–soybeans. This rotation culminates in the seeding of a mixed pasture, of grass and legume, with a productive life of 8 years.

Rotations 2 and 3 are very similar. Both begin and end with crop cycles of 6 years each. They differ in that in rotation 2, in the intermediate segment an improved *Brachiaria* is established, remaining in production during 7 years. In rotation 3, in the same segment, an mixed grass-legume pasture is established.

The forest alternative is represented by planting Caribbean pine, a specie with a high degree of adaptation that produces wood sequesters carbon. Given that the plantation is to be established in native savanna pastures, and because the soil conditions are not appropriate, the strategy is to plant first an improved grass during 4 years, after which it is introduced the pine for the remaining 15 years.

It was decided to simulate a typical farm of 500 hectares which operates with regional cost averages and that has a working capital that has a range of US$ 5,000 to 300,000. For simplicity, the results presented in this report are for the dual purpose production system (DP).

Dual purpose extensive system. At all levels of starting capital, the DP is more attractive economically than the cow-calf (ie., specialized beef) system. When the initial working capital is US$ 300,000 the value of the objective function of the DP is almost 6 times higher than in the specialized beef system. If producers with limited working capital went from specialized beef to DP, their net income would grow 2.5 times.

The greatest economic incentive of the DP is reflected in better shadow prices of the land. The maximum price that a producer with a specialized beef system would be willing to pay per additional hectare would be US$ 135 on average. If the farm were dual purpose, the amount would be US$ 449/ha. The optimal strategy for farms with high starting capital would be to establish a very high proportion of its area with improved forages, 89% (Table 108). On the other hand, farms with low starting capital would appeal to native sabannas as the main source of livestock feeding. Under these conditions, the DP can only generate employment when the starting capital is above US$ 200,000.

Dual purpose system including rotations of grass–crops and conservationist practices of land use. The adoption of rotations between improved forages and crops in the DP system displaces the native sabannas. When high levels of operating capital are available, the improved grass (ie., *B. brizantha* cv Toledo) is highly competitive, occupying a fraction that ranges between 64 and 79% of the available farm area. The rest of the farm is allocated to rotation 2 (Table 109). As the availability of operating capital decreases, the area cultivated with rotation 1 increases. The association *B. decumbens* + *D. ovalifolium* does not appear in the optimal solution per se, but is part of rotation 1.

The introduction of grasses–crop rotations increases significantly the capacity of employment generation of the mixed crop-livestock systems.

Table 108. Dual purpose system Scale*: 500 ha* Extensive system, with no improved forages, no crops, and no forestry

Starting capital available		Land use Ha				Herd inventory (heads)	Net employment generation (# journals)	Value of objective function US$ 000
			Improved forages					
Total US$ 000	Per hectare US$	Native sabanna	Brachiaria Toledo	Association *B. decumbens* + *D. ovalifolium*	Total area utilized (ha)			
300	600	55.7	444.3	0.0	500.0	990	236	6815
200	400	200.9	299.1	0.0	500.0	693	28	4746
100	200	346.2	153.8	0.0	500.0	384	-180	2677
50	100	418.8	81.2	0.0	500.0	231	-283	1643
25	50	455.2	44.8	0.0	500.0	155	-336	1125
10	20	484.3	15.7	0.0	500.0	94	-377	778
5	10	494.0	6.0	0.0	500.0	73	-391	649

As the area under grasses in monoculture decreases, the net generation of employment tends to rise. In farms with the highest levels of starting capital, the introduction of rotations and of conservationist practices of land use increases net income by 13%. Likewise, in the specialized beef system the increase in net income is about 44%. In situations of low availability of starting capital the economic impact of technological adoption is substantially greater. The jump in productivity that implies the adoption of rotations of grasses–crops represents an increase of almost 7 times the net income (Tables 108 and 109).

Dual purpose system with grass–crop rotations, conservationist techniques of land use and forest activities. The addition of the option of forestry in the mixed crop-livestock system influences land use in situations where the availability of starting capital is over US 10,000. As the level of starting capital begins to increase above $10,000 the area under forestry plantations comes to occupy a high fraction of the total available land (81%, Table 112).

The presence of forestry plantations reduces the competitiveness, within the system, of the pastures in monoculture. The improved pastures, that at high levels of starting capital and in a scenario without the option of forestry, occupy 79% of available land, now reduce their participation to only 12% when the option of forestry is included. As in the case of the specialized beef system, the option of carbon sale, given its low current prices, would have limited importance as revenue-producing in dual purpose livestock farms (Table 110). Changes in the price of the carbon, in the range of US$ 5 to 100/mt, would have little incidence on land use changes (Table 111).

Due to the greatest initial productivity of the dual purpose system compared to specialized beef, the introduction of trees in the first one has a smaller economic incidence. The introduction of trees in DP would not lead to substantial changes in the value of the objective function, which means that the shadow prices of land would remain stable. An economic and social externality, resulting from the expansion of areas allocated to forestry, is the reduction of the capacity to generate employment since this activity is less intensive in labor compared to the crop-livestock options.

Forest incentive policies

The application of a forest incentive, equivalent to a CIF of 50%, would stimulate the forestry option among producers with high levels of starting capital, but with a poor effect on the weakest economic groups of producers (Table 113). However, the combination of a forest incentive such as the CIF and an agreement of prepayment of the carbon sequestered would have a great impact in terms of expansion of the forest areas within producers with availability of starting capital under US$ 200,000 (Table 114). Under

Table 109. Dual purpose system Scale: 500 ha. Dual purpose system with improved forages in rotation with crops and conservationist soil practices

Starting capital available		Land use Ha							Herd inventory (heads)	Net employment generation (# jornals)	Value of objective function US$ 000
Total US$ 000	Per hectare US$	Native sabanna	Rotations crop-grass			Improved grass		Total area utilized			
			Rotation 1	Rotation 2	Rotation 3	*Brachiaria* cv. Toledo	Association *B. decumbens* + *D. ovalifolium*				
300	600	0.0	0.0	106.5	0.0	393.5	0.0	500.0	871	780	7684
200	400	0.0	0.0	179.7	0.0	320.3	0.0	500.0	709	1099	6889
100	200	0.0	69.4	235.0	0.0	195.6	0.0	500.0	567	1400	5995
50	100	0.0	205.0	174.7	0.0	120.3	0.0	500.0	661	1253	5535
25	50	0.0	272.8	144.5	0.0	82.7	0.0	500.0	709	1180	5305
10	20	0.0	312.0	128.2	0.0	59.8	0.0	500.0	734	1142	5163
5	10	0.0	319.0	130.2	0.0	50.8	0.0	500.0	727	1157	5102

Rotation 1: Native sabanna – rice/corn ~ soybean –. *B. decumbens* + *D. Ovalifolium*. Rotation 2: = rice/corn ~ soybean - *Brachiaria* cv. Toledo - rice/corn ~ soybean
Rotation 3: rice/corn ~ soybean - *B. decumbens* +*D. Ovalifolium* – rice/corn ~ soybean

Table 110. Economic impact of the sale of carbon in a farm with a dual purpose production system of the Altillanura with different levels of starting capital

Level of starting capital US$ 000	Value of objective function US$ 000		Change in the value of the objective function due to sale of carbon	
	With sale of carbon	Without sale of carbon	Total (US$ 000)	%
300	7932	7788	144	1.8
200	6995	6899	96	1.4
100	6057	5995	62	1.0
50	5588	5535	53	1.0
25	5353	5305	48	0.9
10	5209	5163	46	0.9
5	5145	5102	43	0.8

Table 111. Impact of changes in the price of carbon on the profitability and land use in a dual purpose farm of the Colombian altillanura.

Carbon price US$/mt	Land use			Value of the objective function US$ 000
	Rotation grass-crops		Forestry	
	Rotation 1	Rotation 3		
5	6.3	281.8	211.9	3797
10	6.3	281.8	211.9	3861
20	6.3	281.8	211.9	3995
30	30.3	261.7	208.0	4130
40	30.3	261.7	208.0	4266
50	57.3	239.1	203.6	4402
60	57.3	239.1	203.6	4541
70	57.3	239.1	203.6	4680
80	83.2	217.5	199.3	4821
90	83.2	217.5	199.3	4962
100	83.2	217.5	199.3	5104

Starting capital: US$ 100,000

this scenario, producers with low starting capital (US$ 5,000) would incorporate the option of forest in their production systems by almost one third of the farm (173 ha), which would imply an increase of 9% in net income (Tables 113 and 114).

Impact of technological transformation of livestock systems in situations of low availability of working capital. One of the main problems to transform the predominant extensive livestock systems in the Altillanura, other than the limitations of road infrastructure, access to markets and technological offer, is the lack of working capital which on many occasions impedes the adoption and dissemination of new alternatives of production. To analyze this constraint, different technological scenarios were designed for a livestock farm with a limited starting capital of US$10,000. The transformation of the system with a low starting capital, from the primary stage where the farm depends almost exclusively on native savannas until reaching a phase of modernization and diversification, involves a dramatic growth of its net income, as observed in Table 115. The technological adoption not only makes it possible to utilize all the available family labor, but also generates additional employment.

With intensification through the incorporation of new technological components, the demand on labor increases. When the specialized beef system adopts strategies of conservationist land

Table 112. Dual purpose system. Scale: 500 hectares. Livestock, with improved forages rotation with crops, conservatist soil practices, forrestry options and payment for environmental services (sale of carbon.)

Availability of starting capital		Land use (ha)										
				Rotations grass-crops			Improved grasses					
Total US$ 000	Per ha US$	Forestry Caribbean Pine	Native savanna	Rot 1	Rot 2	Rot 3	*Brachiaria* cv. Toledo	Association *B. decumbens* + *D. ovalifolium*	Total area utilized (ha)	Herd inventory (heads)	Net employment generation (journals)	Value of objective function US$ 000
300	600	405.3	0.0	28.1	8.7	0.0	57.9	0.0	500.0	182	729	7932
200	400	275.8	0.0	139.1	37.5	0.0	47.6	0.0	500.0	374	837	6995
100	200	134.3	0.0	235.4	80.0	0.0	50.3	0.0	500.0	565	983	6057
50	100	63.6	0.0	283.6	101.3	0.0	51.5	0.0	500.0	661	1055	5588
25	50	28.3	0.0	307.7	111.9	0.0	52.1	0.0	500.0	708	1092	5353
10	20	0.0	0.0	312.0	128.2	0.0	59.8	0.0	500.0	734	1142	5209
5	10	0.0	0.0	319.0	130.2	0.0	50.8	0.0	500.0	727	1157	5145

Table 113. With the application of a scheme of forest incentives (CIF of 50%).

Availability of starting capital		Land use (ha)										
				Rotation grass-crops			Improved grasses					
Total US$ 000	Per ha US$	Forestry Caribbean Pine	Native savanna	Rot 1	Rot 2	Rot 3	*Brachiaria* cv. Toledo	Association *B. decumbens* + *D. ovalifolium*	Total area utilized (ha)	Herd inventory (heads)	Net employmen t generation (journals)	Value of Objetive Function US$ 000
300	600	453.7	0.0	0.0	0.0	0.0	46.3	0.0	500.0	102	709	8239
200	400	311.6	0.0	116.8	32.8	0.0	38.8	0.0	500.0	311	829	7209
100	200	151.8	0.0	224.6	77.7	0.0	45.9	0.0	500.0	534	979	6161
50	100	71.9	0.0	278.4	100.2	0.0	49.5	0.0	500.0	646	1054	5637
25	50	31.9	0.0	305.4	111.4	0.0	51.3	0.0	500.0	702	1091	5375
10	20	0.0	0.0	312.0	128.2	0.0	59.8	0.0	500.0	734	1142	5209
5	10	0.0	0.0	329.0	130.2	0.0	50.8	0.0	500.0	727	1157	5145

Table 114. Dual purpose system Scale: 500 ha. Anticipated payment of environmental services d application of a CIF of 50%.

Land use (ha)								Herd inventory (heads)	Net employment generation (journals)	Value of objective function US$ 000
Forestry Caribbean Pine	Native savanna	Rotation grass - crops			Improved grasses		Total area utilized			
		Rot 1	Rot 2	Rot 3	*Brachiaria* cv. Toledo	Association *B. decumbens* + *D. ovalifolium*				
203.9	0.0	0.0	0.0	0.0	296.1	0.0	500.0	656	492	8786
361.7	0.0	0.0	0.0	0.0	138.3	0.0	500.0	306	620	8443
376.9	0.0	53.6	34.2	0.0	35.3	0.0	500.0	182	837	7507
256.9	0.0	110.7	93.3	0.0	39.1	0.0	500.0	300	1040	6556
206.5	0.0	134.6	133.0	0.0	25.9	0.0	500.0	317	1189	6045
181.7	0.0	146.4	162.4	0.0	9.5	0.0	500.0	303	1306	5718
173.4	0.0	150.4	172.1	0.0	4.1	0.0	500.0	299	1345	5609

Table 115. Technological evolution of a cow-calf operation with low starting capital in the Colombian Altillanura.

Level of development of the production system	Land use (ha)							Value of the objective function		Land shadow price	
	Pastures in monocultive			Rotations grass - crops			Forestry	US$ 000	Index	US$/ha	Index
	Native savanna	Improved *Brachiaria*	Association Grass - legume	Rot 1	Rot 2	Rot 3					
1. Extensive livestock with native savanna	482.2	17.8	0.0	-	-	-	-	277	100.0	136	100.0
2. Livestock + grass – crop rotations	0.0	13.7	0.0	343.5	9.9	132.9	-	1560	563.1	2692	1979.4
3. Livestock + grass – crop rotations + forestry	0.0	0.0	0.0	0.0	0.0	359.8	140.2	2704	976.2	4680	3441.2
4. Livestock + grass - crop rotations + forestry + sale of environmental services (C)	0.0	0.0	0.0	0.0	0.0	359.8	140.2	2750	992.8	4763	3502.2
5. Alternative 4,with policy to incentivate forestry (CIF)	0.0	0.0	0.0	0.0	0.0	359.8	140.2	2847	1027.8	4936	3629.4
6. Alternative 5, with anticipated payment for environmental services	0.0	0.0	0.0	9.1	0.0	254.6	236.3	4215	1521.7	6631	4434.6

Table 116. Technological evolution of a dual purpose livestock system with low starting capital in the Colombian Altillanura.

Level of development of the production system	Land use (ha)							Value of the objective function		Land shadow price	
	Pastures in monocultive			Rotations Grass - crops							
	Native savanna	Improved *Brachiaria*	Association Grass - legume	Rot 1	Rot 2	Rot 3	Forestry	US$000	Index	US$/ha	Index
1. Extensive livestock with native savanna	484.3	15.7	0.0	-	-	-	-	778	100.0	546	100.0
2. Livestock + grass – crop rotations	0.0	59.8	0.0	312.0	128.2	0.0	-	5163	663.6	9736	1783.1
3. Livestock + grass – crop rotations + forestry	0.0	59.8	0.0	312.0	128.2	0.0	0.0	5163	663.6	9736	1783.1
4. Livestock + grass - crop rotations + forestry + sale of environmental services (C)	0.0	59.8	0.0	312.0	128.2	0.0	0.0	5209	669.5	9829	1800.2
5. Alternative 4,with policy to incentivate forestry (CIF)	0.0	59.8	0.0	312.0	128.2	0.0	0.0	5209	669.5	9829	1800.2
6. Alternative 5, with anticipated payment for environmental services	0.0	9.5	0.0	146.4	162.4	0.0	181.7	5718	735.0	10317	1889.6

use, crop rotations in order to construct arable layers, the increase in employment is estimated in 1,121 wages. If the farm had the dual purpose system, the increase in employment would exceed 1,500 wages/year. The forestry alternative to produce wood and sequester carbon, at this level of starting capital, is a more attractive optioin in the specialized beef farm. In the dual purpose farm, the forestry option only appears in the optimal solution when the combination of a forest incentive is accompanied by an anticipated payment of carbon sales (Tables 115 and 116).

Conclusions

The traditional livestock systems in the savannas of Llanos of Colombia based to a great extent in the utilization of native pastures as the main forage source, generates levels of productivity and profitability that makes their survival in a globalized world very difficult. The savannas provides a large geographical space with the opportunity of high productive potential, which should be used strategically to conserve its soil resources, classified by experts as very fragile from the physical and chemical standpoint. The simulations of several technological scenarios carried out in this study show that the incorporation of new components to the current livestock systems would constitute a powerful tool to stimulate regional agriculture, while improving the productive capacity of the soil.

In the evaluated scenarios, the level of starting capital determines to a high degree the capacity of the systems to incorporate new technological options. Forestry production would be a good option to the extent that the region invest in reasonable means of transportation and adequate infrastructure for the management and processing of forest products. The current prices in the international carbon market are low and this trend is expected to continue in the next 5–6 years. This circumstance determines that the sale of carbon sequestered by trees and pastures do not represent a significant income in the farm economy and has a low impact on land use.

4.7 Multiplication and delivery of experimental and basic forage seed

Highlights

- Over one ton of seed was produced by the Forage Seed Multiplication Unit at CIAT-Palmra during the 15-month reporting period (September 2004 and December 2005). Five hundred forty-three seed samples, totaling 1.2 t, were dispatched during the same period to eleven different countries.

- The Seed Unit at Atenas continues to produce, procure and deliver under request experimental and basic seed of promising forage germplasm. This year 491 kg of seed were delivered in response to 53 requests from 9 countries; the bulk of the seed was formed by *C. argentea* (96.6 kg), *Brachiaria* spp. (115 kg) and *A. pintoi* (184.4 kg).

4.7.1 Multiplication and delivery of selected grasses and legumes from the Seed Unit in CIAT-Palmira, Colombia

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

Rationale

The delivery mechanism for our technology — improved germplasm — is generally in the form of seed. For many of the plants 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 most reliably be met by internally generated supplies. The Project maintains a modest seed multiplication and processing capacity at headquarters to meet this demand.

Materials and Methods

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.

Results and Discussion

Just over one ton of seed was produced and processed by the Forage Seed Multiplication Unit at CIAT during the 15-month reporting period (September 2004 to December 2005) (Table 117). Project priorities, as reflected by volumes of seed produced of the different forage species, are similar to last year's. A significant proportion of the total (nearly 40%) was seed of *Cratylia argentea*. Significant quantities of *Lablab purpureus* (167.2 kg) and *Canavalia brasiliensis* (59.4 kg) were also produced. Smaller quantities of seed of 34 accessions of 13 additional species completed the total (Table 117).

Table 117. Seed of 63 accessions of 15 species produced and processed by the Forage Seed Multiplication Unit (CIAT-Palmira) between September 2004 and December 2005.

Genus	Species	Number of accessions	Harvest (kg)
Lablab	*purpureus*	13	167.2
Arachis	*pintoi*	1	3.5
Cratylia	*argentea*	9	385.5
Leucaena	*leucocephala*	6	155
Pueraria	*phaseoloides*	2	10
Canavalia	*ensiformis*	3	22.2
Canavalia	*brasiliensis*	7	59.4
Brachiaria	sp.	2	8.5
Brachiaria	*brizantha*	7	101
Brachiaria	*decumbens*	1	50
Brachiaria	*lachnantha*	1	16
Calliandra	*calothyrsus*	5	13.5
Centrosema	*acutifolium*	2	2
Stylosanthes	sp.	1	0.4
Stylosanhtes	*guianensis*	3	37.6
	Totals	63	1031.8

Seed distribution was 20% in excess of production during the reporting period, relying on carryover stocks from 2004 (Table 118). A total of 543 individual samples were distributed to a diversity of end users in 11 different countries (Table 119).

Table 118. Volumes of seed of 24 forage genera distributed by the Forage Seed Multiplication Unit (CIAT-Palmira) between September 2004 and December 2005.

Genus	Kilograms	Genus	Kilograms
Andropogon	4.4	*Hyparrhenia*	0.8
Arachis	2.1	*Lablab*	29.1
Brachiaria	223.0	*Leucaena*	33.8
Cajanus	9.4	*Melinis*	5.2
Calliandra	1.0	*Mucuna*	19.3
Canavalia	24.8	*Panicum*	17.9
Centrosema	17.3	*Paspalum*	3.5
Clitoria	1.0	*Pennisetum*	0.01
Cratylia	738.6	*Pueraria*	1.3
Desmodium	27.3	*Stylosanthes*	7.1
Dioclea	1.5	*Zornia*	7.4
Flemingia	31.8	Total	1207.6

Table 119. Forage seed samples dispatched by the Forage Seed Multiplication Unit (CIAT-Palmira) to eleven countries between September 2004 and December 2005.

Country	Number of Samples
Germany	6
Bolivia	2
Colombia	502
Costa Rica	1
Ecuador	1
United States	1
Honduras	7
Kenya	5
Nicaragua	15
Thailand	1
Trinidad and Tobago	2
Total	543

4.7.2 Multiplication and delivery of selected grasses and legumes from the Seed Unit of CIAT-Atenas, Costa Rica

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

Seed multiplication activities of promising forage germplasm continued during 2005 at the Atenas Seed Unit (Costa Rica) in collaboration with the Escuela Centroamericana de Ganadería (ECAG). The seed either produced or procured is destined to support advanced evaluations and promotions of forage germplasm both by CIAT's projects and regional research/development institutions.

From September 2004 through August 2005 a total of 392.6 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* (105.5 kg), *Brachiaria* spp. (5.3 kg), *Brachiaria* hybrids cv. Mulato and cv. Mulato II (211.9 kg), *Arachis pintoi* (19.9 kg), *Leucaena* spp. (5.8 kg), *Centrosema* spp. (0.3 kg), *Stylosanthes guianensis* AFT 3308 (20.7 kg), *Vigna* spp. (6.5 kg) and *Panicum maximum* (1.3 kg) and *Paspalum* spp. (3.40 kg). Also 12.0 kg of other forage species.

During the period September 2004-August 2005 a total of 490.6 kg of experimental and basic seed was delivered by the Seed Unit of Atenas (Costa Rica).

Table 120 shows that 53 seed requests were received from 9 countries, where most of the requests came from Costa Rica, the host country of the forage project. However, a significant amount of experimental seed was delivery to Guatemala (154.0 kg) and to Honduras (100.7 kg), both countries involved in forage projects with the participation of CIAT.

A high amount of basic and experimental seed of the promising forage legume *Arachis pintoi* (184.4 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.

Table 120. Countries, number of requests and amount of experimental/basic forage seed delivered by the Seed Unit of Atenas (Costa Rica) during the period August 2004-August 2005.

Country	No. of Requests	Forage species (kg)				Total
		Brachiaria spp.	*A. pintoi*	*C. argentea*	Other species	
Colombia	1			0.8		0.8
Costa Rica	35	67.5		41.1	74.5	183.1
Guatemala	6		105.0	43.0	6.0	154.0
Haití	1			1.0		1.0
Honduras	4	18.0	78.0	2.2	2.5	100.7
Kenya	1	2.0				2.0
Nicaragua	3	26.0	1.4	8.5	11.6	47.5
Perú	1	1.0				1.0
Venezuela	1	0.5				0.5
Total	53	115.0	184.4	96.6	94.6	490.6

4.8 Facilitate communication through journals, workshops and the Internet

Highlights

- An expert system to target forages (SoFT) was completed in 2005 and launched at the International Grassland Congress in 2005. Since the time of release of SoFT, 700 to 800 CD copies have been distributed.
- A total of 178 technicians from National Institutions in four Central America countries were trained on pasture establishment, forage seed quality and forage conservation for dry season feeding.
- An international workshop on adaptation of forages/crops to acid soils was organized by EMBRAPA and CIAT. Progress on improving acid soil adaptation of forages/crops was presented and future areas for collaborative research were identified.
- Three issues of Pasturas Tropicales were published in 2005, with contributions from forage researchers from Brazil, Colombia, Costa Rica, and Argentina.
- The newly launched SoFT (Selection of Forages for the Tropics) included in the Forage web page has had a large frequency (11,000-15,000/month) of visit.

4.8.1 Expert systems for targeting forages: Selection of forages for the tropics (SoFT)

Contributors: B.C. Pengelly (CSIRO), B.G. Cook (QDPI), I. J. Partridge (QDPI), D.A. Eagles (CSIRO), M. Peters (CIAT), J. Hanson (ILRI), S. D. Brown (CSIRO), J. L. Donnelly (CSIRO), B. F. Mullen (CSIRO) , R. Schultze-Kraft (University of Hohenheim), A. Franco and R. O'Brien (CIAT)

Rationale

Forage research over the last 50 years has identified many tropical grasses and legumes that have a role in farming systems in developed and developing countries. Information on the adaptation and use of these species 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 of working with a wide range of forages in diverse farming systems. Selecting the right species and germplasm for particular environments and farming systems is a complex task and there is often poor access to information. This has frequently resulted in researchers not being able to learn from past experience, and there has always been a risk that repeating the mistakes of the past will result in lost opportunities and poor use of resources. Moreover, researchers and advisors in contact with communities have usually had poor access to up-to-date information on tropical forages, often resulting in suboptimal suggestions to farmers; a situation further aggravated by the decline in the overall number of forage experts over the last 20 years. In this context the main objectives for development of SoFT were:

- To develop a knowledge system for the identification of forages suitable for specified niches within smallholder farming systems in the tropics and subtropics.
- To promote the system within the "communities" who are using tropical forages.
- To develop a strategy for maintenance and updating the knowledge system.

Results and Discussion

This project attempted to access the best available information that would allow the adaptation and potential use of 180 tropical forage species and their elite cultivars or accessions to be defined and integrated in a single user-friendly database. The database, which includes a simple-to-use tool to assist in the selection of the best-bet species, is now freely available on the Internet (www.tropicalforages.info) and on CD (Photo 39).

The database has five 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 LUCID™ that enables easy identification of best-bet species
iii) a bibliography of more than 6,000 references and abstracts on forage diversity, management and use which will enable users with poor library facilities to access summaries of some of the key literature
iv) global maps of climate adaptation for each species
v) 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 forage specialists who have worked for many years in tropical and subtropical regions of Africa, lower latitude USA, Central and South America, South and South-east Asia and Australia. Selections are made on the basis of 19 criteria (Table 121). The project brought the teams of experts together in workshops in Africa, Asia, South America, Central America, Europe and Australia over a two year period and had input from other forage specialists during the database development.

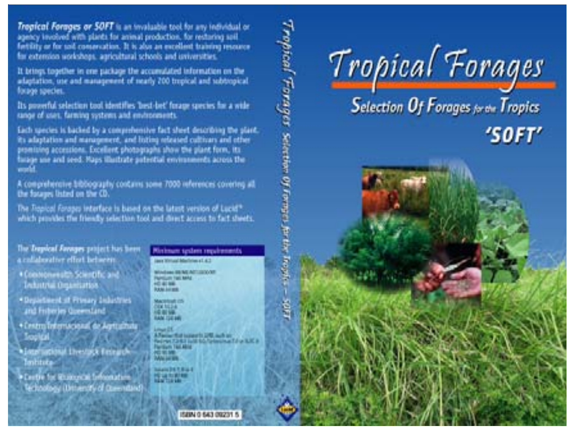


Photo 39. Screenshot Tropical Forages Database "SoFT".

The principal outcome has been summarised information on tropical forage adaptation and use from expert knowledge, available literature and experiential sources made available in a readily accessible and consistent format. With availability on DVD and the Internet, the database allows researchers and advisors to select those forages most suitable for local conditions. Although the database was initially designed for use in developing countries, its content includes species adapted to farming systems in developed countries and is equally applicable in these regions. The database covers a wide range of forage uses and allows users to select among many different farming systems ranging from permanent to short term pastures, with applications in agroforestry, inter-row cropping, cut-and-carry, hedgerows, green manures and ground covers.

The database has also been recognised as a valuable teaching tool for colleges and universities with feedback from many university

Table 121. 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		

staff from a wide range of countries attesting that the database and selection tool will have a major role in improving the way tropical forage science is taught.

The database was promoted during its development via the regional forage workshops attended by most practicing forage agronomists from different regions. Since then promotion has been through the partner organisations, particularly through the International centers (CIAT and ILRI), and in the delivery of a paper at the XXth International Grassland Congress in Ireland in June 2005. In addition to this paper, the project team conducted demonstrations at the Congress and over 100 tropical forage agronomists were able to test the selection tool and trawl the 180 fact sheets. The database is on the internet and each of the partner organisations is taking every opportunity to promote both database and selection tool. This is particularly so with the international institutes who have strong roles in their regions. Since the release in June 2005, there has been a steady increase in the number of visits to the Internet site, from 249 visits in June, to 360 visits in July, 755 in August, 2953 in September and 4810 in October. While larger number of these have been from Australia and the US, the latter with a large participation from Educational Institutions, there have been significant and increasing visits by users in Colombia, from CG centers Mexico, Peru, Brazil. Argentina, France, The Netherlands, Nepal, Guatemala, Switzerland, Thailand, Germany and Kenya.

Future actions

It was agreed at the commencement of the project that the database would reside on the CIAT Internet server and that CIAT would be responsible for its maintenance and its updating. This plan has now been put into place. However it has become apparent even after only a few months that new information needs to be added to the fact sheets. It will be also necessary to translate the database into other languages (i.e. Spanish and French) to encourage its use and application in Latin America and the Caribbean and francophone Africa, respectively.

4.8.2 Training courses in Central America

Contributors: P. J. Argel, G. Pérez, P. Lentes (CIAT), C. Reiber (U. of Hohenheim), H. Cruz (CIAT-DICTA)

During the period October 2004 through September 2005, six training courses on topics related with forage technology were held in Nicaragua, Honduras, Guatemala and Costa Rica, within the frame of the Project Enhancing Beef Productivity, Quality, Safety and Trade in Central America financed by CFC and coordinated by ILRI.

In Table 122 we show that 178 technicians from different national institutions participated in the workshops on topics related with pasture establishment and measurement, forage seed quality, and forage conservation practices. A considerable number of farmers participated as well, particularly in Guatemala and Nicaragua where silage of forages in small plastic bags is being promoted as viable practice of forage conservation for small farmers. Many of the technicians trained are responsible for on-farm forage monitoring in collaborating farms of the ILRI/CFC Project, thus facilitating the documentation of the impact on farm productivity due to the establishment of improved pastures.

During 2005 training courses and field days to demonstrate to farmers how to make hay and silage were also carried out in Honduras as part of BMZ, Germany Special Project. The events carried out are summarized in Table 123.

Table 122. Training courses carried out in participating countries of the project Enhancing Beef Productivity, Quality, Safety and Trade in Central America during the period October 2004 to September 2005.

Country	Date	Participants (No.)	Themes	Participating Institutions/Farmers
Nicaragua	28-29 Oct. 2004	55	Pasture establishment Forage seed quality	IDR*, INTA, UNA, MAG/FOR, Duwest
Honduras	9-11 Nov. 2004	12	Pasture establishment Forage seed quality	DICTA, Duwest
Guatemala	18 March 2005	16	Pasture establishment Forage seed quality	ICTA, U. de San Carlos, MAGA, FECAGUATE
Costa Rica	1 July 2005	15	Pasture measurements	CORFOGA, CGUS, Dos Pinos, Coopemontecillos, ECAG
Nicaragua	21 Sept. 2005	15	Forage conservation	INTA
	22 Sept. 2005	12	Forage conservation	INTA/ Small Farmers,
	23 Sept. 2005	25	Forage conservation	IDR
Guatemala	28 Sept. 2005	28	Forage conversation	MAGA, Small Farmers

* IDR, Instituto de Desarrollo Rural; UNA, Universidad Nacional; INTA, Instituto Nicaraguense de Tecnología Agropecuaria (Nicaragua) and Instituto Nacional de Innovación y Transferencia de Tecnología Agropecuaria (Costa Rica) respectively; MAG/FOR, Ministerio de Agricultura, Ganadería y Forestal; DICTA, Dirección de Ciencia y Tecnología Agropecuaria; ICTA, Instituto de Ciencia y Tecnología Agrícolas; MAGA, Ministerio de Agricultura y Ganadería; FECAGUATE, Federación Guatemalteca de Ganaderos; CORFOGA, Corporación de Fomento Ganadero; CGUS, Cámara de Ganaderos Unidos del Sur; ECAG, Escuela Centroamericana de Ganadería.

Table 123. Training courses carried out in Honduras as part of BMZ, Germany Special Project during the period October 2004 to December 2005.

Event	Dates	Location	Participants		
			M	F	Total
Pasture establishment Pasture seed quality IDR*, INTA, UNA, MAG/FOR, Duwest	28-29/10/2004	Nicaragua			55
Pasture establishment Pasture seed quality DICTA, Duwest	9-11/11/2004	Honduras			12
Pasture establishment Pasture seed quality ICTA, U. de San Carlos, MAGA, FECAGUATE	18/03/2005	Guatemala			16
Pasture measurements CORFOGA, CGUS, Dos Pinos, Coopemontecillos, ECAG	1/07/2005	Costa Rica			15
Pasture conservation INTA INTA/ Small Farmers, IDR	21/09/2005 22/09/2005 23/09/2005	Nicaragua			15 12 25
MAGA, Small Farmers	28/09/2005	Guatemala			28
Training course on pasture seed harvesting and seed quality with emphasis on Toledo grass designed to Victoria small farmers associated in Prasefor (a pasture seed cooperative)	24/04 to 05/05 2005	Yoro, Honduras			
Management and conservation (hay and silage) of forages, theoretical part with participative evaluations	5/21/2005	Sulaco, Yoro, Honduras	12	1 (10 pupils)	23
Management and conservation (hay and silage) of forages, theoretical part with participative evaluations	6/7/2005	Yorito, Yoro, Honduras	20	4	24
Establishment and use of legumes for concentrate production	6/8/2005	Salitre, Yoro, Honduras	4	8	12
Characteristics and management (establishment) of Cowpea, *Lablab purpureus* and *B. brizantha* cv Toledo, hay and concentrate production and its use	6/8/2005	La Savanna, Yoro, Honduras	3	6	9

Continues……

Continued……

Table 123. Training courses carried out in Honduras as part of BMZ, Germany Special Project during the period October 2004 to December 2005.

Event	Dates	Location	Participants		
			M	F	Total
Management and conservation (hay and silage) of forages, theoretical part with participative evaluations	6/9/2005	Las Vegas/Victoria, Yoro, Honduras	13	1	14
Management and conservation (hay and silage) of forages, theoretical part with participative evaluations	6/14/2005	Alauca, El Paraiso, Honduras	13	1	14
Management and conservation (hay and silage) of forages, theoretical part with participative evaluations	6/15/2005	Jamastrán, El Paraiso, Honduras	15	3	18
Management and conservation (hay and silage) of forages, theoretical part with participative evaluations	6/16/2005	Jesus de Otoro, Intibuca, Honduras	6	1	7
Management and conservation (hay and silage) of forages, theoretical part with participative evaluations	6/17/2005	Catacamas, Olancho, Honduras	21	5 (12 pupils)	38
Forage conservation with practical training in little bag silage production	9/13/2005	Yoro, Yoro, Honduras	22	0	22
Silage making with special focus on little bag silage, practice	9/22/2005	Alauca, El Paraiso, Honduras	20	4	24
Silage making with special focus on little bag silage, practice	9/23/2005	Jamastrán, El Paraiso, Honduras	45	5	50
Silage making with special focus on little bag silage, practice	9/24/2005	Victoria, Yoro, Honduras	26	3	29
Forage conservation with practical training in hay and little bag silage, the characteristics of improved forages	9/27/2005	Las Tres Ceibas Olancho, Honduras	22	3	25
Forage conservation with practical training in hay and little bag silage, the characteristics of improved forages	9/26/2005	Las Tres Ceibas Olancho, Honduras	19	8	27
Forage conservation with practical training in silage making (LBS and other silos), the characteristics of improved forages	11/29/2005	El Rodeo, El Paraiso, Honduras	7	2	9
Use of legumes for hay and concentrate preparation presented to 2 non-cattle farmer groups	12/9/2005	Yorito, Yoro, Honduras	2	10	12

4.8.3 International workshop on advances in improving acid soil adaptation of tropical crops and forages (Organizers: EMBRAPA, CIAT and IRD)

Contributor: I. M. Rao (CIAT)

An international workshop on "Advances in improving acid soil adaptation of tropical crops and forages, and management of acid soils" took place in Brasilia, Brazil from 18 to 21 October 2005. This workshop was the result of interaction of a group of EMBRAPA forage researchers that visited CIAT last year to strengthen collaboration between CIAT and EMBRAPA. The event was organized by EMBRAPA (Drs. Ronaldo Andrade and Leide Andrade of CPAC), CIAT (Carlos Lascano and Idupulapati Rao) and IRD (Dr. Thierry Becker outposted staff at CPAC) with funds from Brazilian Government to the CGIAR that are administered via CIAT. The workshop had 30 participants from several centers of EMBRAPA, CIAT, Cornell University, IRD and other partners of EMBRAPA.

The main objectives of the workshop were: (i) To review the progress in improving acid soil adaptation of major food and feed crops and management of acid soils; (ii) To identify future research needs; and (iii) To develop collaborative research program (short and medium term) among EMBRAPA-CIAT and other partners to improve acid soil adaptation of tropical crops and forages and management of acid soil. The program for the Workshop included 1.5 days of invited presentations, 0.5 day of a session on future research needs, 1 day of field visit to CPAC labs and field experiments and a farm in the Cerrados, and 0.5 day of conclusions and final recommendations.

Highlights of the Workshop

- Professor Leon Kochian from USDA-ARS and the Cornell University, USA made the keynote presentation on physiological and molecular mechanisms of aluminum (Al) resistance in crops. Last year, the first gene for Al r ALMT1) was identified and cloned from wheat by a group of Japanese and Australian researchers. Attempts are being made by Cornell and EMBRAPA to clone the Al resistance gene (ALT_{SB}) from sorghum. It is clear that the mechanisms of Al resistance are more complex in rice and maize than in wheat and sorghum.

- CNPMS-EMBRAPA presented their work on breeding, physiology and molecular genetics of maize and sorghum. Researchers at this center have been very successful in releasing a number of acid soil adapted maize and sorghum cultivars for the past few years. The biotechnology group of CNPMS is working closely with the breeders and physiologists in identification and characterization of Al-induced genes in the root apex of grass species (maize, sorghum, rice, wheat, barley, oat and *Brachiaria*).

- CNPGC-EMBRAPA presented the results of team-work on agropastoral production in no-tillage systems in the Cerrados of Brazil. Great progress has been made in understanding vegetation and soil dynamics in a long-term experiment (12 years-old) on agropastoral systems. At present, there are about 6 million hectares that are under no-till systems in the Cerrados. One important observation made at this workshop is the dramatic increase in adoption of *Brachiaria brizantha* cv. Marandu in the Cerrados for the past 15 years due to its productivity potential and spittlebug resistance. This is an indication of need for spittlebug resistant and productive brachiaria grasses for acid soils.

- CIAT- TSBF – LAC presented the work with different partners (University of Hannover, Germany; Diversity Arrays Technology P/L, Australia; Hokkaido University, Japan; Yamagata University, Japan) on screening for Al resistance in common bean and *Brachiaria* and on gene identification for high level of Al resistance in signalgrass (*B. decumbens*).

- CIAT-TSBF-LAC- CORPOICA team working on acid soil management emphasized the contrasting differences in soil bulk density between the Llanos of Colombia and the Cerrados of Brazil (bulk density values are much higher in the Llanos and restrict root development). Results were also presented to demonstrate the need to build-up an arable layer to improve soil quality to facilitate no-till systems in the Llanos using the data from the long-term experiment of CULTICORE and the satellite experiments from Matazul in the Llanos of Colombia.

Conclusions and Recommendations

- Establish a network to develop research on acid soils involving Embrapa Centers (wheat, soybean, maize and sorghum, Cerrados, beef cattle, milk cattle, cotton, rice and beans, western crop-livestock, CENARGEN), International institutions (CIAT, IRD, CIMMYT) and universities (Cornell, UnB, UFRGS, UFLA, UFMG);
- Prioritize multidisciplinary approach including production systems with different crops and

forages;
- Identify prospective funding opportunities;
- Establish a network on phenotyping and genotyping for aluminum resistance and phosphorus efficiency;
- Develop a program for capacity building (e.g., short-term, long-term) in topics related to plant adaptation to acid soils and management of acid soils;
- Provide opportunities for special training in bioinformatics tools;
- Create databases on instrumentation, germplasm characterization and technical capabilities of EMBRAPA and partners; and
- Develop a plan for germplasm exchange and intellectual property rights and credit sharing among the partners.

4.8.4 Diffusion of research results: Pasturas Tropicales

Contributor: A. Ramírez (Independent Publisher) and C. Lascano (CIAT)

In 2005, three issues corresponding to Volume 27 of Pasturas Tropicales were published. The contributions came from researchers in institutions from Brazil (21), Colombia (4), Costa Rica (1) and Argentina (1) (Table 124). As in previous years, a large number of contributions coming from Brazilian institutions were observed. This is a reflection of the importance given to R&D in this country as compared to other countries in the region. In addition, it was interesting to note that publications in 2005 covered research topics not previously received from contributors, such as: agroforestry systems, nutritional value of fodder shrubs, use of organic

Table 124. Subjects and number of published contributions in Tropical Pastures during 2005.

Subject	27(1)	27(2)	27(3)	Institution*	Country
Adaptation of forages	1	1	1		Brazil
Rehabilitation pastures			1	UFRPE, ESALQ, Univ. de Hohenheim-Embrapa	Brazil
Inoculation methods	—	—	1	UFRRJ	Brazil
Seed production	1	—		EPAMIG-Brazil	
Agroforestry	1	1	1	Univ. de Brazilia	Brazil
				Embrapa-Agrobiología	
				EARTH	Costa Rica
Phytopathology	—	1	—	Embrapa-CNPGC	Brazil
Entomology	—	1	—	CIAT	Colombia
New cultivars	—	1	—	CIAT	Colombia
Nutritious quality-shrubs	1	—	—	Embrapa-CPAC	Brazil
Fertilization	—	—	1	UFLA	Brazil
				UFFRJ	
Organic fertilization	1	—	1	Embrapa-Agrobiología	Brazil
Green manure	1	1	1	Embrapa-Agrobiología	Brazil
Establishment	—	1	1	UFRPE	Brazil
				INTA-Univ. de Tucumán	Argentina
Animal production	1	2	—	Corpoica, CIAT	Colombia
				Embrapa-Amazonia	Brazil
Impact of germplasm adoption	—	—	—	CIAT	Colombia
Simulation model/growing	—	2	1	ESALQ	Brazil
Total	**7**	**11**	**9**		

* UFRPE = Universidade Federal Rural de Pernambuco, ESALQ = Escola Superior de Agricultura Luiz de Queiros, UFRRJ = Universidade Federal Rural de Rio Janeiro, EARTH = Escuela de Agricultura de la Región de Trópico Húmedo, CNPGC = Centro Nacional de Pesquisa de Gado de Corte, CIAT = Centro Internacional de Agricultura Tropical, CPAC = Centro de Pesquisa Agropecuária dos Cerrados, Corpoica = Corporación Colombiana de Investigación Agropecuaria.

and green manures, and simulation models. As in previous years, we received contributions related to quality, animal production, and fertilization of fodder species were received and published (Table 124). Finally, the magazine is being edited and produced completely by Tropical Forages Project and this has contributed to its timely distribution.

4.8.5 Update on the Forage Web Site

Contributors: S. Staiger, B. Hincapie, A. Franco and M. Peters (CIAT)

The Tropical Forages Web site is the result of team work between all project members, under the general coordination of the Communications Unit and Support of both the Systems and the Information and Documentation Unit. The website has allowed us disseminate our research results extensively and promptly communicate important news. The site is accessible under the URL http//:www.ciat.cgiar.org/forrajes/index.htm.

In 2005 about 80.000 pages were visited (i.e. 6.625 pages per month) with a high frequency of visits on the Spanish version of the web page. The highest number of downloads were recorded for manuals on *Brachiaria brizantha* cv. Toledo and *Cratylia argentea* cv. Veranera and the Pasturas Tropicales journal. Noteworthy is also the high number of downloads of manuals on seed production of cv. Toledo indicating the high probability of on-farm seed multiplication of this species.

An additional 53000 pages (4.484/month) were visited on the Tropileche website, with a very high number of about 74,000 downloads (6131/month)

In July 2005 the Selection of forages for the tropics (SoFT) web site was launched in collaboration with CSIRO, QDPI, ILRI and the University of Hohenheim the web site can be accessed under URL http//:www.tropicalforages.info (see section 4.8.1). After a slow start the site has been very well accepted by users around the world, with between 11000 and 15000 pages visited per month from September to October. The site is most frequented by users from Australia, the US including educational institutions, Mexico, Colombia and Brazil.