# 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

### 4.1.1 Revised CIAT- ILRI strategy for forages/livestock R&D in Africa

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During 2005 and 2006 scientists from CIAT and ILRI discussed ways to collaborate in Africa in livestock/forage research based on the principles of comparative advantage and complementarity. One outcome of the discussions between the two centers was the preparation of strategy for R&D in Eastern and Southern Africa. The main elements of the strategy are outlined bellow. However, the strategy has not been implemented due financial limitations. Thus a priority in the near future is for CIAT and ILRI to appoint a Forage/Livestock scientist in Africa with the responsibility of creating partnerships and seeking funds to implement forage research.

#### The Problem

Most parts of sub-Saharan Africa are stricken by extreme poverty, and with limited resources for investment. HIV/AIDS is further impoverishing communities and is leading to increased labor scarcity. Livestock play an important role in the crop-livestock systems, which provide a livelihood for the majority of Sub-Saharan African (SSA) farmers. Specialized livestock production systems are mostly extensive in nature and concentrated in the arid and semi-arid zones. There is an evolution going on within the extensive livestock systems to integrate crop production. Productivity of livestock is generally low, and the potential positive contribution of livestock to food sufficiency, household income, asset building, equity, and integrated natural resources management has not been realized.

Problems related to stagnation of smallholder livestock production systems in SSA can be grouped as follows:

1. Poverty:
   a. Livestock systems are characterized by low inputs. Poverty is wide spread, and farmers in the crop-livestock systems prioritize their scarce investments to production of staples or high value crops.
2. Physical environment:
   a. Large parts of the continent have unfavorable conditions for fodder production such as low soil fertility, low annual rainfall and frequent droughts, and high prevalence of animal diseases.
3. Markets and economies:
   a. Low prices for animal products and lack of market orientation of livestock producers.
   b. Lack of infrastructure and policies that do not favor increase of livestock production.
   c. Poor integration of rural communities and private sector.
   d. Unstable political environments.
4. Research and information flows:
   a. Lack of access to information on improved livestock technologies.
   b. Livestock technologies don't bear relevance for end-users.
5. Cultural:
   a. Aim of livestock production for cultural reasons rather than for profit or maximizing productivity.
   b. Low levels of mechanization and peaks of labor demand.

The areas of common interest of research in Africa between CIAT and ILRI are tropical forages and livestock systems. In crop-livestock systems the introduction of high quality forages with adaptation to low fertility soils and to drought is seen as entry point not only to increase livestock productivity but also to reclaim degraded lands. In addition improved forages can result in more efficient use of scarce family labor for harvesting fodder and for feeding livestock. Required investments in smallholder forage systems are usually low, except for labor during the establishment phase, and for returning manure or slurry.

Forages have a high potential to improve livelihoods and environment in the following livestock systems in East and Southern Africa:

1. Intensive dairying. Smallholder stall fed systems with one or two improved cows integrated with crops. Sub-humid zones such as highlands of Kenya, Tanzania, Rwanda and Ethiopia. Although these farmers are resource poor smallholders, they are better off than others in their community who do not own dairy cattle. Some larger and wealthier ranches exist.
2. Semi-intensive dairying. Tethering and herding, sub-humid and semi-arid zones. e.g. cross-bred cattle in Kenya, Uganda, Tanzania. These households are poor to average in terms of wealth.
3. Semi-intensive and intensive small ruminant systems. These livestock systems are usually found across all wealth categories. e.g. Kenya, Uganda, Tanzania, Ethiopia.
4. Intensive beef ranches, e.g. Uganda, Malawi, South Africa. These are owned by wealthy farmers.

Forages can have a medium impact on livelihoods, but high impact on the environment in the following livestock systems:

1. Sedentary semi-intensive herds of cattle and small ruminants. Medium to large numbers of animals, mostly herding on unimproved common property pastures with strategic supplemental feeding. Animals are sold for slaughter during times of cash need or used for dowry payments and other ceremonies. Wealth status ranges from poor to rich, depending on numbers of animals owned. E.g. Uganda, Rwanda, Malawi.
2. Evolving pastoralist dual purpose and mixed animal species. Large herds of cattle, small ruminants and camels by trans-humant pastoralists. High value of property but rarely commercialized. Proportion of agro-pastoralists in this category, who are more market oriented, is growing. Agro-pastoralists have fewer animals and their wealth category is variable. e.g. Kenya, Uganda, Tanzania, Ethiopia.
3. Animal traction based highlands of Ethiopia. Primary purpose of cattle and equines: ploughing and transport. In addition, milk from local cows processed and sold by women. Poor households.
4. Non-ruminant systems, such as pigs, fish, apiculture. E.g. Malawi, Ethiopia, Kenya. Wealth ranges from poor to rich.

Although prices of livestock products are generally low in SSA compared to other parts of the world, livestock production can still be attractive compared to commercial crop production, for which prices are much lower. Grazing resources are becoming scarcer due to pressure on land for other uses by an ever-increasing human population. This has resulted in dwindling numbers of livestock in many places in SSA, which will drive up the price eventually. Alternative ways for increased prices for livestock products are in the export, which has a few yet hard to obtain openings.

**The Strategy**

Opportunities for forage/livestock based technologies in smallholder production systems in Eastern and Southern Africa will be identified and prioritized in areas of high and medium market potential, where high impacts of research can be expected in terms of adoption of improved forage technologies and poverty reduction. Except for the intensive beef ranches, all livestock systems described above are found among poor households. Poor households who do not own livestock, or which have low market potential for the livestock they own, will be targeted through production and sale of forage products which are consumed by the livestock systems in the medium to high market potential category. Forage as a marketable crop could be another arrow on a farmers' bow to kill poverty. Forage technologies to meet farmers' demands will be developed with participatory, market analysis and innovation systems. Partnerships with different public and private institutions will be strengthened to carry out joint research, training and dissemination activities. Public private linkages are a key mechanism for scaling. Thus linkages with private companies (i.e. Papalotla) for seed supply systems and NGO for marketing of dairy products will be assessed. South-south exchange will be promoted as a means of catalyzing dissemination of improved forage/livestock technologies and R&D methodologies. Close linkages will be observed with national partners, and existing networks will be building on such as the ASARECA - Animal Agriculture Network (AAARNET). The joint CIAT-ILRI work will enable national partners to find solutions rather than fix solutions by itself. Once a common research agenda between CIAT and ILRI has been agreed, discussions will be opened with EMBRAPA on a shared strategy for Africa.

**Target research areas**

Smallholder mixed crop-livestock and dairy systems linked to markets will be targeted, where improved forage systems can have a high chance of being adopted and contribute to reducing poverty. In addition, farming systems without livestock or with low livestock market potential will be targeted through fodder or seed production which feeds into other livestock systems.

The following criteria will be used to target the geographic areas and specific subjects of research:

1. High potential to extrapolate and scale out results of the research.
2. High potential to tap markets for livestock or their products.
3. High potential to reduce poverty.
4. Agreement with the partners operating in the area.
5. Close interaction with relevant staff from IRI and CIAT should be possible in the selected location(s).

Arusha, Tanzania will be an appropriate location to base the joint CIAT-ILRI staff. Smallholder integrated crop-livestock systems and intensive dairy systems are prevalent in this region. There are rural and national market opportunities for dairy products. Not far from Arusha, pastoral systems are evolving from extensive herding to mixed crop-livestock systems in large numbers. Innovations can be relatively easily scaled out and up in Tanzania and surrounding countries. Partners in Tanzania have been identified during the joint CIAT-ILRI reconnaissance study in 2001. Expertise exists within both institutions to improve the feed and soil systems through improved forage options, and a range of adapted forage germplasm is available. Arusha is centrally located in the region, with easy access to Nairobi (ILRI - HQ) and Kampala (CIAT Africa office).

**Key activities of the joint research agenda**

**1. Selecting priority intervention areas**

Areas with high concentration of smallholder intensive and semi-intensive dairying, intensive and semi-intensive small ruminant systems, sedentary semi-intensive herding, evolving pastoralist systems, animal traction based highlands, and non-ruminant systems will be mapped in East and southern Africa using secondary information where available, and through discussions with national partners. These maps will be overlaid with mixed crop-livestock systems (excluding the specialized livestock systems) with constraints of land and feed resources and at the same time market opportunities for livestock products, through discussions with partners. Initially, these systems will be mapped for Tanzania, Kenya, Uganda, Rwanda, Lake Kivu region, and Ethiopia. Later the same will be done for Malawi, Zimbabwe, Mozambique, Zambia, Burundi, Sudan and Madagascar. Targeted surveys and stakeholder meetings within the marked areas in the maps will be used to select sites for intervention. Additional criteria for targeting intervention areas are the maps of density of poor livestock keepers; Ethiopia, Eritrea, Uganda, Kenya, Tanzania, Rwanda, Burundi, Malawi and South Africa have high concentrations (2-20 persons per $km^2$) of poor livestock keepers in East and Southern Africa.

**2. Identification of market opportunities**

In order to get a good picture of market opportunities at micro level, one needs to have an understanding of the situation at meso and macro level, which will provide insight in the limitations of the opportunities. Data on production, consumption, export and import of milk and meat will be summarized initially for the priority countries Tanzania, Kenya, Uganda, Rwanda, Lake Kivu region, Ethiopia and later for other countries mentioned earlier. Existing marketing structures within countries will be summarized through discussions with local partners. Ex-ante market and impact studies will be carried out to assess the demand and price elastics of livestock products. Through combined surveys and stakeholder meetings mentioned at activity 1, market opportunities at micro-level will be assessed. A survey will be conducted in targeted areas on sales and demand of forage products, e.g. legume leaf meal, hay, or fresh forage.

**3. Forage germplasm evaluation**

Improved grasses and selected legume accessions with superior mechanisms to deal with abiotic stress factors prevalent in many parts of Africa such as soil acidity, low soil fertility and drought will be evaluated in multilocational researcher - led trials in terms of seasonal biomass production, forage quality and seed yield. A collection of forage species will be maintained in Africa to provide foundation seeds for national seed systems, private seed companies and R&D projects.

**4. Development of forage and food-feed technologies with farmers**

At selected sites, and through national partners, new forages and food-feed crops will be tested and evaluated with farmers. Principles of participatory and action research approaches and participatory monitoring and evaluation will be used to ensure appropriateness for and adoption by end-users. Processes of change will be evaluated in an innovation systems context; weak linkages among essential actor will be identified and strengthened, sustainable ways of information flows sought, and capacity strengthened to innovate. Territorial approaches for marketing related to dairy and crop-livestock systems will be tested and adapted.

**5. Seed production and distribution systems**

Work on forage seed supply systems is an important part of the joint CIAT-ILRI research agenda as a means to raise income and enable scaling. To identify suitable sites for seed production, tools such as Homologue, and CANASTA will be explored. With relatively little extra work, specific adaptation maps can be produced from ongoing CIAT and ILRI activities. Public-private linkages as well as complementary farmer - led efforts will be explored and developed. Linkages with private seed companies (i.e. Papalotla) will be strengthened. This work will also link with existing activities such as work of CIAT on seeds in Eastern Africa.

**6. Reversing land degradation**

Improved forages have the potential to improve soil nitrogen and organic matter, increase water holding capacity of the soil, and stabilize soil in erosion prone areas. These potentials of forages and food-feed crops will be evaluated and optimized in relation to dairy and crop-livestock systems with high market potential. The hypothesis that market opportunities improve farmer investments in natural resources through sustainable use of forages will be tested.

**7. Information systems, capacity building, and enhanced learning**

Rural communities need to have access to high quality and appropriate information about forages and food-feed crops in order to facilitate choices and decisions on what to grow. National partners have the prime responsibility to provide this information in at the places where it is needed. A system will need to be in place to facilitate knowledge management. The new package 'SoFT' provides a model for which forages can grow where. A-AARNET will be the appropriate channel to facilitate knowledge management and capacity building of national partners. Training on forage technologies, seed production, and agro-enterprise development will be targeted where necessary. A regional community of practice under the umbrella of A-AARNET will be established to exchange information and to enhance learning on research approaches which enhance uptake and impact of forage systems.

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

### Highlights

- A strategy for collaboration in forage/livestock R&D in Asia was agreed between CIAT and ILRI based on a common vision, comparative advantages and strengths of the two institutions

- Forage research from 1992 to 2006 has led to considerable adoption of forage technologies and has resulted in the development of new forage-based livestock systems that provide significant livelihood benefits to poor farmers

- Lessons learnt from developing and scaling out of improved forage technologies are providing useful guidance to development practitioners

- Forage legumes are emerging as a viable option for improving village pig production systems through improved protein nutrition

### 4.2.1 Revised CIAT- ILRI strategy for forages/livestock R&D in Asia

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Scientists from CIAT and ILRI after several discussions have identified concrete opportunities for collaboration based on a common vision, comparative advantages and strengths of the two organizations. It is recognized that both institutions should continue their own activities in the area of livestock research for development and, as such, linkages between CIAT and ILRI will range from keeping each other informed of activities through the development and implementation of joint projects.

**Past and current research areas**

CIAT has implemented several regional and bi-lateral forage and livestock-related projects in upland areas of Southeast Asia, starting in 1992, with particular emphasis on
- identification of suitable forage varieties for upland areas in SE Asia,
- development of farmer participatory approaches to forage technology development,

- integration of forages into smallholder crop-livestock systems in upland areas
- developing approaches for scaling out identified forage systems
- formation of an active network of forage researchers and extension workers
- developing approaches for participatory livestock production to market constraints and opportunities
- linking livestock production with other aspects of farming systems (e.g. production and utilization of cassava, sweet potato, etc.)

As these projects developed, the emphasis of projects has broadened from forage evaluation to approaches of working effectively with farmers to integrate forages into crop-livestock systems, to scaling out successful examples, to identifying and overcoming marketing constraints. There is now a very active network of national partners who have been involved in these projects. Weaknesses are in the areas of animal nutrition and policy.

ILRI Initiated projects in the region in 1998, emphasizing:

- development of sustainable technologies for small holder crop-livestock systems
- analysis of existing policy and identification of policy options for smallholder production systems
- development of technologies and participatory approaches to small ruminant enterprises
- formation and support of an active network of livestock researchers and extension agencies

## A common vision

Both CIAT and ILRI are working on ways of promoting increased market orientation of smallholder farmers in the region. This is based on the rapidly increasing demand for meat in Asia which makes livestock production an increasingly attractive farm enterprise. Innovative farmers are looking for ways of expanding livestock production to take advantage of this opportunity. This requires a more market-oriented production system but based on minimal cash inputs, at least during the transitional phase. Forages grown on farm are playing a key role as the enabling factor for intensification as they can provide the additional feed needed with minimal inputs. Access to markets and a good understanding of market demands for meat quality are also critical factors to enable farmers to benefit from improved livestock productivity.

Understanding enabling policies that promote increased smallholder livestock production are needed, particularly at local government level. The benefits of more intensive smallholder livestock production are significant at household level and can be widespread as the vast majority of livestock is in the hands of smallholders.

ILRI and CIAT have the complementary skills to work towards this vision of increasing the productivity and market orientation of smallholder farmers in Asia through better use of feed, livestock resources, marketing and policies through partnerships with the existing networks of national partners.

To achieve this vision the two centers should work together to develop:

1. A Knowledge Network for Livestock in South East Asia based on previous work and existing networks of national partners.
2. Technology, marketing and policy options that support the intensification of smallholder crop-livestock systems, to enable the transition from subsistence to market orientation.

## Principles for collaboration and funding

- Try to seek funding/project opportunities that exploit the complementarity of the two institutions and should not attempt to do all livestock related work as joint activities
- CIAT has had a greater focus on SE Asia, with no activities in S Asia in the livestock area, while ILRI has worked in both areas, with a greater focus in S Asia. Within the obvious personnel constraints, the two centers should attempt to cross-fertilize these activities.

### 4.2.2 A survey of adoption of improved forages in Southeast Asia

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#### Rationale

CIAT commenced forage research in Southeast Asia in 1992 with the introduction of a large range of forge accessions. In 2005, two major CIAT forage projects – the regional Livelihood and Livestock Systems Project (LLSP) and the bi-lateral Forages and Livestock Systems Project (FLSP) in Laos were completed (Table 42). By this time, the long-term commitment of CIAT and its partners had led to significant livelihood benefits and adoption of planted forages by a large number of smallholder households in the region. These were documented in a survey and impact studies and a summary of the results is provided in this section.

The survey commenced with assembling a list of households growing forages at pilot sites; from these lists up to 50 households were selected randomly for semi-structured interviews. More than 500 households were interviewed across all pilot sites. In addition, several well-targeted impact studies were conducted; these evaluated the impact of specific production systems such as cattle fattening, cow-calf production and herbivorous fish production.

#### Adoption of forages

Following a slow initial rate of uptake in the first few years, the adoption rate accelerated and almost 10,000 households had adopted planted forages at pilot sites by mid 2005 (Figure 47). Planted forages had also spread beyond project sites and the developed technologies were incorporated into development plans by local governments, NGOs and development projects. Adoption beyond project sites has been considerable (> 10,000 households) and is accelerating. Planted forages are becoming the ‘normal practice’ in many areas in the region.

The main forage species used were the grasses *Panicum maximum* ‘Simuang’, *Brachiaria humidicola* ‘Tully’ and ‘Yanero’, *Brachiaria* hybrid ‘Mulato’, *Brachiaria brizantha* ‘Marandu’, *Paspalum atratum* ‘Terenos’, *Setaria sphacelata* ‘Lampung’ and *Pennisetum* hybrid ‘King grass’ and the legume *Stylosanthes guianensis* ‘Stylo184’. The reason farmers first grew grasses was that these have a much higher yield than legumes and quantity of feed (rather than quality) was the primary concern of farmers. The average area of planted forages on farms increased to about 2,500 m$^2$ with many farms having areas of 2,000 – 3,000 m$^2$ (Figure 48).

Farmers, almost exclusively, managed planted forages as cut-and-carry feed. Less than 5% of households at pilot sites reported that they occasionally graze their animals on planted forages. This is a significant departure from the perception commonly held in both the research and development community that forages should be used as grazed pastures. Farmers planted and managed forages like food crops, looking after each plant carefully. At several sites (e.g. Daklak, Vietnam), some households irrigated forages in the dry season. Another indicator of the intensity of forage production was the use of manure and fertilizer applied to forage areas. The vast majority of farmers (>90%) apply manure and/or fertilizer to their forages to ensure high productivity; only at sites with very extensive production systems (e.g. Malitbog, Philippines and Savannakhet, Lao PDR) was the use of manure for forages not yet adopted extensively.

Farmers use planted forages for many purposes (Figure 49). Almost all farmers used forages for cow-calf production with most using planted forages as a supplementary feed throughout the year or for providing feed when cows were kept

**Table 42**. CIAT forage research projects in Southeast Asia, 1992-2006.

| Period | Project | Emphasis |
|---|---|---|
| 1992–1994 | ‘Forage Seeds Project’, managed by CIAT and CSIRO (Australia) and funded by the Australian Government (AusAID). Working with national partners in Indonesia, Malaysia, Philippines and Thailand. | Introducing and screening of a broad range of forage germplasm (>500 accessions) for sub-humid environments. |
| 1995–1999 | ‘Forages for Smallholders Project’ (FSP), managed by CIAT and CSIRO, and funded by the Australian Government (AusAID). Working with national partners in Indonesia, Lao PDR, Malaysia, Philippines, P.R. China, Thailand and Vietnam. | Developing appropriate forage technologies through regional and farmer participatory evaluation. |
| 2000–2002 | Phase-2 of the ‘Forages for Smallholders Project’, managed by CIAT and funded by the Asian Development Bank (ADB). Working with national partners in Indonesia, Lao PDR, Philippines, P.R. China, Thailand and Vietnam. | Participatory approaches to scaling out of forage technologies. |
| 2003–2005 | ‘Livelihood and Livestock Systems Project’ (LLSP), managed by CIAT and funded by ADB. Working with national partners in Cambodia, Indonesia, Lao PDR, Philippines, P.R. China, Thailand and Vietnam. | Developing improved feeding systems (based on forages) to increase returns of livestock production and improve scaling out approaches. |
| 2000–2005 | ‘Forage and Livestock Systems Project’ (FLSP), managed by CIAT and funded by the Australian Government (AusAID). The FLSP was a bi-lateral pilot development project in Lao PDR. | Participatory development and dissemination of forage technologies, including a large capacity building component. |
| 2004-2005 | Project Preparatory Technical Assistance (PPTA) to design a Participatory Livestock Development Project in Lao PDR, managed by CIAT in collaboration with ILRI and financed by the Asian Development Bank (ADB). | Working with ILRI to design a livestock development approach that would work in an ADB loan project in Laos. This integrated lessons learnt from past forage research in Southeast Asia. |
| 2005–2007 | Capacity Building for Smallholder Livestock Systems (CBSLSP), managed by CIAT and funded by the Asian Development Bank (ADB) | Using the approaches developed by the FSLP and LLSP, design an effective mentoring system that allows the rapid scaling out of forage and livestock innovations. |
| 2006–2008 | ‘Legumes for village pigs in Lao PDR’ (L4PP), managed by CIAT and funded by the Australian Government (ACIAR). | Investigating the opportunities of using forage legumes as a protein source for pig production. |
| 2007-2010 | ‘Enhancing livelihoods of poor livestock keepers through increasing use of fodder’, part of a SLP project operating in Ethiopia, Syria and Vietnam coordinated by ILRI; the Vietnam component is managed by CIAT; funded by IFAD. | Improve our understanding of the factors and processes that determine the success of fodder interventions in developing countries. |

near the village for some weeks after giving birth. At some sites, farmers fed planted forages to draught cattle when they were used for ploughing or during period of flooding (e.g. Cambodia) when access to other feeds was difficult. Since 2002, a very exiting development has been the emergence of fattening systems for cattle. At first farmers in Daklak, Vietnam started to buy older thin cattle, to which they then fed planted forages for 2-3 months before selling them to traders for slaughter. This fattening/finishing of cattle before slaughter proofed to be a very profitable activity and many farmers, at other pilot sites where this idea was introduced, have

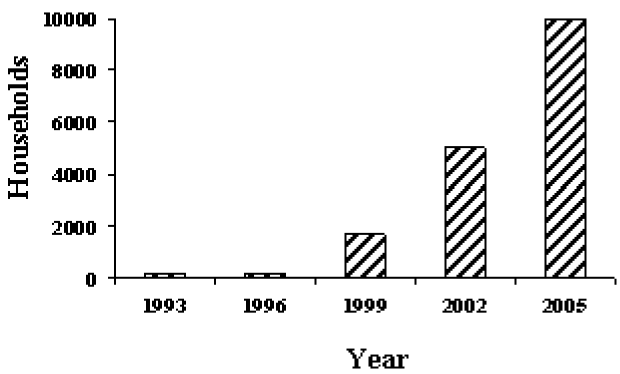


**Figure 47.** Farmers adopting planted forages at pilot sites (1993-2005).

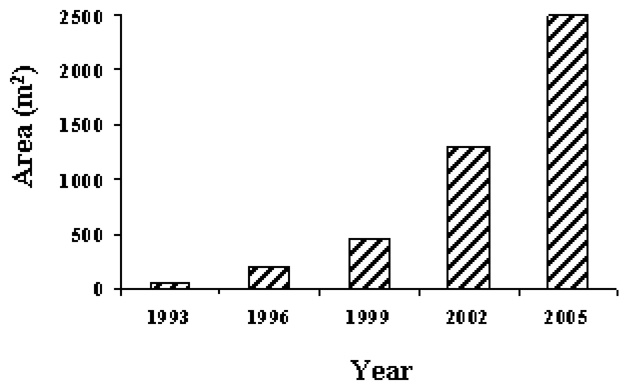


**Figure 48.** Average size of planted forages per household from 1993 to 2005.

also started to fatten cattle (Figure 49). In fattening systems, farmers used 100% planted forages rather than to use planted forages as a supplementary feed; this required approximately 800m$^2$ per animal. The main grasses used in these systems were *Panicum maximum* 'Simuang', *Pennisetum purpureum* 'Napier' and *Brachiaria* hybrid 'Mulato'. In these situations, farmers manage planted grasses very intensively with high rates of manure and fertilizer, and supplementary irrigation if available. Some farmers were using supplementary concentrate feed to achieve higher daily weight gains and there is an opportunity to introduce legumes as a source of cheap, farm-grown protein.

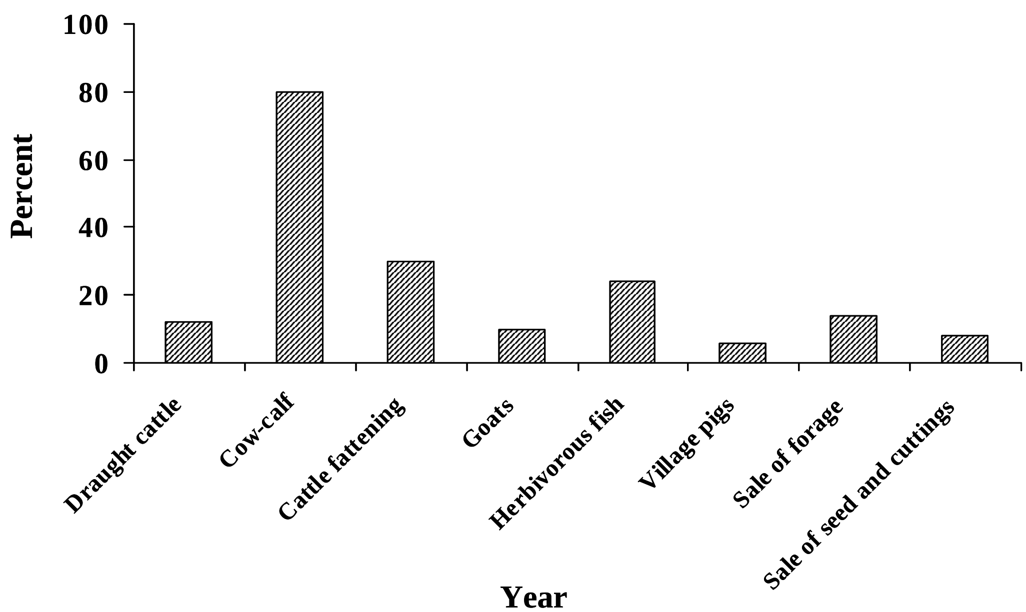


**Figure 49.** Use of forages in 2005.(total exceeds 100% as many farmers use forages for more than one purpose)

Several other unexpected forage uses developed. These were the feeding of planted grasses (mainly *P. maximum* 'Simuang') to herbivorous fish in Vietnam, feeding of the legume *Stylosanthes guianensis* 'Stylo 184' to village pigs in Lao PDR and the sale of fresh forage as feed to other farmers in Thailand and Vietnam (Figure 49).

## Impacts

The main livelihood impacts of planted forages were considerable labor savings and higher income from increased sales of animals (from both improved animal productivity and the ability to raise more animals per household). These resulted in a significant increase in the return to labor from livestock production. The area of forage planted by farmers at almost all project sites was sufficiently large to experience not only labor saving but also substantial improvements in animal production (Table 43). An investment of 0.2 ha of planted forages is sufficient for fattening two cattle. At most sites, the area of planted forages was much larger than these minimum areas.

Several impact studies were conducted to document the impact of planted forages on the livelihood of households. Initially farmers grew forages in small areas on non-cropping land (e.g. road sides, between fields, on slopes not suitable for crops), however, households wanting to increase their forage area had to use areas that had previously been grown to crops. This has occurred at most sites with farmers converting their less productive cropping areas such as upper paddy fields to planted forage areas. This replacement of crops with planted forages reflects the higher returns from livestock production. Below are three examples.

**Table 43.** Minimum area of planted forages required for livelihood benefits.

| Use of forages | Forage area |
|---|---|
| Saving labor (convenience) | 300-500 $m^2$/farm |
| Fattening cattle or buffalo | 800-1,000 $m^2$/animal |
| Cow-calf production | 500-1,000 $m^2$/cow |
| Forages for herbivorous fish | 500-700 $m^2$/pond |
| Legumes for pigs | 100-250 $m^2$/pig |

**1. Cattle fattening:** In Daklak, Vietnam, smallholder farmers started short-term fattening to finish cattle for sale to the slaughter house. Planted forages replaced less productive coffee plantations which had been planted when coffee prices were high. An impact study was conducted with 30 randomly selected households which compared cattle fattening with the previous use of the area where planted forages were now grown for cattle fattening. The average area of coffee replaced was 1,200 $m^2$. The mean daily liveweight gain of cattle in the fattening system was 669 g, based on planted grasses (mainly the grass *Panicum maximum* 'Simuang') and a small amount of concentrate feed (on average 2 kg/day). The net profit from fattening cattle was USD 511 per year compared with USD 90 for coffee from a 1,200 $m^2$ field, making cattle fattening a very attractive option.

**2. Grass carp fish production:** In Tuyen Quang, northern Vietnam, many households have fish ponds for producing grass carp. An impact study was conducted with 30 randomly selected households which compared fish production before and after adoption of planted forages. On average, farmers in the study had 2,400 $m^2$ of fish pond and had planted 540$m^2$ of forages (mainly *Panicum maximum* 'Simuang') to feed to their fish. One of the most important benefits of having planted forages was a saving of labor for feeding fish. The mean labor requirement for producing fish over one production cycle (8-10 months) was 648 hours before households had access to planted forages and 308 hours since planting forages, a very significant saving of scarce family labor. At the same time pond productivity increased from 75 kg to 122 kg of fish harvested per 100$m^2$ of pond, a 38% increase in productivity. Households also reported that they had been able to increase the area of fish ponds by almost 30% since using planted forages. The net income per fish pond increased from USD 84 to USD 283 and the return to labor increased from USD 0.25 to USD

1.28 per hour. The very significant benefits of using forage-based feeding systems, both in terms of net income and the much more attractive return on labor, explains the rapid uptake of this technology. The opportunities provided by planted forages – reduced labor and increased pond productivity – enabled many households to shift from raising some fish for home consumption to producing fish for the local market; a very profitable livelihood activity for households including those with very small land holdings as only small areas are required for ponds and forage plots.

**3. Cow-calf production systems:** A study, conducted in Ea Kar, Daklak, Vietnam, assessed the impact of adoption of planted forages on households practicing cow-calf production. The study used farmer group discussions and conducted 47 individual household interviews (27 household with planted forages and 20 households practicing traditional cow-calf production based on native feeds and extensive grazing). The main impacts of planted forages were larger herd size, a change in the management system from grazing to partial confinement (and providing cut-and-carry feed), a change from native cattle breeds to cross-bred animals, increased sales and higher returns to labor. The mean herd size was 6.9 animals for adopters and 4 animals for non-adopters (which was close to the average herd size of adopters before they had planted forages). Adopters were also able to raise crossbred (Red Sindhi x Native) cattle (77% for adopters and 27% for non-adopters), which have higher nutritional requirements but also a higher sale value than native cattle. The average income from the sale of cattle during the preceding year was USD 756 for adopter and USD 441 for non-adopters. Farmers who adopted forages were able to substantially reduce or eliminate altogether the large amount of labor needed for supervised grazing, with only a small additional amount of labor required for cutting grass. On average, adopters were spending less than half the amount of time looking after their cattle than the non-adopters (3.0 versus 6.8 hours/day) resulting in higher returns to labor. Returns to labor for adopters were USD 0.69 per hour, compared to USD 0.18 per hour for non-adopters.

Other very significant cash income generation opportunities were the sale of fresh forage to livestock producers and traders, particularly in Thailand and in northern Vietnam, and from feeding legumes to pigs (see next section, 4.2.2). At many sites, early adopters also obtained benefits from the sale of planting material and more recently from the sale of seed. In all cases, households used the additional income from sales of livestock to improve living conditions for the family, for educational expenses of children and to invest into their agricultural production.

## Lessons learnt

Many important lessons for the successful development of planted forage systems and scaling out of forages for smallholder farmers emerged from this research. These can be grouped into those that are essential, and those that make technology development and scaling out easier or more difficult.

### 1) Essential components

- Livestock have to be important to the livelihood of farmers in the target area otherwise they will not be willing to invest the time and effort needed to evaluate and integrate planted forages.

- Farmers must have and recognize that they have a problem with feeding their animals. Traditional, communal feed resources are insufficient to support the production system and farmers are forced to invest more and more time in feeding their livestock. This must be recognized as a problem by farmers, and provides the entry point for working together.

- Employing a participatory approach to engage with farmers in developing and integrating forages into their farming system. Addressing the main problem (often labor shortage or lack of feed) ensures that farmers are willing to invest time and effort in evaluating the use of planted forages.

- Encouraging farmer learning, experimentation and innovation (Horne and Stür 2005); farmers will develop uses and ways of integrating and managing planted forages that are appropriate for their situation (e.g. forages for herbivorous fish, legumes for village pigs, using cut-and-carry for *Brachiaria humidicola*). This has resulted in high-impact systems that are compelling examples for others to adopt.

- Having suitable, well-adapted forage varieties that can deliver significant improvements to livestock production systems. There are many cases where ill-adapted species had been introduced previously without success, but widespread adoption occurred once a well-adapted variety was introduced (Tuhulele *et al.* 2007; Gabundada *et al.* 2007).

- Having long-term commitment. The forage technology development phase takes several years, as those involved have to evaluate, adapt and innovate with planted forages before these will provide significant livelihood benefits. Often, farmers realized that planted forages opened new opportunities and changed their livestock management and feeding system to take full advantage of the new feed resource. This process of learning and innovating takes time, however, the process can be quite fast when new sites are linked to more advanced sites where expertise in participatory forage technology development has already been developed. One example is Cambodia which benefited from experience from other countries and was able to develop fodder banks for feeding cattle during the flooding period within 2 years; a process that would have taken 3-5 years previously.

- Scaling out has to be based on compelling examples of a group of farmers receiving significant livelihood benefits from having adopted planted forages. These become learning sites for scaling out.

- Engaging key stakeholders such as development practitioners (extension service, animal health worker, NGOs and development projects) and service providers (such as traders and suppliers) is needed in scaling out successful forage technologies.

- Linking producers to markets. A better understanding of what markets demand and pay for different products generates interest and demand for improved feeding systems among farmers.

**2) Factors that make it easier or more difficult to develop and scale out planted forages**

- The degree of change of the production system required to integrate planted forages effectively. For example, the idea of planting forages on their own land and using this for cut-and-carry is relatively easy for farmers who already keep animals in pens and go out to cut natural feed from communal areas. The required system change is relatively small. On the other hand, farmers who manage their livestock in extensive systems (such as free-range grazing) have to make several significant changes to their management system to be able to take advantage of planted forages.

- The need for fencing increased the cost of planting forages. It is easier and cheaper to grow planted forages in areas where all animals are already constrained or penned, as no fences are required to protect the forage plots from grazing animals. In areas with unsupervised grazing, the need for a secure fencing adds significantly to the cost of utilizing planted forages and greater benefits are needed to offset these costs. There has been a trend for local government to prohibit free grazing, at least for part of the year, and to make animal owners responsible for damage to crops and planted forages. Such regulations help the adoption of planted forages.

- Ease of propagation; being able to propagate forages vegetatively promotes the spread of forages as farmers are not dependent on suppliers of seed. Dependence on seed requires the development of seed supply systems which provides an additional hurdle.

- Champions of particular forage technologies can accelerate the scaling out process. Without a project or a local champion, scaling out will still happen as long as the developed planted forage examples provides significant livelihood benefits but the rate of spread may be slow (Tuhulele *et al.* 2007).

- Population density and infrastructure also play a role in scaling out of forage technologies. Intensive farming systems with high population density are more conducive to the spread of good ideas and technologies from farmer-to-farmer than more extensive systems where there is less contact between farmers. For example, the rate of adoption was much slower in the extensive farming system (and poor road system) of Central Kalimantan compared with the fast uptake of planted forages for cattle fattening in more intensive farming systems in the Central Highlands of Vietnam.

## Conclusions

Planting forages on their own land was the key factor that enabled smallholder farmers to improve livestock production. Planted forages significantly improved household income and, most importantly, the returns to labor from livestock production. The initial benefit from planted forages was, almost invariably, labor savings from easy access to feed. Subsequently, improved growth of animals receiving planted forages emerged and farmers look for ways of maximizing the opportunities provided by the new resource. This led to improved feeding and management systems, which provided significant benefits to farmers.

Participatory approaches to technology development were an essential component of success and produced several unexpected innovations such as forages for herbivorous fish production. Scaling out requires different methodology from participatory technology development and the involvement of a different set of stakeholders. This was most successful in cases where scaling out was based on high-impact, compelling examples which had been developed and adopted by a group of smallholder farmers.

The key role of planted forages in enabling smallholder farmers to intensify their extensive livestock production system and become more market-oriented has been accepted by development agencies in Laos. Similarly, the participatory approaches developed for forage technology development and scaling out have attracted interest from development practitioners. Both forage technologies and approaches for working with smallholder farmers have been integrated into large development project, ensuring that the results of our research have widespread impact.

Adoption of planted forage technologies is continuing to accelerate and the main challenges now are to (a) help farmers to continue to improve animal productivity to become more competitive, enable regular supply of animals and to link more effectively with markets to ensure maximum returns for higher quality animals, (b) address non-feed production constraints such as animal health, animal management, input supplies and marketing, and (c) address factors limiting scaling out such as supply of planting material of the most suitable forage varieties, and ensure access to useful information and training for new practitioners engaged in forage and livestock research and extension.

### 4.2.3 Legume supplementation of village pigs in Lao PDR

**Contributors:** Phonepaseuth Phengsavanh (CIAT/NAFRI), Werner Stür (CIAT), Soukanh Keonouchanh (NAFRI) and Esther van Hoeve (previously ILRI)

#### Rationale

An unexpected outcome of the introduction of planted forages in Southeast Asia was the use of the forage legume *Stylosanthes guianensis* CIAT 184 (Stylo 184) as a supplementary feed for village pigs. Farmers found that pigs liked Stylo 184 and reported (i) significant labor savings as Stylo 184 could be used instead of naturally occurring green feeds which take a long time to collect, and (ii) improved growth rates and productivity of pigs.

Rearing pigs is a widespread smallholder livelihood activity in the northern mountainous regions of Lao PDR, contributing substantially to household incomes, especially among upland ethnic groups where rural poverty is endemic. Traditional feed resources for pigs (native tubers, banana stems and leafy vegetables from the forest) are, however, declining from overuse. Labor to collect pig feed and fuel to cook it, mainly provided by women, is also a major constraint. Consequently, village pigs are commonly underfed and chronically protein deficient, resulting in poor productivity.

A project was designed to investigate the potential of using forage legumes as a supplement for village pigs. ACIAR agreed to fund this research from January 2006 to December 2008. The objectives of the project are:

1. To collate and analyze baseline information of the existing pig production systems in upland Lao villages.
2. To determine the nutritional factors of legumes that are responsible for improved pig productivity, and evaluate best-bet legumes for their feeding value for pigs.
3. To scale-out the integration of Stylo 184 in smallholder pig feeding systems, using Stylo 184 as a model for investigating on-farm factors that influence adoption of forage legumes.
4. To develop guidelines for scaling out of improved pig feeding systems using forage legumes.

The project is managed by CIAT and the National Agriculture and Forestry Research Institute (NAFRI). The QDPI&F is providing support in the area of pig nutrition.

The project commenced in May 2006 and has completed two studies which are reported below. In 2006, other project activities (not yet completed) include nutritional analysis of commonly used feeds and potential forage legumes, a feeding experiment to document the potential growth rate and protein deposition of native pigs (information needed for evaluation of current feeding systems and to provide a basis for feed formulation), establishment of a community of practice and development alliance for scaling out of Stylo 184 with interested researchers, NGOs, local government extension services and development projects. Results of these activities will be reported in 2007.

#### A study of the impact of feeding Stylo to village pigs

This study was designed to quantify the impact of feeding Stylo 184 to pigs in smallholder pig production systems in Lao PDR. Feeding Stylo to pigs was a farmer innovation and reports from individual farmers indicated substantial benefits in terms of time saved for collecting green feeds and improved growth of pigs. The study was carried out in 11 villages in two districts in Luangphabang and Xiengkhuang provinces. The survey team consisted of CIAT staff, national partners from the National Agriculture and Forestry Research Institute (NAFRI) and staff of the Provincial Agriculture and Forestry Offices (PAFO) from Luangphabang and Xiengkhuang provinces and the District Agriculture and Forestry Offices (DAFO). Villages included in the study were selected on the basis of experience with using Stylo for pigs and those with longer experience of growing and using Stylo for pigs were selected preferentially as the study aimed to capture the experiences of farmers as well as impact on production and livelihood of producers. The only other selection criterion was to ensure that the main ethnic groups engaged in pig production were included in the study (Lao-loum, Hmong and Khmu).

Two study methods – Farmer focus group discussions and semi-structured interviews of randomly selected households - were used in the survey. Farmer focus meetings were organized in each village to gain a general understanding of pig management in each village, experiences of utilization of Stylo for feeding pigs and production and livelihood impacts. Household interviews were conducted immediately following each village meeting. A total of 30 households, including 7 women were interviewed. These represented the three main ethnic groups engaged in pig production in Laos: Hmong (4 households), Lao-loum (10 households) and Khmu (15 households).

The result of the study showed that there were two main impacts: (1) Improved growth rate of pigs, and (2) Time savings, as farmers (mostly women) no longer needed to collect naturally-occurring green feeds. Growth rates were estimated by asking respondents to estimate the initial and final sale weight of pigs kept in pens for fattening, and to recall the length of time taken from the start of the fattening period to sale of the animal. This information was used to calculate an average daily growth rate (ADG).

The mean age and weight of piglets at the start of fattening was 4 month when piglets weighed 14-15 kg, and sale weight was estimated at 65kg. Using Stylo as a supplementary feed reduced the length of the fattening period from 18 to less than 9 months (Table 44). This effect was consistent across villages and meant that Stylo supplementation increased average daily gain (ADG) from 107g per day in traditional feeding system to 207g per day for pigs supplemented with Stylo. Clearly, there may be factors other than Stylo supplementation that also played a role (e.g. better management, Stylo being fed in addition to other feeds rather than as a substitute for other feeds) but the consistency and magnitude of the response shows that Stylo has had a major impact on pig productivity. The average area of Stylo grown per household was 320 $m^2$.

The second impact was the saving of time and labor for collecting and cooking pig feed. If farmers had plenty of Stylo 184, the time needed to feed pigs could be reduced from more than 3 hours to 1.5 hours (Table 45). Farmers feeding only rice bran and Stylo were able to reduce the time needed for feeding to 40 minutes a day, as they no longer needed to cook feed. Even farmers with small areas of Stylo saved almost one hour per day.

Feedback from farmers showed that this time saving is regarded as highly significant as labor during the crop growing season is in short supply. Villages engaging in shifting cultivation require a huge amount of labor for weeding crops (estimated at 136 person-days per hectare). Freeing labor at this time of year is valued

**Table 44.** Productivity of growing pigs supplemented with traditional green feeds or Stylo.

| | Traditional green feeds (no Stylo) | Supplemented with fresh Stylo | SE |
|---|---|---|---|
| Duration of production cycle, months | 18.0 | 8.7 | 0.95 |
| Initial Weight, kg | 14.0 | 15.0 | 0.4 |
| Final Weight, kg | 65.3 | 65.1 | 3.2 |
| Calculated ADG, g/day | 107 | 207 | 12.2 |

**Table 45.** Time needed to feed village pigs before and after adoption of Stylo.

| Items | Before | | Now (with Stylo) | | | |
|---|---|---|---|---|---|---|
| | Time spent (min) | Who does the work? | Small Stylo area (not enough for feeding daily) | Large area of Stylo (enough to feed daily) | | Who does the work? |
| | | | | Mixed feed + Stylo | Rice bran + Stylo | |
| Collecting feed | 125 | W/M | 55 | 0 | 0 | W/M |
| Cook | 50 | W | 50 | 50 | 0 | W |
| Feeding | 20 | W | 20 | 20 | 20 | W |
| Collecting Stylo | - | - | 20 | 20 | 20 | M |
| Total | 195 | | 145 | 90 | 40 | |

tremendously. Farmers invested the 'freed' time in other farm activities including better management and health care of pigs. Reducing labor requirements was an excellent entry point for working with pig farmers in upland areas of Laos.

This study showed the potential of forage legumes to provide significant benefits in terms of improved growth and greatly improved the returns to labor by halving labor inputs into pig production. The improved growth response to Stylo 184 supplementation is likely to be related to improved protein supply and this will be investigated in controlled feeding experiments in 2007.

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### Survey of village pig production systems in northern Laos

A survey of a broad range of smallholder pig systems was conducted to supplement the information collected in the impact study reported above. The impact study was carried out in villages where Stylo 184 had already been adopted and thus represented a small and biased sample. This survey covered a broad range of pig systems and included the three main ethnic groups engaged in pig production in Laos. The rationale for this decision was that different ethnic groups raise and manage pigs in different ways. The survey was conducted in 6 villages in three districts in Luangphabang and Xiengkhuang provinces from 13 March to 12 April 2006. The survey team consisted of L4PP staff, national partners from NAFRI, PAFO and DAFO.

Two study methods - village group discussions and semi-structured interviews of randomly selected households - were used in the survey. Village meetings were organized in each village to gain a general understanding of pig management in each village, the importance of pig production to farmers' livelihoods and to provide a list of pig-raising households in each village for random selection of households for interviewing. The team encouraged participation of women in the village discussions as the raising of small animals (such as pigs and poultry) is usually the responsibility of women. Household interviews were conducted immediately following each village meeting. A total of 30 households were interviewed representing the three main ethnic groups engaged in pig production in Laos: Hmong (13 households), Lao-loum (11 households) and Khmu (6 households). There were 12 women among the respondents.

The survey showed that there are three main pig production systems in the uplands of Laos: (1)

Free scavenging system; (2) Confining pigs in enclosures; and (3) Penning. The type of system employed was related to the purpose of raising pigs and ethnicity of the producer. The two main purposes of raising pigs were: (1) Piglet production and (2) Fattening pigs. Half of the respondents were engaged mainly in fattening while the other half was producing piglets (Table 46).

**Table 46**. Main purpose of pig production, stratified by ethnicity of producer.

| Ethnicity of producer | Number of households | |
|---|---|---|
| | Piglet production | Fattening |
| Hmong | 10 | 3 |
| Khmu | 4 | 2 |
| Lao-loum | 1 | 10 |

All Lao-loum producers, except one, were engaged in pig fattening, buying weaned piglets from piglet producers and fattening for sale. Most Hmong and two thirds of Khmu producers were producing piglets for sale. Just over 50% of producers were keeping pigs in pens (Table 47); these were mainly producers fattening pigs for sale while piglet producers mostly kept sows and piglets in enclosures or used a semi-scavenging system.

**Table 47.** Production systems, stratified by ethnicity of producer.

| Ethnicity of producer | Number of households using | | |
|---|---|---|---|
| | Semi-scavenging | Enclosure | Pens |
| Hmong | 4 | 6 | 3 |
| Khmu | 1 | 2 | 3 |
| Lao-loum | 0 | 1 | 10 |

All respondents kept native pigs; these were either Moo Lao-soung (Hmong producers) or Moo lat (Khmu and Lao-loum producers). These breeds are well adapted to free range systems, where they can scavenge part of their feed. Local breeds are high-fat, swaybacked breeds, which produce more fat than meat. This has been important traditionally as pig fat has been the only oil/fat available for cooking in remote villages.

Farmers producing piglets mostly kept 1-2 sows (mean = 1.3) and, at the time of the survey on average had 5-6 piglets (mean = 5.5). Many piglet producers also fattened 1-2 pigs (mean = 1.4) which they had not able to sell or which they especially selected for fattening for special traditional ceremonies (such as New Year, weddings or religious celebrations). Farmers, who specialized in fattening pigs for sale, on average, produced 2-3 pigs per fattening cycle. Not every farmer keeps a boar. In most villages, there were only a few boars available for servicing sows and in some village no boars were available and the service had to come from another village.

The main feeds for pigs were planted crops such as maize and cassava (and to a lesser extent canna and sweet potato with leaves fed to pigs as green feed), crop by-products such as rice bran and broken rice, and green feed occurring naturally in local areas. Almost all producers reported that they fed rice bran and some green feed (fresh leaves) to their pigs (Table 48). In Lao-loum villages (lowland rice producers), producers fed mainly rice bran, sometimes mixed with broken rice or brewery waste (rice grain) and green feeds. Maize and cassava was used by most Hmong producers, while Khmu producers used maize and some cassava.

Feeds are not available year-round and cannot be stored safely for long periods. Therefore, feed is mostly poorly balanced in terms of energy and protein. Protein, in particular, appears to be

**Table 48.** Feed resources for pigs, stratified by ethnicity of producers

| Feed resources | Number of respondents | | |
|---|---|---|---|
| | Lao-loum | Hmong | Khmu |
| | (n = 11) | (n = 13) | (n = 6) |
| Rice bran | 11 | 13 | 6 |
| Broken rice | 5 | 0 | 0 |
| Maize | 2 | 11 | 5 |
| Cassava | 2 | 12 | 2 |
| Green feed | 9 | 13 | 6 |

**Table 49**. Time spent collecting and preparing feed for pigs.

| Activity | Wet season | | | Dry season | | |
|---|---|---|---|---|---|---|
| | Mean | Median | Range | Mean | Median | Range |
| | | (minutes) | | | (minutes) | |
| Collecting feed | 113 | 105 | 30-120 | 126 | 120 | 30-180 |
| Preparing and cooking | 57 | 60 | 30-60 | 56 | 60 | 30-60 |

lacking in the diet for much of the year. Most farmers fed pigs twice a day, in the morning and late afternoon. All pigs received the same diet, and most farmers fed pigs were fed as a group with larger and dominant pigs being able to secure a larger amount of feed than smaller, more timid animals. Respondents reported that women spend up to 3 hours per day collecting natural green feeds and cooking feed for pigs (Table 49). This is a very time consuming activity for upland farmers, who need a lot of time for weeding and tending to upland crops.

The survey estimated growth rate of pigs in fattening systems by establishing the initial weight of pigs when they enter the fattening pen, the final weight at sale and the length of time taken for fattening. The mean length of the fattening cycle of pigs fattened for sale was 15.4 months which resulted in a calculated ADG of 111g (Table 50). Growth rate of pigs fattened by Hmong farmers for traditional feast was very similar with 110 g per day. The growth rate data collected in this survey are almost identical to those established in the Impact study reported in the previous section.

Sows produce, on average, 1.5 litters per year. Mean litter size was 7.4 piglets per litter, but only 3.9 piglets survived to weaning. The high mortality appeared to be related to poor hygiene (many dying from diarrhea caused by unspecified bacterial diseases) and poor nutrition of the sows during lactation. Squashing of piglets was not mentioned as a cause of mortality. Disease epidemics are a major concern of producers. All villages reported disease outbreaks (most likely Classical Swine Fewer) that killed 90% or more pigs in the village within the last few years. The results of this survey provide a baseline for subsequent impact assessment. They also showed that significant improvements in pig production can only be achieved by addressing the three main constraints of (i) poor feeds (both quality and quantity), (ii) high mortality of piglets, and (iii) outbreak of disease epidemics. In areas, where Stylo 184 has been introduced, farmers have started to improve not only feeding but also management (e.g. better housing, clean water supply) and health (vaccination and quarantine of pigs coming into the village); we hypothesize that is related to the improved growth rates and better returns to labor, which have made pig production a more attractive farm enterprise and thus worthy of investment. Forage legumes are emerging as a pivotal factor that enables and encourages farmers to develop more market-oriented pig production systems.

**Table 50.** Growth rates of pigs in fattening systems.

| | Fattening pigs for sale (n = 16) | | | Fattening pigs for traditional feasts among Hmong producers (n = 13) | | |
|---|---|---|---|---|---|---|
| | Mean | Median | Range | Mean | Median | Range |
| Length of fattening period (months) | 15.4 | 16.5 | 7-24 | 21.3 | 24.0 | 8-24 |
| Initial Weight (kg) | 12.7 | 13.5 | 6-20 | 43.3 | 40.0 | 30-50 |
| Final Weight (kg) | 63 | 60 | 40-100 | 117 | 110 | 60-130 |
| Average daily gain (g) | 111 | 110 | 83-195 | 108 | 111 | 83-145 |

### 4.2.4 Future forage research in Southeast Asia

**Contributors:** Werner Stür (CIAT)

Forage research in Southeast Asia had several phases. The early phase (1992-1999) was characterized by forage accession introductions, nursery and regional evaluations and development of forage technologies with farmers using participatory approaches.

From 2000-2005, more applied research projects integrated forage technologies into a broad range of farming systems by working closely with farmers and these resulted in new forage-based livestock systems that provide significant benefits to farmers' livelihood. Improved livestock production based on forage technologies reduced labor inputs in livestock production and increased the income of poor households, resulting in significantly improved returns to labor.

These results 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. These projects also resulted in the identification of new research issues such as Stylo 184 for village pigs and forages for herbivorous fish production.

In 2007, a new research project in Vietnam will aim at (i) better understanding the factors and processes that influence the success of fodder innovations by analyzing forage adoption patterns in Vietnam and (ii) further develop forage-based livestock production systems using 'smart' feeding strategies designed to increase the returns from livestock production.

This 4-year project is part of a multi-country project (Syria, Ethiopia and Vietnam) managed by ILRI on behalf of the Systemwide Livestock Programme; the Vietnam component of this IFAD-funded project will be managed by CIAT. We will also pursue opportunities for funding for (i) research on feeding forages to herbivorous fish, (ii) research on forage-based cattle production systems for flood-prone areas in Cambodia, (iii) research on developing appropriate private sector supply systems for forage seed and planting material, and (iii) developing a knowledge management system for forage and livestock technologies in collaboration with ILRI to make innovations in livestock research more easily available to the development sector.

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

**Highlights**

- Improved grasses were planted in 62 collaborating farms in 4 countries of Central America. Forage yield of the different cultivars has been variable across farms but consistently superior to the local pasture.

- Farmers in a pilot study in Northern Valle del Cauca, Colombia selected the following forage options to be sown in semi-commercial plots of 1 to 10 ha: *Brachiaria* hybrids cvv. Mulato, Mulato II, *B. brizantha* cv.*Toledo, B. dictyoneura*, *Cratylia argentea*, *Leucaena leucocephala*, *Vigna unguiculata* and *Lablab purpureus.*

### 4.3.1 Revised CIAT- ILRI strategy for forages/livestock R&D in Central America

**Contributors:** F. Holmann (CIAT), C. Lascano (CIAT), E. Perez (ILRI) and B. Perry (ILRI)

CIAT and ILRI have identified Central America as the focal region for their joint activities in Latin America because of the region's combination of large numbers of poor households dependent upon livestock and the potential for research-based improvements to their livelihoods. Thus scientists from the two centers developed a long-term R&D program that uses a demand-driven and production-to-consumption approach to improving rural livelihoods and increasing employment through livestock-based enterprises. Current and projected increases in the demand for livestock products both from within the region and to satisfy international markets are the basis for the program and the approach summarized bellow.

#### Outputs

Through policy options, institutional reforms and technological interventions the joint agenda should deliver improved:

1. input and output markets for smallholder livestock producers;
2. smallholder farm productivity;
3. value-added post-harvest;
4. management of natural resources,
5. rural livelihoods and increased employment.

#### Strategy

The program's emphasis will be to deliver outputs and outcomes that contribute significantly to poverty reduction and that are applicable regionally. To achieve significant impacts on poverty, the program should target resource-poor producers and their input and output market agents. Because of their importance to resource-poor producers in Central America, the program will focus on dual-purpose (meat and milk) cattle systems and with legume based feed resources for monogastric (swine and poultry) as means of linking small farmers to markets. The marketing of milk and value-added dairy products has a particularly important role to play in improving rural livelihoods based on these systems. Resource-poor families can take advantage of new market opportunities by raising pigs or chickens, activities that require small initial investments. Such production of monogastrics is a livelihood diversification strategy that can improve family nutrition, provide much needed cash income.

It is expected that opportunities for reducing poverty will arise mainly from identifying and responding to domestic, regional and international market demands rather than from providing a technology "push". Responses to these demands are expected to call upon CIAT's forage technologies (which may include supporting non-livestock keepers to supply processed forages) and its expertise in natural resource management, rural agro-enterprises and participatory methods, while ILRI will provide expertise in marketing, animal genetics, health and nutrition, policy analysis and livestock systems. The program's emphasis will be group activities to increase the bargaining power of the smallholder livestock producers and of their market agents along the production-to-consumption chain and to improve the responsiveness and effectiveness of services. A key international public good to be delivered by the program will be the process by which an integrated natural resource and production-to-consumption systems perspective is developed in a region with close links to a large neighboring market.

#### Implementation

In the short and medium term it is expected that the funds to finance the staff and operational costs for the implementation of the R&D program will come from special projects aimed at o strengthening the R&D program and to ensure the continuity of the joint agenda's implementation.

### 4.3.2 On farm evaluation in Central America of selected forage accessions and cultivars

**Contributor:** P. J. Argel (CIAT)

As part of the ILRI/CFC Project, the establishment of improved forage component was completed in 62 collaborating farms of Honduras (15 farms), Guatemala (9), Nicaragua (20) and Costa Rica (18). A total of 2,242 kg of experimental forage seed was delivered to collaborating institutions during the course of the project, and this represented 207 ha established with improved pastures in farms of participating countries.

Grasses established are dominated by improved cultivars of the genus *Brachiaria,* mainly the hybrids cvv. Mulato and Mulato II; also *B. brizantha* cv. Toledo is an important component in farms located in heavy soils exposed to prolonged dry seasons. Meanwhile, *Cratylia argentea* cv. Veraniega has been the forage shrub legume more widely planted.

On-farm dry matter yields (DM) of improved forages was measured in Costa Rica in collaborating farms during the reported period. Results showed that yields of the introduced grasses were very similar, with the exception of the naturalized grass *Hypharrenia rufa* (Jaragua) that produced lower yields and is probably the more common grass in all cattle farms of the subhumid tropics in Central America (Table 51). Within grass cultivar there is ample variation in forage yield due to different re-growth ages and soil and climatic conditions of the farms. However, it is clear that improved grasses have high DM yields that can contribute to higher stocking rates compared to the naturalized grass.

**Table 51.** Dry matter yields of improve and native grasses in collaborating farms of the ILRI/CFC Project in Costa Rica.

| Species/Cultivar | kg DM/ha | Days of rest (No.) | Farms (No.) |
|---|---|---|---|
| *B. brizantha* cv. Marandu/ | 2746 | | |
| *B. decumbens* cv. Basilisk | (1532-3961)* | 25 | 2 |
| *B. brizantha* cv. Toledo | 2368 | 21 | 1 |
| *B.* hybrid cv. Mulato | 2250 | 22 | |
| | (1281-2948) | (20-25) | 4 |
| *P. maximum* cv. Tanzania | 2223 | 25 | 1 |
| *Hyparrhenia rufa* (Jaragua) | 1100 | 18 | 1 |

*In brackets DM yield range

Monitoring productivity responses of improved forages in Guatemala, Honduras, Nicaragua, and Costa Rica (on-farm monitoring and evaluation during rainy season of improved pasture technologies) has been difficult to implement in the Project. Poor management practices and the difficulty to have permanent group of animals in the farms to monitor, has made it difficult to measure animal production. However, both farmers and technicians are aware that milking cows increase milk yields when grazing improved pastures. On farm monitoring of animal performance in improved pastures will be emphasized during 2007.

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

**Contributors:** C.V. Durán (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; in 2005 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), in 2006 the municipalities of Buga, Tulúa and Zarzal were added. The initiative now reaches directly 300 farmers. Altitudes in the 8 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 a voting 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

In 2006, twenty-two technical visits were carried out, to follow up experiments including semi-commercial plots and participatory evaluations with the farmers of Roldanillo, Versalles, Sevilla, Bolívar and El Dovio (photo 9). So far the species considered to be the best adapted were the grasses *Brachiaria* hybrids cvv. Mulato, cv. Mulato II, *Brachiaria brizantha* cv. Toledo, the herbaceous legumes *Canavalia brasiliensis*, *Centrosema pubescens* and *Arachis pintoi,* the annual legumes *Vigna unguiculata* and *Lablab purpureus* and the shrubs *Cratylia argenteas*, *Leucaena leucocephala* and the local control *Tithonia diversifolia*. Adaptation of *Panicum maximum* and *Brachiaria humidicola* was also good although in some cases limited by contamination of the commercially obtained seed. *Desmodium velutinum* performed well in only one site, while *Clitoria ternatea* was not well adapted to the conditions of the study site.

For farmer selection the following parameters were important: Palatability, color, forage on offer, adaptation to low fertility soils, tolerance to drought, tolerance to pest and diseases, dry matter production, cover, rooting capacity, persistence and adaptation to variable altitude and soil fertility. Based on these criteria, farmers selected the following forage options to be sown in semi-commercial plots of 1 to 10 ha, and a total of 25 ha sown: *Brachiaria* hybrids cvv. Mulato, Mulato II, *B. brizantha* cv.*Toledo, B. humidicola*, *Cratylia argentea*, *Leucaena leucocephala*, *Vigna unguiculata* and *Lablab purpureus*. A strategy of shared expenses was employed, with the Project providing half of the seed, while the farmer bought the other half.

Among the forages , the associations (10 ha) of the grasses Toledo, Mulato and Mulato II with the leguminous shrubs *Cratylia argentea* and *Leucaena leucocephala* and the multipurpose legumes *Vigna unguiculata* and *Lablab purpureus* established best.

Several meetings with farmers to advance testing with semi-commercial plots were realized and the farmer cooperative COGANCEVALLE added to the group of partners. As well results were socialized to farmers and technicians including employees UMATAS (Government extension service) and COGANCEVALLE. Further faros have been selected for semi-commercial plots (40 ha), with 40 and 100 farmers involved directly and indirectly respectively. Training is another component of the initiative having trained so far more than 150 farmers and technicians in establishment, management, utilization and conservation of forages.

**Photo 9.** Farmer field visit to semi-commercial plots in Roldanillo, Norte del Valle.

## 4.4 Adaptation of forage conservation technologies by smallholders in hillsides livestock systems

### Highlights

- Farmer-led experiments showed higher profitability of farm made legume products (i.e. cowpea hay and cowpea-based concentrates) compared to commercial concentrates for milk production

- Farmer-led experiments showed higher profitability for grass (*Brachiaria brizantha* cv Toledo) and sorghum silage compared to maize silage.

- The little bag silage technology was found suitable as a) tool in the introduction, promotion, and extension of silage technology and b) entry point for silage making in dual –purpose farms.

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 strategy in the co-development of forage conservation technologies followed the subsequent steps: 1. Site selection based on diagnosis; 2. Farmer trainings (in theory and practice); 3. On-farm evaluation of technology; 4. Multi-actor information exchange and scaling out; and 5. Monitor adaptation, adoption and diffusion processes.

Steps 1 and 2 were elaborated in detail in the Annual Report 2005. Here we report advances on step 3 (technology evaluation), in which the potentials of innovative forage technologies as dry season feed alternatives are assessed. In feeding experiments, their effect on livestock production is compared to prevalent dry season feed supplements such as maize silage and commercial concentrates.

In the Yoro area, as in many similar environments elsewhere in Honduras, there is a shift from meat oriented production with Brahman cattle to milk oriented production with an increasing share of dairy breeds. This implies a change from traditional low input, low output livestock farming systems to higher input, higher output farming systems. Animal nutrition in terms of feed quality and quantity is a key element in supporting this change, especially during the dry season. Improved forages, silage, hay and concentrates that are increasingly being used by farmers in the area can contribute to overcome seasonal feed constraints and maintain farm productivity. However, there is a lack of information how to use these technologies and resources more efficiently. The following constraints to efficient technology use have been identified:

1) Natural and introduced forage resources are often not managed adequately i.e. pasture and cut and carry grasses are generally used in an advanced stage of maturity, thus their potential, in terms of quality and quantity forage production, is under-exploited. During the dry season, overgrazing of pasture resources frequently occurs, leading to pasture degradation and reduced productivity.

2) Maize is the predominant forage for silage production in the Yoro area, however, the opportunity costs for maize silage increase as maize prices increase.

3) Farmers often supplement unreasonable high levels of concentrate in order to maintain body condition of animals and/or to increase milk production, which increases production costs significantly. Alternative native or introduced protein rich forage resources are little used.

Different collaborative on-farm trials were conducted to address these constraints and validate different conserved forage options under local socio-economic and biophysical conditions with the aim to increase livestock production and productivity to respond effectively to future market challenges.

The following forages were tested on-farm: *Vigna unguiculata* (cowpea) hay and grain concentrate, *Brachiaria brizantha* cv Toledo silage, Sorghum silage, and *Cratylia argentea* silage.

### 4.4.1 Effect of harvest time and drying procedures on quality and losses of hay of three cowpea (*Vigna unguiculata*) accessions

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#### Rationale

In systems of small and medium producers livestock productivity is limited by low quality and quantity of feed in critical periods such as long dry seasons. One alternative is the production of high quality legume hay at the end of the wet season. However quality, appearance and palatability of hay from legumes such as cowpea can be affected by cutting time, drying process and climate; losses in the process of hay making until utilization can be considerable depending on the process employed. Moreover, in contrast to temperate climate, where haymaking has a long tradition and normally relies on special machinery for cutting and drying, in smallholder systems in the tropics the lack of these direct manipulation of the hay crop is an alternative. The cowpea materials selected for this study have also been utilized in haymaking in Central America where quality problems have been reported and the possibly factors are considered for this study.

#### Material and Methods

Contrasting cowpea accessions, i.e. early, medium and late maturing types were used for the study. The materials selected, 9611, IT95K-52-34 y IT89KD-288, are characterized by a high forage and good grain production and have a wide adaptation to both acid and alkaline soils. The experiment was established in two contrasting environments, CIAT – Palmira (alkaline soils, lower rainfall) and CIAT – Quilichao (acid soils, higher rainfall), the cowpea sown at a density of 190.000 plants/ha).

In addition to the different cowpea accessions the following treatments were included: a) two cutting times, i.e. 6 and 8 weeks after sowing, 8 weeks corresponding to pre-flowering time; b) three drying methods i.e. field drying (SC), on cement and cut (SPP) and on cement without cutting (SPN), representing potential scenarios under farmer conditions. A split-plot design with three replications was utilized. The variables included forage quality analysis (IVDMD, CP, NDF and ADF), agronomic evaluation (DM yield, hay yield, leaf: stem ratio) and organoleptic observation (smell, color). For the assessment of color a scale from 1 to 7 was employed, where 1) represents green-reddish, 2) variable, 3) brown 4) light brown 5) 50/50 (green brown), 6) opaque green y 7) dark green.

#### Results and Discussion

Biomass yields were higher at the later cutting time (pre-flowering time) in both Palmira and Quilichao, with accession IT95K-52-34 having the highest yields. Comparing DM yield with hay yield, as expected the latter were lower due drying and handling losses; in Palmira water-logging and diseases let to yield reductions.

In Table 52 yield losses at the time of utilization as affected by treatments are shown. Whereas in Palmira the effects of drying method varied between accessions ($P > 0.05$), in Quilichao highest losses were recorded for field drying for all three accessions, though again not significant ($P < 0.05$). In general losses were below 10%, independent of drying method.

Pooling the three accessions drying method and time of cutting resulted in significant ($P<0.05$) differences in IVDMD, with treatment SPN (cement drying, not cut) and the earlier cut having the higher values in both locations, but no significant ($P > 0.05$) differences were found for CP (Table 53.). The low digestibility of the later cut in Quilichao could be accounted for by a longer drying time than in Palmira; moreover the dark green color of the hay indicates the presence of saprophytic fungi with sign of initial decomposition of tissue though the smell remained pleasant.

**Table 52.** Yield loss for haymaking as affected by drying method for three accessions of *Vigna unguiculata* (Caupi) in Palmira and Quilichao, 2006.

| Site | Accession | Drying method* | Yield loss for haymaking % |
|---|---|---|---|
| Palmira | IT95K-52-34 | SC | 3 |
| Palmira | IT95K-52-34 | SPP | 3 |
| Palmira | IT95K-52-34 | SPN | 2 |
| Palmira | 9611 | SC | 3 |
| Palmira | 9611 | SPP | 5 |
| Palmira | 9611 | SPN | 2 |
| Palmira | IT89KD-288 | SC | 5 |
| Palmira | IT89KD-288 | SPP | 9 |
| Palmira | IT89KD-288 | SPN | 3 |
| Mean | | | 4 |
| | | | ns |
| Quilichao | IT95K-52-34 | SC | 8 |
| Quilichao | IT95K-52-34 | SPP | 6 |
| Quilichao | IT95K-52-34 | SPN | 5 |
| Quilichao | 9611 | SC | 9 |
| Quilichao | 9611 | SPP | 7 |
| Quilichao | 9611 | SPN | 5 |
| Quilichao | IT89KD-288 | SC | 9 |
| Quilichao | IT89KD-288 | SPP | 8 |
| Quilichao | IT89KD-288 | SPN | 5 |
| Mean | | | 7 |
| | | | ns |

*SC: field drying; SPP: on cement and cut; SPN: on cement without cutting

**Table 53**. Yield loss for haymaking and hay quality of three accessions of *Vigna unguiculata* (Caupi) in Palmira and Quilichao, 2006.

| Site | Drying method* | Yield loss for haymaking | IVDMD % | CP |
|---|---|---|---|---|
| Palmira | SC | 3.8 | 73 | 20 |
| Palmira | SPP | 5.7 | 73 | 20 |
| Palmira | SPN | 2.4 | 75 | 20 |
| Mean | | 4 | 73 | 20 |
| LSD (P<0.05) | | 1.6 | 1.5 | NS |
| Quilichao | SC | 8.8 | 64 | 21 |
| Quilichao | SPP | 7 | 73 | 21 |
| Quilichao | SPN | 5 | 75 | 23 |
| Mean | | 6.9 | 71 | 21 |
| LSD (P<0.05) | | 1.7 | 1.4 | NS |

*SC: field drying; SPP: on cement and cut; SPN: on cement without cutting

Leaf:stem ratio in Quilichao was not affected by cutting time, while in Palmira the earlier cutting time resulted in a higher leaf:stem for two of the accessions, though not significant (P > 0.05) due to interaction between accession and cutting time (Table 54).

In the organoleptic assessment only samples from Quilichao showed the variable color characteristic, confirming the negative effects of alternate drying and wetting due to rain during haymaking. The green-reddish colour was found in only a few samples from Palmira, likely due to infection with *Oidium* sp., with the fungus turning reddish during drying. The dark, light green and opaque green, green/brown (50/50) and light brown colors considered desirable were found with hay from both locations, with the opaque green natural color of the plant characterized in the literature as indicator of a good hay being the most abundant.

The smell of all treatments, including the hays affected by disease and sub-optimal drying was pleasant, varying slightly between sweet and herbal. In contrast to Honduras no serious quality effects due to drying method, climate and cutting method were encountered. Of particular interest are the positive results from Quilichao where haymaking met wet conditions unusual for the season of the year.

**Table 54**. Yield loss for haymaking and leaf:stem ratio of has for three accessions of *Vigna unguiculata* (Caupi) as affected by cutting time (6 and 8 weeks after planting) in Palmira y Quilichao, 2006. The 8 weeks cut represents the preflowering stage

| Site | Accession | Cutting time in weeks after planting | Yield loss of haymaking % | Leaf:stem ratio |
|---|---|---|---|---|
| Palmira | IT95K-52-34 | 8 | 3 | 1.2 |
| Palmira | IT95K-52-34 | 6 | 2 | 1.5 |
| Palmira | 9611 | 8 | 2 | 1.5 |
| Palmira | 9611 | 6 | 4 | 2.2 |
| Palmira | IT89KD-288 | 8 | 4 | 1.6 |
| Palmira | IT89KD-288 | 6 | 7 | 2.3 |
| Mean | | | 4 | 1.7 |
| (P<0.05) | | | NS | |
| Quilichao | IT95K-52-34 | 8 | 6 | 2.1 |
| Quilichao | IT95K-52-34 | 6 | 7 | 2.4 |
| Quilichao | 9611 | 8 | 7 | 2.1 |
| Quilichao | 9611 | 6 | 7 | 1.9 |
| Quilichao | IT89KD-288 | 8 | 7 | 2.1 |
| Quilichao | IT89KD-288 | 6 | 7 | 2.1 |
| Mean | | | 7 | 2.1 |
| (P<0.05) | | | NS | |

### 4.4.2 Effect of feeding cowpea (*Vigna unguiculata*) hay and grain on milk yield

**Contributors:** C. Reiber, R. Schulze-Kraft, M. Peters, P. Lentes, V. Hoffmann, H. Cruz and C. Lascano

Supplementation of dairy cows with commercial concentrates is a practice widely used by farmers in the Yoro area, especially during the dry season. This practice elevates production costs per litre of milk and reduces farm productivity. Alternative protein sources, which can be produced on-farm, promise higher returns per litre of milk. Well adapted, i.e. drought tolerant, forage legumes such as cowpea (*Vigna unguiculata*) have been promoted among farmers. Cowpea is a highly palatable, digestible and nutritive feed source with a crude protein (CP) content of 14-21% in the foliage, and 18-28% CP in the grains. A number of studies have shown that the use of cowpea as fodder has a positive effect on ruminant performance. The first experiment reported here focuses on cowpea hay while the second experiment on cowpea grain. Both were tested as partial substitutes of commercial concentrate with milking cows.

### 4.4.2.1 Effect of feeding cowpea hay on milk production

#### Materials and Methods

The type of experiment that was carried on the farm was agreed with the farmer and this included the selection of the cows and the feed rations (collaborative-collegiate mode). The study was conducted in a farm near Victoria, Yoro, Honduras. The area is located at an altitude of 395 m.a.s.l and has a temperature ranging from 22 to 32 °C and an average annual rainfall of 1150 mm with a 6- month dry season.

Fresh forage production of cowpea (accession IITA 284/2) was approximately 18 tons/ha. An area of 3600 m² of cowpea was cut for hay in the early flowering stage (mid November), sun-dried or dried under a roof for one day each case. Drying under a roof was applied to minimize leaf losses normally occurring the field. About 1.2 tons of cowpea hay was harvested of which about 0.46 tons were used for the experiment.

The experiment was conducted in the dry season of 2006 (February to March). Eight crossbred cows (Holstein x Brown Swiss x Brahman) were selected. Criteria for the selection of the cows were a lactation period between three and five months, number of weaned calves, similar live weight and body condition. Based on these criteria cows were equally distributed in two groups and included in a Double Reversal Design. The experiment lasted 42 days divided in three periods of 14 days each.

The basic feed ration (BFR) was maintained during the whole experiment and was the same for all cows: BFR = 9.1 kg maize silage (DM 35.3%) + 13.6 kg sugar cane (DM 25%) + 6.8 kg maize straw (DM 70%).

The following treatments were applied:

1. Treatment A (“cowpea hay mix”): BFR + 3.64 kg concentrate + 2.73 kg cowpea hay

2. Treatment B (“concentrate mix”): BFR + 5.45 kg concentrate (control)

In treatment A 1.8 kg of commercial concentrate (PC 22%) was substituted by 2.73 kg of cowpea hay (PC 16.2%).

The feed was supplemented in two rations, one in the morning and one in the afternoon during milking. Cows did not graze during the experiment. Live weight was measured every seven days, in the beginning and in the end of each sub-period using a digital livestock balance. Measurements were always done at the same time of the day (in the morning after milking) to avoid live weight changes due to differences in the degree of rumen fill. Milk production for each cow was recorded twice daily.

For statistical analysis of milk production, data from the first seven days (adaptation phase) of each period were excluded and data from day 8 to day 14 were taken for each treatment and group and subsequently analyzed using non-parametric tests (Mann-Whitney Test).

## Results

**Feed intake:** The cows consumed all the offered BFR ration (11.4 kg of DM/cow -Table 55). on average, daily DM intake was 3.5% of live weight.

**Table 55**. Total feed consumption in kg DM/cow/day

| | BFR | Cowpea Hay | Concentrate | Total DM intake |
|---|---|---|---|---|
| Treatment A (cowpea hay mix) | 11.4 | 2.3 | 3.2 | 16.9 |
| Treatment B (concentrate mix) | 11.4 | 0.0 | 4.8 | 16.2 |

5.45 kg commercial concentrate (88%) corresponds to 4.8 kg DM
3.64 kg commercial concentrate (88%) corresponds to 3.2 kg DM
2.73 kg cowpea hay (85%) corresponds to 2.32 kg DM

**Milk production:** Statistical analysis revealed no significant difference between treatments ($P > 0.05$). In the overall experiment, the "concentrate treatment" showed 0.64 kg higher milk production than the "cowpea hay" treatment (Table 56).

**Table 56**. Average milk production per treatment

| | N | Mean (kg/cow) | Std. dev. | Range for 95% confidence interval for mean (kg/cow) |
|---|---|---|---|---|
| Cowpea hay mix | 84 | 12.54 | 1.18 | 12.28 - 12.79 |
| Concentrate mix | 84 | 13.18 | 1.41 | 12.88 - 13.49 |

**Liveweight changes:** The overall weight averages of both groups showed that cows lost weight when supplemented with the concentrate treatment (-0.59 kg/cow/day) whereas they gained weight during the cowpea hay treatment (0.19 kg/cow/day). The difference between the treatments, however, was not significant ($P > 0.05$).

**Cost-benefit analysis:** The cost of the feed ingredients, income and profitability were with a 95% confidence interval for mean milk production. Table 57 shows the costs for the feed components of the basic feed ration (BFR) totalled 0.31 $US/cow.

**Table 57.** Costs of ingredients in basic feed ration (BFR)

| Feed | $UScent/ Kg FM | $UScent/ Kg DM | Kg FM/cow | $UScent/ cow |
|---|---|---|---|---|
| Maize silage (35.5% DM) | 1.40 | 3.96 | 9.1 | 12.74 |
| Sugar cane chopped (25% DM) | 0.81 | 3.24 | 13.6 | 11.02 |
| Maize straw (90% DM) | 1.03 | 1.14 | 6.8 | 7.00 |
| TOTAL | | | | 30.76 |

The total feed ration (TFR) costs were 1.43 and 1.78 $US/cow for Treatment A and Treatment B, respectively (Table 58).

The cost: benefit analysis showed that the net income and the profitability per unit of milk were significantly greater (probability of 100%) for the cowpea hay treatment than for the concentrate treatment (Table 59).

This means that the lower milk production with the cowpea hay treatment was more than compensated by the lower feed cost due to the use of the relatively cheaper cowpea hay compared to commercial concentrate.

**Table 58**. Costs for total feed ration per cow and treatment

| | Basic feed ration | Concentrate ($US/cow)[1] | Cowpea hay ($US/cow)[2] | Total |
|---|---|---|---|---|
| Cowpea hay mix (A) | 0.31 | 0.98 | 0.14 | 1.43 |
| Concentrate mix (B) | 0.31 | 1.47 | 0.00 | 1.78 |

[1] Concentrate cost: 0.27 $US/kg; [2] cost per kg of cowpea hay: 0.05 $US/kg

**Table 59.** Ranges (lower and upper bound of standard deviations) and mean values for income, costs and profitability of cowpea hay and concentrate rations

| | Cowpea hay ration | Concentrate ration |
|---|---|---|
| Total (dry season) feed cost ($US/cow/day) | 1.43 | 1.78 |
| Dry season feed cost + labour cost[1] ($US/cow/day) | 1.55 | 1.90 |
| Milk production (kg/day) | 12.28 - 12.79 | 12.88 - 13.49 |
| Cost of milk ($US/kg) | 0.126 - 0.121 | 0.147 - 0.141 |
| Gross income from milk sale[2]/cow | 3.56 - 3.71 | 3.74 - 3.91 |
| Net income/cow/day | 2.01 - 2.16 | 1.84 - 2.01 |
| Net income/kg of milk | 0.164 - 0.169 | 0.143 - 0.149 |
| Net income/cost (profitability) per liter milk | 130 - 140 | 97 - 106 |

[1] Milk price: 0.29 $US/liter (1 liter is considered as 1 kg)

## Discussion

Milk production was higher with the all concentrate treatment. However, analysis of live weight changes indicated that, on average, cows gained weight during the cowpea treatment whereas they lost weight during the concentrate treatment. Although there is a significant difference in milk production in favour of the commercial concentrate-treatment (0.64 kg/cow/day), the cowpea hay treatment resulted in a significantly higher net income and a significantly improved cost-benefit ratio of 130-140% compared to 97-106% for the commercial concentrate treatment. This is due to the lower cost for cowpea hay compared to commercial concentrate.

### 4.4.3 Partial substitution of commercial concentrate with cowpea grain

**Contributors:** C. Reiber, R. Schulze-Kraft, M. Peters, P. Lentes, V. Hoffmann, H. Cruz and C. Lascano

## Rationale

An innovative farmer participating in the project added cowpea grains and maize to a relatively low cost commercial concentrate (min 12% CP, 8.4 $US per 50 kg bag) and compared it to another more expensive higher quality commercial concentrate (min 20% CP, 12.1 $US per 50 kg bag). Cows accepted the concentrate with cowpea which resulted in higher milk production . In order to test the effect of cowpea as a concentrate substitute a more formal experiment was agreed with the farmer (collaborative-collegiate participation mode).

## Material and Methods

The experiment was carried out in a farm near Sulaco, Yoro at an altitude of about 446 m.a.s.l. The temperature ranges from 22 to 32 °C with an average annual precipitation of about 1000 mm and a 6 months dry season. The experiment was conducted in the dry season 2006 (March to April). Six crossbred cows (Brahman x Brown Swiss) were selected. The cows had between 2 and 6 births and more than 2 months of lactation at the time of the experiment. Their body condition score was 2.75-3.00. The cows were distributed in two groups of three cows each. The experiment, employing Double Reversal Design lasted 30 days divided in three periods of 10 days each whereas in the first period, all cows passed through the control treatment. In following periods cows in the two groups switched between treatments:

Control: During the first period, the cows of the two groups were supplemented with the same concentrate that was already used by the farmer (control). During the second and third period, each group rotated thorough treatments 1 and 2.

Treatment 1 (T1): BFR + 1.4 kg commercial concentrate (maintenance, min 12% CP) + 1.4 kg ground maize + 1.4 kg ground cowpea grain

Treatment 2 (T2): BFR + 4.1 kg commercial concentrate (min 20% CP)

Where: Basic feed ration (BFR): 12.3 kg silage (mix of 85% sorghum, 7.5% maize and 7.5% cowpea foliage) + pasture; Control: BFR + 2.7 kg commercial concentrate (maintenance, min 12% CP) + 1.4 kg maize

For statistical analysis of milk production data from day 4 to day 10 were taken for each treatment and group and subsequently analyzed using non-parametric tests (Mann-Whitney Test).

## Results

**Feed quality and intake:** The elaborated concentrate included 33% commercial concentrate (13.8% CP), 33% ground maize (10.3% CP) and 33% ground cowpea (26% CP), and had a CP content of 16.7%. The concentrate mixture used as control (66% commercial concentrate "maintenance" and 33% ground maize) had 12.6% CP. Both concentrates were accepted readily by the cows. The commercial concentrate "lechera nutricia" reached a CP content of 22.5%.

The dry matter consumed averaged 3.7 kg for the silage mixture, 3.6 kg for the concentrate and about 1.4 kg of pasture grass with a total of about 8.7 kg DM/cow/day (on average 2.5% of live weight).

**Milk production:** Milk production was highest for the control (8.47 kg/cow), followed by T2 (8.26 kg/cow) and T1 (7.68 kg/cow). The difference between T1 and T2 as well as the difference between the control and T2 were not significant ($P > 0.05$). However, the difference between the control and T1 was significant ($P < 0.05$) (Table 60).

**Table 60**. Average milk production (kg/cow) per treatment

| | N | Mean | Std. deviation |
|---|---|---|---|
| Control | 36 | 8.47 | 1.26 |
| T1 | 42 | 7.68 | 1.14 |
| T2 | 42 | 8.26 | 1.72 |

**Cost-benefit analysis:** In Table 61 we show the costs for the different feed ingredients. Beside pasture, silage (mainly sorghum) is the cheapest (0.012 $US) available forage source. The costs per kg of maize silage and cowpea grain depend mainly on the harvested amount and therefore have to be calculated for each case. The total feed costs per ration was highest for T2 (1.13 $US) and cheapest for T1 (0.75 $US).

**Table 61.** Feed costs (US$/kg and US$/cow).

| | Silage | Concentrate (maintenance) | Concentrate ("lechera nutricia") | Cowpea Grain | Maize grain | Total |
|---|---|---|---|---|---|---|
| US$/kg | 0.012 | 0.17 | 0.24 | 0.11 | 0.16 | |
| Control (US$/cow) | 0.15 | 0.46 | 0.0 | 0.0 | 0.22 | 0.83 |
| T1 (US$/cow) | 0.15 | 0.23 | 0.0 | 0.15 | 0.22 | 0.75 |
| T2 (US$/cow) | 0.15 | 0.0 | 0.98 | 0.0 | 0.0 | 1.13 |

**Table 62.** Mean values for costs, income and profitability for the treatments

| | Total feed cost ($US/cow) | Milk production (kg) | Cost/kg of milk ($US) | Gross income/cow through sale of milk[1] | Net income/ cow | Net income/ kg of milk | Profitability (benefit/cost) per liter of milk |
|---|---|---|---|---|---|---|---|
| Control | 0.83 | 8.47 | 0.098 | 2.46 | 1.63 | 0.190 | 196% |
| T1 | 0.75 | 7.68 | 0.098 | 2.23 | 1.48 | 0.191 | 200% |
| T2 | 1.13 | 8.26 | 0.14 | 2.40 | 1.27 | 0.147 | 112% |

[1] Milk price: 0.29 $US/liter (1 liter is considered as 1 kg)

The cost-benefit analysis (Table 62) reveals that the net income and profitability per unit of milk was highest for the cowpea treatment (200%) and lowest for the commercial concentrate treatment (112%). This means that the lower milk production produced with the cowpea treatment (and the control) is more than compensated by its lower cost.

## Discussion

The experiment confirms farmers' observation that there were no significant differences in the acceptance and in milk production between the farm-prepared concentrate including 33% cowpea grain and the more expensive commercial concentrate. Cost-benefit analysis revealed significant differences for net income (0.21 $US/cow/day) and profitability in favour of the cowpea mixture. Considering a farm with 10 cows and a supplementation period of four months, the farmer would save about 250 $US by substituting the expensive commercial concentrate with the cowpea-maize-mixture.

## General discussion

Cowpea hay as well as cowpea based concentrate proved effective as partial substitute to commercial concentrate in terms of cost-benefit ratio. Further experiments are needed in order to investigate the effect of a total substitution of commercial concentrate with cowpea products. On-farm produced protein sources such as cowpea fodder and grain would have likely less price fluctuations and are less dependent on international markets than concentrates based on imported ingredients.

Regarding the current development of concentrate costs, it is expected that they become even more expensive, partly due to the increased demand of land and agricultural products for bio-fuel production. Therefore, it is important to offer farmers alternatives such as forage legumes to remain competitive. Both farmers, who conducted the cowpea-concentrate experiments, continued cultivating it for concentrate, increasing the area planted or subcontracting to other farmers. These farms are used as demonstration cases for farmer to farmer dissemination.

In Yorito, the farmer association "CREL" is forming a concentrate enterprise as result of institutional cooperation and as consequence of the continuously increasing costs of commercial concentrates. Moreover, poor non-livestock farmers, i.e. local CIAL (local agricultural research committee) groups are presently producing cowpea with the objective of establishing trade relations with CREL livestock farmers. Cowpea based concentrates need to compete with imported feed ingredients such as soybean, However, cowpea can be intercropped in maize or produced at the end of the dry season, filling a niche that could contribute to additional food, feed and/or income generation of small farmers.

### 4.4.4 Effect of substituting maize silage with *Brachiaria brizantha* cv. Toledo silage on milk production and productivity

**Contributors:** C. Reiber, R. Schulze-Kraft, M. Peters, P. Lentes, V. Hoffmann, H. Cruz and C. Lascano (CIAT)

**Rationale**

Maize is currently the most widely used forage source for silage in the area of Yoro. However, maize production for silage is considered by farmers to be expensive and could compete with maize production for food. During the last three years the use of alternative forages for silage such as sorghum, King Grass, sugarcane and recently Toledo has been increasing. Farmer-led on-farm experiments were conducted in order to evaluate the potential of sorghum and *Brachiaria brizantha* cv. Toledo silage compared to maize silage in milk production and productivity.

*Brachiaria brizantha* cv. Toledo was first introduced to the Yoro region in 1998 by DICTA and CIAT. Toledo was selected by farmers as one of the most promising pasture grasses for the region. Criteria of farmers were its adaptability, production and drought tolerance. Since 1999, the total area cultivated with Toledo has been increasing rapidly to about 400 ha in 2004. It is estimated that about 40-50% of the livestock keepers have adopted Toledo.

Until now, Toledo has been used under direct grazing. Nevertheless, in view of its high biomass production (up to 30 tons DM/ha/year), it could also be used as cut-and-carry grass for supplementation as fresh feed, or as conserved forage in form of hay or silage. This experiment compares Toledo silage with maize silage with respect to animal production and productivity.

**Material and Methods**

The farmer elaborated Toledo silage independently, and a formal experiment was planned with input from farmer and the researchers (collaborative mode). The experiment was carried out in a farm near Victoria, Yoro, at an altitude of 363 m.a.s.l. The temperature ranges from 22 to 32 °C with an average annual precipitation of 1150 mm and a 6-month dry season.

The feeding experiment was conducted in the dry season of 2006 (February to March). Eight crossbred cows (Simmental x Brahman, Brown Swiss x Brahman) were selected, with a lactation period of more than two months, two to three calves and a similar live weight and body condition. Cows were distributed in two groups of four cows each. The cows were fed on a time-restricted ration of maize silage and Toledo silage from 9 am to 2 pm. After that cows grazed on *Andropogon gayanus* and *Brachiaria* hybrid cv. Mulato pastures.

The following treatments were applied:

Treatment A: Maize silage + concentrate + pasture
Treatment B: Toledo silage + concentrate + pasture

Cows were assigned to a Double Reversal Design that lasted 42 days divided in three periods of 14 days each. Milk production for each cow was recorded daily in the morning. For statistical analysis of milk production, data from the first seven days (adaptation phase) of each period were excluded and data from day 8 to day 14 were taken for each treatment and group and subsequently analyzed using non-parametric tests (Mann-Whitney Test). Live weight was measured every seven days. This was done at the beginning and end of each sub-period using a digital livestock balance.

**Results**

**Feed quality:** The maize silage (31% DM) had a pH 4, which indicates that it fermented well. The good quality of the silage was confirmed by the pleasant sweet smell and its green colour

**Table 63.** Average milk production per group and treatment in kg/cow

| | | Group 1 | Group 2 | Average | Range for 95% confidence interval for mean (kg/cow) |
|---|---|---|---|---|---|
| Maize silage (A) (N=63) | Mean | 5.50 | 5.65 | 5.55 | 5.32 – 5.78 |
| | N | 42 | 21 | 63 | |
| | SD | 0.88 | 0.99 | 0.91 | |
| Toledo silage (B) (N=63) | Mean | 5.02 | 5.64 | 5.43 | 5.18 – 5.68 |
| | N | 21 | 42 | 63 | |
| | SD | 0.83 | 1.02 | 0.99 | |
| Difference (A) –(B) | | 0.48 | 0.01 | 0.12 | |

(organoleptic mark 1 = very good). Toledo silage had a lower DM content (25.6% DM), with a pH 5which indicated that fermentation was not optimal. However, organoleptic evaluations of Toledo silage including smell, texture, and colour indicated a good quality. Maize silage had a higher crude protein content than Toledo silage (6.44% vs. 5.04%). FDN content was 73.42% for Toledo silage and 70.61% for maize silage.

**Feed intake:** The cows consumed all the maize silage (31% DM) offered (13.6 kg of FM per day which equals 4.2 kg/cow/day of dry matter). During the first days of the adaptation phase, Toledo silage (25.6% DM) offer was varied to ensure maximum intake, which turned out to be 11.1 kg FM/cow/day or 2.8 kg DM per cow. Thus intake of Toledo silage was considerable lower than the maize silage DM intake. Average commercial concentrate (22% CP) supplementation was 2.6 kg/cow in both treatments.

**Milk production:** Results indicated no significant difference ($P > 0.05$) in milk production between Group 1 and Group 2. However, when the results of the groups were analyzed separately higher milk production due to the maize silage treatment was significant for Group 1 (0.48 kg/cow/day; $P < 0.05$) but not for Group 2 ($P > 0.05$; 0.01 kg/cow/day) (Table 63). Averaging the two groups there was a difference of 0.12 kg/cow in milk yield in favor of the maize silage, but this difference was not significant ($P > 0.05$).

**Cost-benefit analysis:** In Table 64 we show the feed costs for each treatment, which averaged 0.90 $US and 0.81 $US for treatment A and treatment B respectively. In Table 65 we present the range and mean values for income, costs and profitability of the two silage treatments.

The cost-benefit analysis indicates that net income and profitability were slightly higher for treatment B (Toledo silage) compared to treatment A (maize silage). This means that the lower milk production (and lower gross income from milk sale) was more than compensated by the lower cost of Toledo silage (Figure 50).

**Table 64.** Feed costs ($US)

| | Silage Consumed (kg FM) | Silage cost/kg | Silage cost/cow | Concentrate[1] cost/cow | Total feed cost/cow |
|---|---|---|---|---|---|
| Treatment A (with Maize silage) | 13.6 | 0.015 | 0.20 | 0.70 | 0.90 |
| Treatment B (with Toledo silage) | 11.1 | 0.01 | 0.11 | 0.70 | 0.81 |

[1] Concentrate cost: 0.27 $US/kg

**Table 65**. Ranges (lower and upper bound of standard deviations) and mean values for income, costs and profitability of maize and Toledo silage

| | Treatment A | Treatment B |
|---|---|---|
| Total (dry season) feed cost ($US/cow/day) | 0.90 | 0.81 |
| Dry season feed cost + labour cost[1] ($US/cow/day) | 1.018 | 0.928 |
| Milk production (kg)/day | 5.32 – 5.78 (5.55)[2] | 5.18 – 5.68 (5.43) |
| Cost of milk ($US/kg) | 0.191 – 0.176 (0.183) | 0.179 – 0.163 (0.171) |
| Gross income from milk sale[3]/cow | 1.54 -1.68 (1.61) | 1.50 – 1.65 (1.57) |
| Net income/cow/day | 0.52 – 0.66 (0.59) | 0.57 – 0.72 (0.64) |
| Net income/kg of milk | 0.098 – 0.114 (0.106) | 0.110 – 0.127 (0.118) |
| Net income/cost (profitability) per litre milk (%) | 51 – 65 (58) | 61 – 78 (69) |

[1]Labour (milker) cost: 0.118 $US/cow/day;
[2] Numbers in brackets are mean values; [3] Milk price: 0.29 $US/litre (1 litre is considered as 1 kg)

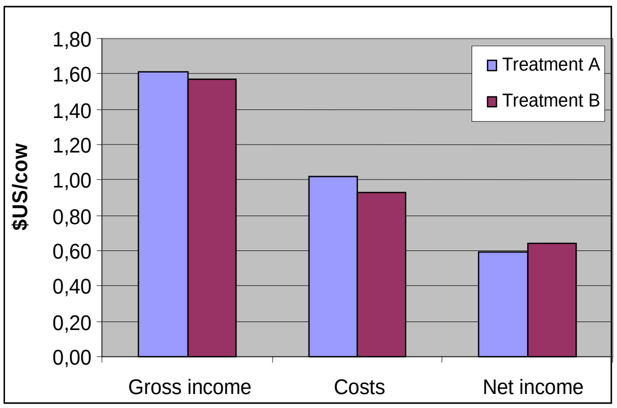


**Figure 50.** Gross income, costs and net income.

The mean difference of net income per kilogram of milk between treatments is 0.012 $US. For a farm producing 100 litres per day, this would mean about 1.2 US$ more net income per day. However, non-parametric tests didn't reveal significant differences between treatments for net income and profitability.

## Discussion

Irrespective of the treatments, average milk production slightly and constantly decreased whereas average live weight increased during the experiment. Differences between maize silage and Toledo silage were not significant in terms of milk production and live weight. Moreover, net income and profitability did not show significant differences between treatments.

However, the trend of results shows that the slightly lower milk production with the Toledo silage treatment was more than compensated by lower treatment costs, which resulted in a slightly higher profitability compared to the maize silage treatment. The experiment indicates that Toledo silage is a feasible, valuable and economically attractive alternative to maize silage.

### 4.4.5 Effect of sorghum and maize silage on milk yield

**Contributors:** C. Reiber, R. Schulze-Kraft, M. Peters, P. Lentes, V. Hoffmann, H. Cruz and C. Lascano (CIAT)

## Rationale

The majority of the farmers using maize for silage believe it to be superior to other forages. However, we have been observing an increasing use of sorghum silage in the last three years in Honduras. In a farmer-led experiment, forage sorghum and maize silage were supplemented in an alternated manner to milking cows. The farmer and the workers observed a higher milk production always when sorghum silage was fed the day before with a difference of 8-10 litres from 14 cows (0.6-0.7 litres/cow) for each day compared to maize silage. The farmer was encouraged to continue with his experiment under conditions of prolonged periods of maize and sorghum silage supplementation (collegiate-collaborative mode) in order to evaluate the production and productivity of maize and sorghum silage supplementation in milk production.

## Materials and Methods

Maize and sorghum (Christiani, HF 802 hybrid) were cut for silage at maturity (milky to doughy). In September 2005, an area of 0.79 ha of maize was ensiled in a trench silo with 45 $m^3$ capacity which was opened after three months in December. An area of 1.4 ha of sorghum was ensiled in December in a heap silo with 48 $m^3$ capacity which was opened after two months in February 2006. Fresh probes were taken along in a cooler for laboratory analysis of pH and quality measurments. Fermentation quality of silages was additionally assessed by organoleptic characteristics of smell, colour and texture. Three Brahman-Brown-Swiss (37/63%) crosses in good body condition, with a lactation period of more than two months and more than 3 births were selected. Sorghum and maize silage were offered from 5 to 11.30 am and from 3 to 4.30 pm (time restricted supplementation). The following treatments were applied:

Treatment A: Sorghum silage + 2 kg concentrate (min 20% CP) + pasture (Toledo)

Treatment B: Maize silage + 2 kg concentrate (min 20% CP) + pasture (Toledo)

The feeding trial, lasted 30 days divided in three periods of 10 days, i.e. period 1: Sorghum silage (A); period 2: Maize silage and period 3: Sorghum silage (A). Milk production for each cow was recorded daily. For statistical analysis of milk production, data from the first three days (adaptation phase) of each period were excluded and data from day 4 to day 10 were taken for each treatment.

## Results

**Silage quality and intake:** The pH values in combination with the DM contents indicate that both silages had fermented well and were an-aerobically stable (Table 66). This was confirmed through organoleptic evaluations of smell (pleasantly sweet, absence of butyric or strong acid smell), colour (green) and texture (intact), in which both silages resulted with grade “very good”. It is possible that the pH values of the silages increased during the period when the probes were transported to the laboratory and therefore it is expected that the real pH was lower in the silos.

Visible losses due to spoilage at the side walls were minimal (< 5%) in both silos. Crude protein contents were similar with 7.5% for sorghum silage and 7.8% for maize silage. Neutral detergent fibre (NDF) content was higher for sorghum silage (85.3%) than for maize silage (75%).

Intake of fresh maize silage (30.5% DM) averaged 18.2 kg FM , whereas intake of fresh sorghum silage (35% DM) averaged 22.8 kg. In addition to the higher FM intake of sorghum silage compared to maize silage, difference of total daily DM intake were even greater (8.0 vs. 5.6) due to the higher DM content of sorghum silage.

**Milk production:** The average milk production with sorghum silage was 11.33 litres/cow

**Table 66.** Silage quality

| Material | DM (%) | pH | CP (%) | Ether Extract (%) | NDF (%) | Ash (%) |
|---|---|---|---|---|---|---|
| Sorghum silage | 35 | 4.8 | 7.52 | 2.46 | 85.32 | 7.77 |
| Maize silage | 30.5 | 4.6 | 7.84 | 2.61 | 75.01 | 7.88 |

**Table 67.** Cost for maize and sorghum production

| Item | Maize silage | | Sorghum silage | |
|---|---|---|---|---|
| | Lps[1]/mz | $US/ha | Lps/mz | $US/ha |
| Ploughing with tractor | 800 | 60.2 | 800 | 60.2 |
| Oxen for seedbed preparation | 500 | 37.6 | 500 | 37.6 |
| Labour for sowing | 200 | 15.0 | 200 | 15.0 |
| Seed | 40 | 3.0 | 409 | 30.8 |
| Fertilizer (urea) | 200 | 15.0 | 0 | 0 |
| Fertilizer (NPK:18-46-0) | 200 | 15.0 | 200 | 15.0 |
| Labour application fertilizer | 150 | 11.3 | 150 | 11.3 |
| Plant protection measures | 90 | 6.8 | 90 | 6.8 |
| Labour for weeding | 1000 | 75.2 | 1000 | 75.2 |
| Total | 3180 | 239.1 | 3349 | 251.8 |

[1]Lps = Lempiras (Honduran currency)

(N = 42; Std. Dev. = 1.82), which is 2.54 litres higher than with maize silage (8.79 litres/cow, N = 21; Std. Dev. = 1.25). The reason for the great difference in intake and milk production between the two silages could not be explained by quality parameters.

**Silage costs:** In Table 67 we show that sorghum production cost was slightly higher than maize due to higher seed cost.

In Table 68, silage production costs for maize and sorghum are listed. The cost of sorghum silage per kilogram was slightly higher compared to maize silage mainly due to a lower biomass production (17.1 tons/ha compared to 28.6 tons/ha), which is very low compared to results from elsewhere in Honduras, differences between maize and sorghum due to lower fertilization of sorghum (maize received an extra does of 130 kg/ha urea and less water availability for sorghum as it was planted after maize harvest at the end of the rainy season. Therefore, production costs can not directly be compared. In the calculation for sorghum silage cost, it is not considered that sorghum re-growth was harvested two times more. Silage from the second (and third cut) is cheaper since land preparation and establishment costs are not included in the calculation.

**Cost-benefit analysis:** The cost-benefit analysis was calculated with (a) sorghum silage costs of 0.024 $US/kg (only considering the first cut), and (b) the same costs for maize and sorghum silage (0.019 $US/kg). Case (b) serves as example how the higher palatability (or intake) of sorghum silage in this case influenced income and profitability. In Table 69 we show the feed costs for each treatment, with total feed costs for treatment A of 1.09 $US/cow, and 0.97 $US/cow, respectively, and 0.89 $US/cow for treatment B.

**Table 68.** Cost for maize and sorghum silage

| | Maize silage | | Sorghum silage | |
|---|---|---|---|---|
| | Lps/1.125 mz | $US/1.125 mz | Lps/2 mz | $US/2 mz |
| Production cost | 3578 | 188.3 | 6698 | 352.5 |
| Labour for ensiling process (harvest, transport, compaction) | 2640 | 138.9 | 2080 | 109.5 |
| Plastic | 360 | 18.9 | 400 | 21.1 |
| Gasoline for chopper | 173 | 9.1 | 173 | 9.1 |
| Chopper cost | 1000 | 52.6 | 1000 | 52.6 |
| Total | 7751 | 407.8 | 10351 | 544.8 |

**Table 69.** Feed costs ($US)

| | Silage intake (kg FM) | Silage cost/cow | Concentrate[1] cost/cow | Total feed cost/cow |
|---|---|---|---|---|
| Sorghum ration | 22.8 | (a) 0.55<br>(b) 0.43 | 0.54 | 1.09 (a)<br>0.97 (b) |
| Maize ration | 18.2 | 0.35 | 0.54 | 0.89 |

[1] Concentrate cost: 0.27 $US/kg; sorghum silage costs: 0.024 (a) and 0.019 (b) $US/kg

In Table 70 we present the ranges and mean values for income, costs and profitability of the two silages. The cost-benefit analysis showed that net income and profitability were higher for treatment A (sorghum silage) compared to treatment B (maize silage), for both scenarios, (a) and (b). This means that the higher cost of sorghum silage (due to higher consumption) is more than compensated through higher milk production.

For (a): Non-parametric tests revealed significant differences between treatments for net income per cow but not for net income per litre and profitability. The mean difference of net income per cow between treatments is 0.54 $US. For a farm with 10 cows producing the same amount of milk over a 3 month period, this would mean about 486 $US more net income.

For (b): Non-parametric tests revealed significant differences between treatments for net income per cow, net income per litre and profitability. The mean difference of net income per cow between treatments is 0.66 $US. For a farm with 10 cows producing the same amount of milk over a 3-month period, this would mean about 594 $US more net income.

## Conclusion

The results confirm farmers' experience that with sorghum silage milk production was higher compared to maize silage under prevalent farm conditions. Sorghum provides additional advantages over maize such as its ability to re-sprout reducing production costs and production delay and its higher drought tolerance allowing farmers to extend production into the dry season. As a consequence, maize is being substituted by sorghum for silage in the Yoro region.

**Table 70.** Ranges (lower and upper bound of standard deviations) and mean values for income, costs and profitability of treatments with maize silage and sorghum silage

| | Treatment A (sorghum silage) | Treatment B (maize silage) |
|---|---|---|
| Total (dry season) feed cost ($US/cow/day) | 1.09 (a)<br>0.97 (b) | 0.89 |
| Dry season feed cost + labour cost[1] ($US/cow/day) | 1.19 (a)<br>1.07 (b) | 0.99 |
| Milk production (litres/day) | 10.76 – 11.89 [2] (11.33) | 8.22 – 9.35 (8.79) |
| Cost of milk ($US/litre) | (a)0.111 – 0.100 (0.105)<br>(b) 0.099 -0.090 (0.094) | 0.120 – 0.106<br>(0.113) |
| Gross Income from milk sale[3]/cow | 3.12 – 3.45 (3.29) | 2.38 – 2.71 (2.55) |
| Net income/cow/day | (a) 1.93 – 2,26 (2.10)<br>(b) 2.05 – 2.38 (2.22) | 1.39 – 1.72 (1.56) |
| Net income/litre of milk | (a) 0.179 – 0,190 (0,185)<br>(b) 0.191- 0.200 (0.196) | 0.169 – 0.184<br>(0.177) |
| Net income/cost (profitability) per litre milk (%) | (a) 161 – 190 (176)<br>(b) 192 – 222 (207) | 141 – 174 (157) |

[1]Labour cost: 0.1 US$/cow; [2] Numbers in brackets are mean values; [3] Milk price: 0.29 $US/litre

### 4.4.6 Participatory experimentation with little bag silage technology (LBS)

**Contributors:** C. Reiber, M. Peters, R. Schultze-Kraft, P. Lentes, H. Cruz and C. Lascano (CIAT)

#### Rationale

Little bag silage (LBS) is seen as a promising technology for small-scale farmers. In Honduras, LBS can play an important role in creating awareness on the suitability of forage conservation for smallholder farmers and has been employed during farmer trainings and field days to train farmers in concepts and principles as an entry point for forage conservation technologies. The objective of the research is to evaluate the potentials and constraints of LBS for smallholders under Honduran conditions. Results presented in the Annual Report 2005 are complemented with this contribution.

#### Results

During a field day in Las Vegas/Victoria, seven LBS of about 40 kg each were elaborated. Wilted and chopped Toledo was ensiled using different additives. For demonstration purposes, one bag was made without additives, two bags with chopped sugarcane and two bags with citrus fruits (limón Persa) as additive. During a fair, two of the bags were presented to farmers. The smell of the silage with citrus fruits was reported to be extremely good and farmers were impressed about both, the bag silage technology and the feasibility of making good quality with citrus pulp added to Toledo silage. The good quality was confirmed by pH 3.8 and the ready acceptance by cows who had never been fed silage before. In Candelaria, problems with grass silages were reported and farmers complained about the bad smell. The main problem detected was the low amount of molasses added to the grasses and high moisture content in the silos, both due to the plant material itself and due to far too much water added to the molasses. A workshop was organized in which 21 silage bags of 30 kg each and different treatments were elaborated with farmers and subsequently stored in a closed room. The purpose of the workshop was to demonstrate farmers, a) that bag silage is a feasible alternative, and b) that the quality of Toledo silage can be improved by wilting and adequate addition of water soluble carbohydrates. After four months, another workshop was held in which the bags were opened for evaluation. In Table 71 we summarize the results.

Farmers' reported the best smell for the wilted silages with molasses and sugar cane followed by the moist silage with molasses. Additional pair-wise rankings revealed that wilted silage was preferred to moist silage and silage with additive was preferred to silage without additive. Nevertheless, losses due to fungi were greater in the wilted silages. This can be explained by the

**Table 71.** Toledo silage bags with different treatments

| Treatment | Number of bags | pH | Smell (1-5)[1] | Farmers' ranking | Losses (%) Range and (average) |
|---|---|---|---|---|---|
| 1. Moist (22% MS), without additive | 3 | 4,4 | 2 | 6 | 0-10 (5) |
| 2. Moist (22% MS) with molasses (6%) | 4 | 4,5 | 4 | 3 | 0-7 (4) |
| 3. Wilted (40% MS) without additive | 2 | 6,0 | 3 | 5 | 0-100 (50) |
| 4. Wilted (40% MS) with molasses (6%) | 4 | 3,9 | 4 | 1 | 0-80 (32) |
| 5. Wilted (40% MS) with sugar cane (20%) | 4 | 4,7 | 4 | 1 | 0-15 (5) |
| 6. Wilted (40% MS) with dissolved sugar blocks (6%) | 4 | 4,2 | 3-4 | 4 | 10-100 (40) |

[1] 1 = rotten, disgusting; 2 = bad; 3 = acceptable; 4 = good; 5 = very good

fact that air exclusion is more problematic with forages showing higher DM contents.

### Constraints to adoption of LBS

Even though many farmers participated in events where the LBS technology was presented and/or personally elaborated LBS for testing, after two years, no adoption has yet occurred. Restrictions to success with LBS include availability of suitable and cheap plastic bags, high silage losses due to perforation of plastic bags caused by inappropriate handling and rodents (e.g. rats and mice), and lack of adequate storage facilities in many smallholder farms. Moreover silage adoption by smallholders is often restricted by access to a chopper as hand-chopping is cumbersome, time- and/or labour-intensive. Small-scale farmers with chopper rather adopted other silo types with higher capacities (i.e. heap and earth silos), either instantly or after having tried LBS.

### Potential utility of the LBS Technology

In spite of no adoption, the LBS technology can be employed as a) a useful demonstration, experimentation and learning tool that can be used as adaptable prototype in farmer trainings and field days due to its rapid elaboration, b) to get farmers started in experimenting with silage technology at a low risk. LBS does not require additional manpower and can be elaborated in periods of low labor demand, can make use of small areas of cultivated high quality forages and other feed resources and can be ensiled solely or in combination. To be successful the choice of plastic material appears important We identified a bag having a high density, caliber 7, double layered, sealed at sides and rolled up as one piece, with high tensile strength material resistant to tearing as most suitable. The bags can be cut according to the needs, the two ends to be sealed through knotting. The plastic material is available in many remote areas and sold at a price of 57-81 US$ cent per meter depending on the location and the quantity purchased. Per silage bag of 30 kg, about 1.4 meters of plastic are necessary, which costs about 1 US$/bag. If intact, it can be used again reducing costs. The use of any form, e.g. a plastic barrel, in which the plastic bag is elaborated, revealed to be very useful, especially when using bags of higher capacity in order to improve compaction at the margins (Photo 10A), to avoid stretching and to prevent perforations of bags by coarse stems. The form is cut open at one side and clasped or held together by a rope or belt while filling and compacting the forage. It needs to be opened in order to be able to take out the bag of the barrel (Photo 10B). Perforation and tearing of bags during silage preparation, caused by e.g. plant parts, fingers or shoes, as well as during storage need to be sealed immediately with a high quality adhesive tape. Adequate storage, i.e. protection from animals (as well as sun-light), is key for the success with LBS. Possibilities to reduce risk of perforation caused by animals are natural or chemical pesticides, cats and burying of the bags in the ground.

**Photo 10A.** Compaction of LBS

**Photo 10B**: Opening of the barrel

### 4.4.7 Stimulating innovation among small farmers of low cost forage conservation technologies in Nicaragua

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**Rationale**

Feed shortage during the 5-6 months dry season severely limits livestock production and farm income in the subhumid areas of Central America. The Forage Program of CIAT has developed and promoted improved grass and legume species suitable for grazing, cut/carry systems and silage and hay production. In addition we have been working on adapting silage technologies to smallholder systems. Results indicate that feeding silage or hay to milking cows is profitable. In Las Segovias farmers produced hay and silage amounting to a total of almost 14 MT (Table 72). In San Dionisio (Matagalpa) only three farmers out of an initial nine produced hay or silage: sorghum silage from 0.15ha, Cratylia silage from 0.1 ha and Mulato hay from 0.7 ha. The produced material in Las Segovias was used for the feeding experiments outlined in Table 73.

**Table 72.** Hay and silage production in Las Segovias

| Farmer | Locality | Cattle | Technology | Area (ha) | Prod. (kg) | Yield (MT/ha) | Remark. |
|---|---|---|---|---|---|---|---|
| Alejandro Rugama | La Trinidad | no | Cratylia silage | 0.11 | - | | failed |
| | | | Vigna hay | 0.14 | 164 | 1.1 | |
| | | | Sorghum + Lablab | 0.05 | 300 | 6.7 | |
| José Angel Alaníz | La Trinidad | no | Mulato silage | 0.18 | 680 | 3.9 | failed |
| Martín Joya | La Trinidad | no | Mulato silage | 0.20 | - | - | failed |
| | | | Toledo hay | 0.17 | 2681 | 15.5 | |
| José Daniel Rodas | La Trinidad | no | Cratylia silage | 0.06 | 273 | 4.5 | |
| José Ines Rayo | La Trinidad | yes | Cratylia silage | 0.20 | - | | failed |
| J. Cruz Garcia | La Trinidad | yes | Lablab hay | 0.32 | 300 | 1.0 | |
| Orlando Rodas | Condega | yes | Toledo hay | 0.53 | 6720 | 12.7 | |
| Rodolfo Valdivia | Estelí | yes | Cratylia silage | 0.20 | 1140 | 5.7 | |
| Wilfredo Castillo | Estelí | yes | Mulato silage | 0.53 | 1360 | 1.4 | |

**Table 73.** Feeding experiments with dry season forages in Las Segovias

| Farmer | Locality | Technology | Treatment |
|---|---|---|---|
| J. Cruz Garcia | La Trinidad | Lablab hay | T1: grass+sorghum<br>T2: grass+sorghum+hay |
| Orlando Rodas | Condega | Toledo hay | T1: pasture<br>T2: pasture + hay+ molasses |
| Rodolfo Valdivia | Estelí | Cratylia silage | T1: crop residues (70%) + sugarcane (30%) + molasses<br>T2: crop residues (70%) + sugarcane (30%) + molasses + Cratylia silage |
| Wilfredo Castillo | Estelí | Mulato silage | T1: farmer’s practice + concentrates<br>T2: farmer’s practice + Cratylia silage |

One experiment showed that a daily ration of 4.5 kg of Cratylia silage substituting 3.6 kg of concentrates (basal ration: sorghum + *Pennisetum* spp. + molasses) did not have any negative effect on milk production, whereas the variable costs of the Cratylia supplement were only 5-10% of the concentrates.

### 4.4.8 Improved feeding systems for smallholder dairy cattle in Nicaragua with emphasis in the dry season

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**Rationale**

The objective of this project jointly carried out by ETH (Zürich), CIAT and INTA (Nicaraguan national agricultural research institute) is the participatory development of alternative and environmentally sound dry season feeding options in different agro-ecological zones in the hillsides of Latin America, which contribute to sustained milk production and improved milk quality during the dry season and reduce the dependence on purchased supplements.

**Availability and quality of local and introduced forages:**

To assess seasonal variations in dry matter production and feeding value of local and introduced forage species, in Las Segovias (El Tule) plots were established at two locations with eight grasses (four local and four introduced), seven legumes (two local, five introduced) and five (two local, three introduced) shrubs. Of the legumes, *Mucuna pruriens*, *Canavalia brasiliensis* and *Vigna unguiculata* performed best in terms of agronomic characteristics. In verification on-farm trials, both in El Tule and in San Dionisio (Matagalpa), differences in biomass production between the different grasses were considerable, *Brachiaria* hybrid 36061 “Mulato” showing a yield of 7.8 MT/ha, followed by *Brachiaria brizantha* “Toledo” (6.2 MT/ha), *Hyparrhenia rufa* (4.2 MT/ha) and *Brachiaria* hybrid 36087 “Mulato II” (4.0 MT/ha).

**Improved forage management and supplementation strategies for the dry season**

In 2006 dry season experiment cycles with introduced (i.e. *Brachiaria* hybrids, *Brachiara brizantha* “Toledo”) and local (i.e. *Hyparrhenia rufa*) pastures were conducted in El Tule and San Dionisio. In El Tule cows produced more milk when grazing introduced pastures (0.1-0.3 lts per cow per day), in San Dionisio there were no differences between introduced and local species. Fat content was also similar, but “Mulato” showed a considerably higher content in protein (Table 74).

**Table 74.** Pasture yields, milk production and milk quality, El Tule / San Dionisio, 2006

| | El Tule | | San Dionisio | | | |
|---|---|---|---|---|---|---|
| | Yield (MT/ha) | Milk production (lt/cow/day) | Yield (MT/ha) | Milk production (lt/cow/day) | Fat (%) | Protein (%) |
| *Brachiara* hybrid 36061 “Mulato” | 7.8 | 2.9 | 4.4 | 3.9 | 4.7 | 4.0 |
| *Brachiara* hybrid 36087 “Mulato II” | 4.0 | 3.1 | | | | |
| *Brachiaria brizantha* 26110 “Toledo” | 6.2 | 3.0 | 5.8 | 4.0 | 4.8 | 3.4 |
| *Hyparrhenia rufa* (“Jaragua”) | 4.2 | 2.8 | 1.4 | 4.0 | 4.6 | 3.4 |

These small differences in milk production are probably due to the limited genetic potential of the animals in the trials. Differences in live-weight gain and other production characteristics were not taken into account in the measurements.

## 4.5 Promotion of forage technologies to enhance competitiveness of livestock systems in LAC

### Highlights

- Costa Rica's livestock and beef industry performs very unsatisfactorily and as a result farmers cannot recover the opportunity cost of the capital invested in the land, making this beef activity uncompetitive

- In dual purpose cattle systems in Olancho, Honduras, Central America purchased supplements (62% of the farms) is the most important cost driver in the dry season.

- Low and lowest performers operating dual purpose cattle farms use purchased feed supplements in the dry season to maintain body condition of the herd, while farms with a better feed base produce milk.

- Lowest performers operating dual cattle farms in Honduras combine resource constraints with deficiencies in management. Obstacles for the adoption of multi-purpose forage options are related to lack of cash and low return to investment on supplemental feeding to low genetic potential of cows for milk production.

- Early adoption by farmers in Yoro, Honduras of improved forage technologies to supplement milking cows in the dry season is most probable among top and medium performers given that they have financial reserves to test new technologies, and possess cows with better genetic potential to respond to high quality feed

- Incorporation of new forage/crop technologies in the current livestock systems in the Llanos of Colombia would constitute a powerful tool to stimulate regional agriculture, while improving the productive capacity of the soil.

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

### 4.5.1 Critical Issues to Promote Technical Change and Enhance the Efficiency and Competitiveness of the Beef Sector in Costa Rica

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This study aims to: (1) describe the economic agents of the meat chain in Costa Rica as well as its commercial and legal relationships; (2) identify the inter-relationships between links, technological levels, efficiency indicators, installed capacity (scale), and level of occupation; (3) characterize and estimate cost and price structures and the generation of value along the different links of the chain; (4) identify critical costs that can be modified through technological interventions, policies, or other actions; and (5) determine biological and economic risk factors throughout the chain. A methodology that identifies and determines the costs and benefits in each segment was developed to estimate the generation of value in monetary terms throughout the meat chain.

Costa Rica's meat sector has clearly suffered a downward trend since the mid-80s, with an annual decrease in production of 0.1% over the past 20 years despite the reduction of the herd inventory, which decreased from 2.3 million heads in 1985 to only 1.1 million in 2004. Government investment in the sector fell from 5% of the national budget in the early 1990s to only 1.5% at the beginning of this decade. Total farm credit of both public and private sectors has suffered a marked decline. In 1990 it represented 15% of total placements (4% in livestock production) and in 2002 these had fallen to only 5% (1.7% corresponded to livestock credit).

Productivity indicators reflect the poor dynamics of Costa Rica's livestock sector. The annual gross earning per unit area was estimated at US$44/hectare for cattle ranches, at $126/hectare for dual-purpose farms (including income from sale of milk), and at $135/hectare for farms where development and cattle fattening activities were carried out. This gross income is considered extremely low if the commercial value of land on beef farms is used as reference. This value ranges between US$1,000 and $2,000/hectare.

The aforementioned biological inefficiencies, combined with the high cost of land, hinder the recovery of the opportunity cost for capital invested in the land, making meat-related activities fairly uncompetitive. Because of its low productivity, the cattle-raising system pays family labor wages under the legal minimum.
Based on the assumption that the only cost in cash is that of farm labor, cattle ranches would be paying family labor a wage equivalent to 60% the legal minimum. Therefore it is imperative that the public and private sectors join efforts throughout the chain to increase the productivity and efficiency of this primary sector by facilitating the adoption of improved technologies.

Auctions yield a relatively good profit; however, when analyzed on a calendar day basis, they are not so attractive because of the low use of installed capacity (see Table 75).

A strategy that could prove useful to improve the efficiency of Costa Rica's auction system would be to integrate the different events in order to share fixed operational costs. Administrative and operational staff could rotate among existing auctions since their dates are different. This scheme would help reduce fixed costs and the commission charged, without affecting profits and improving efficiency in this link of the chain.

The industrial sector (municipal and industrial slaughterhouses) shows a low occupation of installed capacity, which results in high operational costs and very low labor efficiency. The estimates of total operational costs of slaughter range between US$32 and $66 per animal (Table 76).

If the estimated unit costs are compared with the rates collected for slaughtered beef (US$15-$23), municipal slaughterhouses would appear to work at a loss and industrial slaughterhouse with a very low margin of profit thanks to by-products (hide and viscera). The retail sector (butchers and supermarkets) present the best performance in terms of efficiency and profitability. The rate of profit, expressed as the fraction of the final price paid by the consumer that remains in hands of the butcher as retribution for his/her work, varied broadly—from 3% to 40%, with an average of 32% (Table 77). If these rates of profit are compared with those of other alternative retail businesses (approximately 8%), then this type of activity generates excellent margins of profit at very low risk. The value generated throughout the chain, as percentage of the final value of young bulls at retail price, is distributed as follows (Figure 51): rancher (19%), auctioneer (1%), fattener (34%), transporters (6%), slaughterhouse (7%), and retailers (33%). The

**Table 75.** Operational characteristics of auctions: type of animals bought or sold, operating costs, and income.

| Indicator | Auction | | | | | Average |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | |
| Year of establishment | 1997 | 1993 | 1984 | 2001 | 1993 | 1994 |
| Commission collected (%) | 4 | 3.5 | 3.8 | 3.5 | 4.0 | 3.8 |
| Installed capacity (# animals/day) | 900 | 500 | 600 | 500 | 800 | 660 |
| Average no. transactions per event (# heads) | 500 | 390 | 300 | 290 | 750 | 446 |
| Capacity used (%) | 55 | 78 | 50 | 58 | 94 | 68 |
| Weekly operation (# of days) | 1 | 2 | 1 | 1 | 2 | 1.4 |
| Real capacity used (%) | 9.2 | 26 | 8.3 | 9.7 | 31.3 | 15.8 |
| Categories of animals bought or sold at the auction (%) | | | | | | |
| * Culled cows | 10 | 60 | 35 | 6 | 30 | 28 |
| * Weaned calves | 25 | 15 | 15 | 20 | 15 | 18 |
| * Weaned female calves | 20 | 5 | 5 | 9 | 10 | 10 |
| * Young bulls for finishing | 30 | 5 | 10 | 25 | 20 | 18 |
| * Heifers for slaughter | 10 | 10 | 30 | 33 | 20 | 21 |
| * Finished males | 5 | 5 | 5 | 7 | 5 | 5 |
| Most frequent distance from the auction to the farm (km) | 25 | 40 | 30 | 60 | 50 | 41 |
| Labor at the auction (# people) | | | | | | |
| * Auction day | 32 | 25 | 29 | 16 | 34 | 27 |
| * Day without auction | 9 | 9 | 6 | 4 | 12 | 8 |
| Monthly operational costs[1] ($) | | | | | | |
| * Labor | 7,440 | 6,200 | 5,790 | 3,500 | 11,363 | 6,859 |
| * Services | 250 | 220 | 240 | 200 | 290 | 240 |
| Gross monthly income[2] ($) | 22,733 | 36,151 | 14,679 | 12,076 | 76,048 | 32,337 |
| Net income per event ($) | 3,474 | 3,433 | 1,997 | 1,934 | 7,437 | 3,655 |
| Net income per animal bought or sold per event ($) | 6.94 | 8.80 | 6.66 | 6.67 | 9.92 | 7.80 |
| Net income per animal bought or sold per calendar day ($) | 0.99 | 2.51 | 0.95 | 0.95 | 2.83 | 1.65 |

[1] Estimate based on an average cost of US$550/permanent worker, including social benefit costs for days without auction and US$25/day for transitory workers on auction days.

[2] Estimate based on the proportion of animals, according to category, that arrive at the auction, number of animals bought or sold per event, 2005 sale price, and commission collected by each auction.

distribution of the value generated along the meat chain is completely inequitable and is not consistent with the risk faced by the different actors forming the chain. The inequity observed in the distribution of the added value reflects a clearly dominant position in the market of several actors of the chain, which allows them to capture a very high fraction of the benefits. The generation of value along the chain ranges from US$0.28/animal per day for the rancher to US$46/animal per day for the butcher. The highest proportion of added value is concentrated at the final end of the chain. The butcher or supermarket obtains 164 times greater value from the same animal in the same time unit than the rancher but faces a lower risk because his/her raw materials, equipment, and infrastructure are usually covered by insurance policies.

**Table 76**. Some operational characteristics of municipal and industrial slaughterhouses in Costa Rica.

| Variable | Municipal Slaughterhouses | | | Industrial Slaughterhouse |
|---|---|---|---|---|
| | **1** | **2** | **3** | |
| Volume slaughtered (heads/month) | 45 | 150 | 650 | 7,635 |
| Days of operation per month (#) | 17 | 13 | 26 | 26 |
| Capacity of daily slaughter (heads) | 7 | 50 | 85 | 500 |
| Capacity currently used (heads) | 38 | 23 | 29 | 59 |
| Initiation of operations (year) | 1985 | 2002 | 1974 | 1964 |
| Annual proportion of post-slaughter rejections (%animals) | <0.1 | <0.1 | <0.1 | <0.1 |
| Origin of cattle slaughtered (%) | | | | |
| a. Small producer | | | 4 | NA |
| b. Medium producer | | 50 | 12 | NA |
| c. Large producer | | | 54 | NA |
| d. Butcher's shops | 100 | 50 | 30 | NA |
| e. Supermarkets | | | | NA |
| f. Others | | | | NA |
| Agent of the chain that assumes the post-slaughter risks of confiscation | Cattle owner | Cattle owner | Cattle owner | Cattle owner |
| Availability of insurance policy (Yes, No) | Yes | Yes | Yes | Yes |
| Permanent employees (#)[1] | 3 | 16 | 33 | 757 |
| Productivity of labor (# of animals slaughtered per worker) | 15 | 9.4 | 19.7 | 76.3 |
| Operational costs ($/month) | | | | |
| g. Labor | 1,650 | 8,800 | 18,150 | 416,350 |
| h. Electricity | 140 | 1,070 | 2,525 | 64,080 |
| Cost of slaughter ($/head)) | 39.80 | 65.8 | 31.8 | 62.9 |
| Cost of maquila ($/head) | 20 | 23 | 20 | 15 |

[1] Of the total no. of employees, about 100 work in slaughter-related activities.

The competitiveness of this meat chain is the sum of the efficiency and productivity of all the links that form it. A weak and rather poor demand for beef at the final link of the chain hinders the adoption of technology in the primary link of the chain, so it becomes a vicious cycle that generates low productivity and competitiveness. The low demand for beef implies reduced levels of slaughtering, which impedes the full use of the installed capacity of slaughterhouses and processing plants. This, in turn, hinders the generation of economies of scale and causes high unit costs that reduce the competitiveness of meat products in both domestic and foreign markets.

To promote technical change and enhance the efficiency and competitiveness of the value chain of Costa Rica's beef sector, we recommend the following: (a) learn from other chains, for example the poultry chain, by identifying actions that could improve the meat chain; (b) milk breeding cows when a milk market exists as a mechanism to increase family income because wages are currently below the legal minimum; (c) promote the creation of livestock funds as a mechanism to create social capital, reduce transaction costs, and improve chain productivity and profitability; (d) promote massive adoption of forage species with an emphasis on summer feeding to reduce weight losses of the national herd, improve farm profits, and promote modernization through the adoption of improved technologies; and (e) establish a standard systems for beef cuts based on quality and price, allowing the differentiation of offers for different consumer groups, among others.

**Table 77.** Monthly operational costs, breakeven point, and profits of urban and rural butcher's shops in Costa Rica (US$/kg).

| Variable | Butcher's Shop | | | | | | | Average |
|---|---|---|---|---|---|---|---|---|
| | Urban neighbor-hood | Urban neighbor-hood | Urban neighbor-hood | Urban market place | Urban market place | Rural market place | Rural market place | |
| Workers (#) | 22 | 13 | 3 | 24 | 5 | 2 | 4 | 10.4 |
| Labor cost[1] | 7150 | 12100 | 1650 | 13200 | 2750 | 1100 | 2200 | 5735 |
| Energy cost | 787 | 886 | 886 | 591 | 303 | 290 | 394 | 591 |
| Lease of locale | 3937 | 4000 | 3937 | 350 | 295 | 300 | 280 | 1871 |
| Cost of insurance policy | 157 | 158 | 160 | 158 | 157 | 150 | 140 | 154 |
| Operational cost | 12031 | 17144 | 6633 | 14299 | 3505 | 1840 | 3014 | 8351 |
| Beef sales (kg/month) | 6495 | 25980 | 3464 | 30310 | 8660 | 4243 | 3810 | 11852 |
| Total sales of meat (kg/month)[a] | 12990 | 43300 | 4619 | 43300 | 12371 | 7072 | 6350 | 18635 |
| Breakeven point[2] (kg beef/month) | 4500 | 4500 | 800 | 5000 | 1400 | 1200 | 1200 | 2800 |
| Operational cost per kg meat sold ($/kg)[3] | 0.93 | 0.40 | 1.44 | 0.33 | 0.28 | 0.26 | 0.47 | 0.45 |
| Average cost of kg dressed carcass and viscera[4] | 3.06 | 3.05 | 3.06 | 3.06 | 3.06 | 3.06 | 3.06 | 3.06 |
| Average sale price of kg meat for breakeven point[5] | 3.99 | 3.45 | 4.50 | 3.39 | 3.34 | 3.32 | 3.53 | 3.51 |
| Average sale price to consumer[6] of dressed carcass plus viscera | 4.63 | 4.63 | 4.63 | 4.63 | 4.63 | 4.63 | 4.63 | 4.63 |
| Net earnings per kg meat sold ($/kg) | 0.64 | 1.18 | 0.13 | 1.24 | 1.29 | 1.31 | 1.10 | 1.12 |
| Net earnings per kg meat sold (%) | 16.0 | 34.2 | 2.9 | 36.6 | 38.6 | 39.5 | 31.2 | 31.9 |

a. Includes all species.
1 Assuming an average cost per month of US$550 per worker, including social benefit costs.
2 No. kg beef that should be sold monthly to cover operational costs of butcher's shop.
3 Calculated by dividing total operational cost of butcher's shop by kg meat of all species sold monthly.
4 Calculated on the basis of the sale price of one 276-kg carcass at $611 by the slaughterhouse to the butcher's shop plus 16 kg viscera at $35 for a total of $646 divided by 211 kg salable meat (267 kg carcass multiplied by 78% salable meat minus 6% fluid loss). The survey did not ask for this value, but it was estimated on the basis of carcass sales of slaughterhouses.
5 Calculated on the basis of the sum of operational cost per kg beef sold plus average cost of purchasing kg meat from the slaughterhouse.
6 Estimate based on Table 4 for a young male bull and does not reflect the differences of prices that exist between butcher's shops; as a result, this is an approximate indicative.

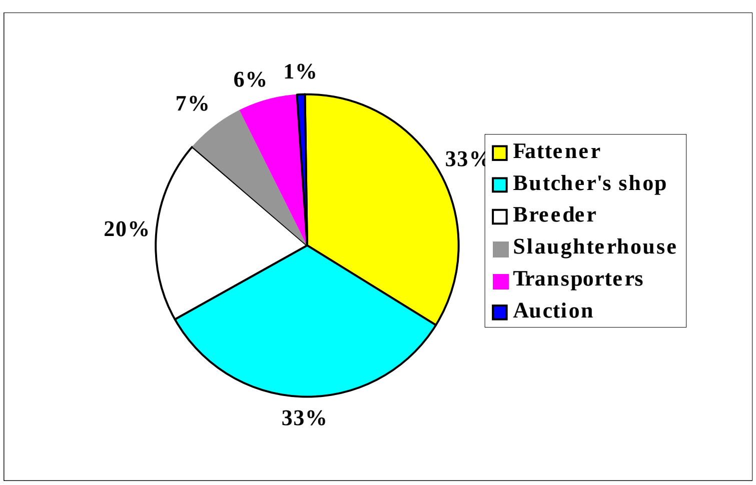


**Figure 51.** Value generated throughout the chain as percentage of the final value of a fat young bull at retailer price.

### 4.5.2 Management and farm characteristics that favor or impede efficient resource use in dual-purpose cattle systems in Central America

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#### Rationale

Since the 1950s, pasture area in Central America has more than tripled. This growth was accompanied by a diminution of forest land, since progress in livestock technology was slow and the widening pasture area was the dominant response to the incrementing demand for livestock products.
During the last 30 years, meat and milk consumption in developing countries has grown 3 times as fast as in developed countries. Projections to 2020 foresee an annual growth of meat demand by 3% and an increase in milk demand by 2.9 % for developing countries. However, between 2001 and 2003 the milk production in Honduras, a developing country, staggered 14% behind milk consumption. Thus the Honduran livestock sector has yet to take advantage of this comparably favorable market. In Honduras, there is a drastic contrast in poverty rates between urban areas (27.6 %) and rural areas (72.2 %). Moreover, the livestock sector is a major employer in rural areas; hence improvements in the livestock sector will likely have positive effects on livelihoods of the rural poor.

The low milk productivity of Central American cattle systems is related to various factors, including the low genetic potential of the commonly used dual-purpose cattle and, the low quality and quantity of feed resources, used in the prolonged dry season of commonly between 4 and 8 months in Honduras and Nicaragua. During the dry season of Central America milk production drops sharply, about 40 % lower than in the rainy season, when feed resources from green pasture are abundant.
The national and regional statistics for Honduras confirm the Central America-wide trends in milk production. The department of Olancho accounts for 20.14% of the national pasture land. In Olancho, cultivated and improved pastures make up 23.7 % of the agricultural land and natural pastures 36.9 %. The share of natural pastures in Olancho exceeds the country average by 14 %. Among the 18 departments, Olancho has the highest total number of milking cows in Honduras (167.107 heads), of which 45.4 % are milked in the dry season, while the share of milked cows rises to 63.2 % in the wet season. Total dry season milk production of Olancho is 41.48 % lower than in the wet season.

The data on poverty, land use, and milk production reveal that an intensification of the livestock sector through enhanced resource use would strongly contribute to sustain incomes of farmers. At the same time, the intensification of the livestock systems, in the sense of an increased production per unit, is as an opportunity to prevent land degradation by overgrazing. The experience of the past also indicates that the intensification of the livestock sector is needed to prevent further loss of forest areas. .

More intensive cattle management through an optimized use of forages can help reduce the degradation of natural resources and lead to a scale neutral increase of incomes from smallholders to large cattle farmers. One option for farm intensification is the use of tropical forage grasses and legumes, as cattle farmers largely depend on grazing of naturalized pastures and degraded improved pastures as a feed resource. Forages can help maintain the natural resource base and mitigate the farmers' dependency on external inputs. A key aspect of livestock system intensification is the correct application of forage technologies.
Socio-economic studies for the livestock farming systems of Olancho have concentrated on specific parts of the farming system, and have

not covered the representative zones of the province.

There are no studies available which analyzes the socio-economic situation of the typical farmers of Olancho using levels of success in milk production in the dry season. Such an analysis contributes to deriving more appropriate extension and development concepts for each category of farms. The objective of this paper is to explore which types of management and farm characteristics favor or impede efficient resource use. The paper develops pathways out of unproductive systems to more efficient income generation in milk and beef production enterprises from representative zones of Olancho.

The strategies farmers follow are analyzed first for their economic efficiency, followed by an assessment of the eco- and social- efficiency of the production. It is hypothesized that the low or inefficient productivity of farms in the dry season is related to an exaggerated use of purchased supplements. Farms which do not possess sufficient forage as a feed resource are caught by the "concentrate trap", when they feed commercial concentrates to animals of low genetic potential for milk production to maintain the herd in times of forage scarcity. In order to achieve this, the milk production systems and the underlying strategies of farms are analyzed and compared on their cost efficiency to derive appropriate solutions for intensification.

## Materials and methods

**Questionnaire Databank and Data Collection**: The data used for this paper were collected by means of a comprehensive socio-economic questionnaire. This procedure was applied in order to take into account the diverse structures of farms and the different feeding strategies.. Prior to developing the questionnaire, a contextual analysis was carried out to define which areas of the farming systems had to be included in the data collection. The focus was laid on dry season problems and on the definition of farm and family income generating activities. Using the information gathered from the pre-survey activities, a standardized questionnaire and database structure were 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.

The population of the study consists of typical livestock farmers in Olancho and was split in two samples, each with distinct sampling procedures.

a. To assess the economic conditions of the representative livestock holder, the sampling plan covered a randomized sample of 69 farms distributed to five sub-study areas, which represent the most important agricultural zones of Olancho. These zones were chosen to represent as much area as possible of prolonged dry season in Olancho. Zones were selected consulting local experts and maps. Gradients between the study areas represent altitudinal and ecological change, as well as a distance gradient from the departmental capital. The largest distance between the two sampled farms is 91 km. The municipalities covered are Juticalpa and San Francisco de Becera in the valley of Guayape river (22 farms sampled), San Francisco de La Paz at the foot of the mountain (23 farms sampled), Gualaco on the top of the mountain (7 farms sampled), and San Esteban with two ranching zones descending the mountain (9 and 8 farms sampled).

b. A sample of 13 farms, referred to in the text as positive deviances, was selected using expert knowledge. This sample covers farms that use a higher level of technology, specifically forage technology. Positive deviances were defined by outstanding use of forage options, such as silage, hay, improved grasses, and legumes. Extra large farms were not accepted as positive deviances.

For the randomized sample the survey team consisted of two technicians from DICTA (Dirección de Ciencia y Tecnología Agropecuaria), the Honduran national agricultural research institute, and two CIAT staff members (a research assistant and the first author). The survey was conducted between July and

September 2005. The selection of the individual farms for sample a was done randomly in the field as follows. Without knowing the farms in the area, the team selected the route to follow for the day and interviewed every third household, provided that they had cattle. Targeted sampling for sample b was done employing expert knowledge from partner institutions, such as DICTA and UNA (Universidad Nacional de Agricultura, Catacamas). Unknown farms were identified by asking farmers about farms in the area that apply forage conservation or another forage technologies. The team for the assessment of the positive deviances consisted of the first author accompanied by a DICTA technician and sometimes by a collaborator from UNA. The data collection for the positive deviances took place between September and December 2005.

Once the entered data were verified, full cost accounting was used for the generation of results from the survey. Before interpreting the results of the analysis, data were checked for outliers on the family income in US$ per year when stratified according to herd size classes. Extreme values were found for 6 cases. These cases were not considered in the representation of average values thus the number of farms shrinks 76.

**Assessment of costs and Income calculations:** The gross income from milk per farm per year was calculated, by summing up the liters of milk produced in the dry season and the wet season and multiplied by the respective milk price without deducting any cost.
To obtain net income, all production costs were deduced from the gross income. Production costs include all purchased inputs and farm inputs, costs for renting machinery and services, e.g., hiring of external labor force, and contracting a team of oxen.

The production costs also include the opportunity cost of the family labor force used on the farm. The degree to which family members participated in farm work differed from case to case and was valued with the wage paid for external labor force assessed for each farm. Working on other farms with this salary would be the alternative for the farmers.

Production costs for the dry season were calculated in detail using the following variables: feeding cost of purchased supplements, production cost of forage grown for the dry season, cost of silage and hay, cost of cut and carry forage production, the salaries for workers, the opportunity cost of family labor used for dry season milk production (in Honduras most farms milk by hand), cost of veterinary services and medicines.
For the wet season, costs include feeding of purchased supplements, cut and carry forage production, weeding cost of pastures fertilization of pastures, the salaries for workers, the opportunity cost of family labor, veterinary services and medicines.

Farm income includes the income from livestock and the income from annual and permanent crops. As farms usually use a part of their products for home consumption farm income includes products sold (cash income) and the opportunity cost of products consumed (kind income).

The extent to which a farmer falls into the concentrate trap, as defined above, was assessed by the performance of the herd in milk production during the dry and wet seasons and this was set in relation to the expenses for commercial concentrate.

**Grouping of farms:** The grouping of farms applied uses gross margins to measure economic success. Performance groups can be formed in various ways e.g., based on superficial areas or units of production. For a comprehensive comparative analysis of dry season milk production in Olancho, data were grouped into four classes, using percentile intervals of the monthly dry season net milk income per cow in milk. Farms that did not benefit from milk production in the dry season were considered in a separate group.

The performance classification is as follows:

1. Lowest performers: farms that did not make money out of milk in the dry season and those losing money
2. Low performers: between 0 and 50 % percentile,
3. Medium performers: between 50 and 80 % percentile,
4. Top performers >80 % percentile

For the grouping of the performance classifications all farms surveyed in both samples were joined, combining the positive deviance farms with the typical farms. This was done to see if the dry season milk production strategies of the positive deviances bring higher returns per cow than in the rest of the sample.

Methods applied for the comparative analysis between groups of farms include descriptive statistics (mean averages, standard deviations, frequencies etc), stem and leaf tests, and linear regression models and non-parametric tests (Mann-Whitney test).

## Results

**Characterization of production and income status:** When farms are grouped according to the net income per cow per month of dry season, the income differences between these groups are highly significant (P-value <0.01) (Table 78). Since the sample covers various climatic zones, it was checked if the performance in milk production was due to these climatic differences, which were assessed by farmer information on the length of the dry season. The shortest dry season is on the mountain top (2.7 moths), while the other zones have between 4.6 and 5.5 months of dry season. Although the difference is high, statistical tests proved that success category was not determined by climatic conditions. Other parameters, which one could expect to differ between performance groups, e.g., the age of the farm owner or his years of experience in milk production, were tested for differences between groups, but were shown to be similar, and thus these parameters do not differentiate the groups.

**Income from milk in the performance groups:** The comparison of net and gross income per cow per month for the dry and wet seasons is shown in Figure 52 and Table 78. Irrespective of the season, on average the lowest performers do not recuperate their expenses. The gross income is eaten up by production costs even in the wet season. While some farms lose only a little, others lose a lot. The error bars representing the standard deviation in the figures show that there are farms, which lose even in the wet season.

**Table 78.** Income per cow of performance groups in the dry and wet seasons, Olancho.

| | | Lowest N = 24 | Low N = 13 | Medium N = 23 | Top N = 16 |
|---|---|---|---|---|---|
| | | A | B | C | D |
| Net income per cow per month dry season | Mean | -15.63 | 5.62 | 14.29 | 32.49 |
| | Std. Deviation | 22.90 | 3.09 | 3.15 | 13.20 |
| | Significance | B,C,D[a] | C,D[a] | D[a] | |
| Net income per cow per month wet season | Mean | -1.83 | 18.41 | 18.16 | 27.90 |
| | Std. Deviation | 24.26 | 7.64 | 9.45 | 14.59 |
| | Significance | B,C,D[a] | D[c] | D[b] | |

[a] the hypothesis of non-significant differences between groups could be rejected with a probability of >= 99 % according to Mann-Whitney U test.
[b] the hypothesis of non significant differences between groups could be rejected with a probability of >= 95 % according to Mann-Whitney U test.
[c] the hypothesis of non significant differences between groups could be rejected with a probability of >= 90 % according to Mann-Whitney U test.

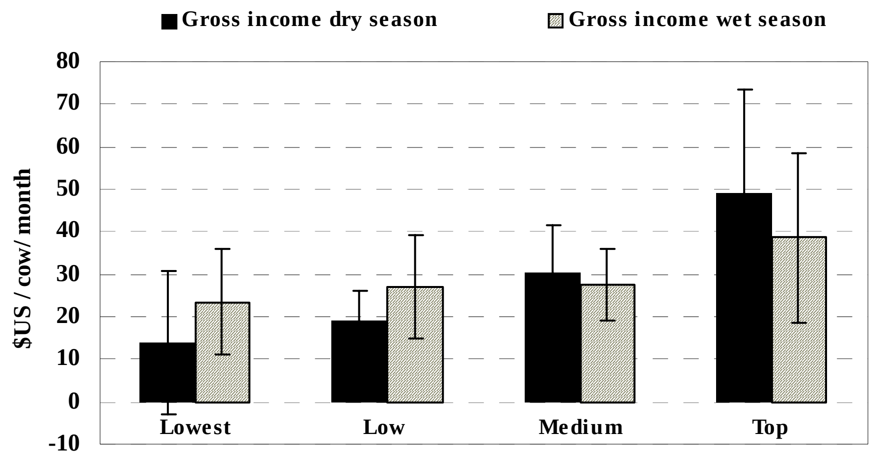


**Figure 52.** Comparison of wet and dry season gross income from milk of success groups, Olancho, 2005.

The dry season gross income per cow of the low performers is about 73 % of their wet season gross income. But when the production costs are deducted, wet season income is more than 3 times higher.

When the gross income from milk in the dry and wet season (Figure 52) is compared, medium and top performers show higher income per cow in the dry season. On gross income level, the lower production in the dry season (Table 85) is compensated through the higher milk prices (Table 84). Transferring this to net income (Table 78), the medium performers do not manage to benefit from the higher milk price, because their net income from milk in the dry season is lower than in the wet season. Only the top performers are able to increase their benefit in the dry season.

**Gross milk income and value per cow:** Throughout the sampled farms, the value of cows in milk was higher than the one of dry cows i.e. cows currently not in lactation (Table 2). The value per cow in milk serves as an indicator for the genetic potential for milk production. This relation was confirmed by farmers' experience: As a rule of thumb, farmers add 1,000 Lempira (52 $US) to the basic value of the cow for each liter of milk produced per day.

As shown in Table 79, positive deviances show the highest commercial value per milking cow. The differences between positive deviances, small and large farms were confirmed by non-parametric tests (p-value < .05), and to a lesser extent for medium size farms (p-value 0.08). Although the average price per cow in milk among extra large farms is considerably lower than the average of the positive deviances, the differences were not significant. This is due to heterogeneity among extra large farms.

To illustrate this, the yearly gross income per cow was set into a linear regression model, as

**Table 79.** Average farm assets in $US according to herd size classes: Per livestock head and totals, Olancho.

| | Small | | Medium | | Large | | Extra large | | Positive deviances | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Value per head | N | Mean | N | Mean | N | Mean | N | Mean | N | Mean | Mean |
| Cows in milk | 25 | 520 | 17 | 569.66 | 11 | 468.9 | 11 | 584 .69 | 12 | 780.7 | 581.6 |
| Dry cows | 19 | 385.04 | 15 | 429.82 | 11 | 373.21 | 11 | 476.08 | 12 | 567.98 | 450.4 |

Note: small: 1- 19, medium: 20 – 49 large, 50-99: extra large: > 100 dependent variable, and is described as: the number of cows in milk in the dry season and the value per milking cow (in $US). Model quality estimators (Table 80) confirm a good quality for the model in general and for the individual variables. The regression explained 81.2 % of the variation of the dependent variable. Values of the t-test for the coefficients of the individual variables were good and show high levels of significance. But the standard error of the estimation is high.

Model description:
Yearly Gross income from milk =
a + b * X1 + c * X2

| | |
|---|---|
| a = | Constant |
| b = | Coefficient for X1 |
| c = | Coefficient for X2 |
| X1 = | Value per cow in $US |
| X2 = | Number of cows in milk in the dry season |

There are differences in the value per cow and as the regression shows, these differences reflect in the genetic potential for milk production of the herds (Tables 80 and 81). As one would expect from the regression model, lowest performers have the cheapest cows and top performers the most expensive ones. The herds of the low and medium performers are comparable concerning the price per animal. With cows of the same price, medium performers are significantly more cost efficient in milk production than low performers. The lower cost efficiency in milk production of low performers has something to do with the management of the herds.

**Table 80.** Regression model for the whole sample $R^2$= 0.821.

| | Unstandardized Coefficients | | T | Sig. |
|---|---|---|---|---|
| | B | Std. Error | | |
| (Constant) | -3281.892 | 974.034 | -3.369 | .001 |
| X1 | 6.922 | 1.499 | 4.619 | .000 |
| X2 | 292.807 | 19.485 | 15.027 | .000 |

**Representation of herd sizes in performance groups:** To see how herd size plays on performance, farms were divided into herd size classes and plotted in respect to their performance group membership (Figure 53). The positive deviances were kept separate, irrespective of their herd size. The bulk of the lowest performers are small farms, but it is not automatic that small farms lose. They are present in each success category.

Medium size farms are more or less equally represented from lowest to medium performers. Medium size farms and positive deviances are equally represented among top performers. Together, they make up 70 % of the top performers. Large and extra large farms typically perform medium and low. About 23 % of the low performers are extra large farms. Those farms identified as positive deviances in Olancho appear among low medium and top performers.

**Table 81.** Value per milking cows in performance groups.

| | | Lowest N = 24 | Low N = 13 | Medium N = 23 | Top N = 16 |
|---|---|---|---|---|---|
| | | A | B | C | D |
| Value per milking cow $US | Mean | 482.46 | 562.75 | 565.22 | 723.68 |
| | Std. Deviation | 117.86 | 249.78 | 253.52 | 314.91 |
| | Significance | C[c],D[a] | | | |

[a] the hypothesis of non-significant differences between groups could be rejected with a probability of >= 99 % according to Mann-Whitney U test.
[b] the hypothesis of non significant differences between groups could be rejected with a probability of >= 95 % according to Mann-Whitney U test.
[c] the hypothesis of non significant differences between groups could be rejected with a probability of >= 90 % according to Mann-Whitney U test.

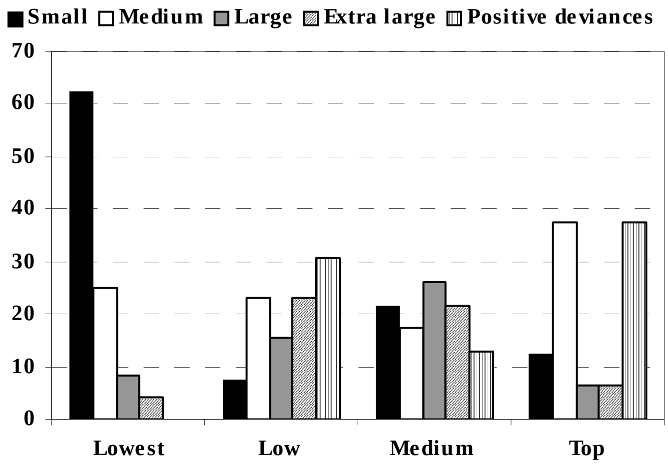


**Figure 53.** Performance group breakdown into cattle herd sizes, Olancho.
Note: small: 1- 19, medium: 20 – 49 large, 50-99: extra large: > 100

In the dry, lowest performers have proportionately fewer cows in milk than the other groups. This can be explained by a high presence of small farms (62.5%) among the lowest performers (Figure 53 and Table 82). Lowest performers have a lower share of improved pastures than the other groups and thus use a high percentage of naturalized pastures, which lose nutritive quality faster in the dry season. Apart from the observation that low performers have a slightly higher share of cows in milk in the dry season than the other groups from low to top, the differences are not marked. Only the lowest performers show a clear decline of cows in milk in the dry season, while the others maintain nearly the same shares of cows in milk throughout the year.

The efficiencies per unit of land are summarized in Table 83. The comparison of the yearly livestock income per ha of pastures and other forages

**Table 82.** Production conditions of farms in performance groups.

| | | Lowest N = 24 | Low N = 13 | Medium N = 23 | Top N = 16 |
|---|---|---|---|---|---|
| | | A | B | C | D |
| Improved pastures % of area | Mean | 46.79 | 62.74 | 74.70 | 61.77 |
| | Std. Deviation | 42.10 | 37.68 | 28.20 | 33.98 |
| | Significance | C[b] | | | |
| Cows in milk dry season | Mean | 35.74 | 64.97 | 60.43 | 61.50 |
| | Std. Deviation | 37.56 | 19.28 | 21.30 | 14.61 |
| | Significance | B, C, D[a] | | | |
| Cows in milk wet season | Mean | 61.24 | 58.62 | 63.92 | 62.4 |
| | Std. Deviation | 24.94 | 9.82 | 21.09 | 23.89 |

[a] the hypothesis of non-significant differences between groups could be rejected with a probability of >= 99 % according to Mann-Whitney U test.
[b] the hypothesis of non significant differences between groups could be rejected with a probability of >= 95 % according to Mann-Whitney U test.
[c] the hypothesis of non significant differences between groups could be rejected with a probability of >= 90 % according to Mann-Whitney U test.

**Table 83.** Land use efficiency per farm in US$ \ha\ year, Olancho.

| | | Lowest N = 24 | Low N = 13 | Medium N = 23 | Top N = 16 |
|---|---|---|---|---|---|
| | | A | B | C | D |
| Livestock income per ha of pasture and other forages | Mean | -59.61 | 163.34 | 173.33 | 215.28 |
| | Std. Deviation | 377.31 | 130.28 | 101.74 | 191.96 |
| | Significance | B,C,D[a] | | | |
| Farm income per ha of arable land crops and livestock | Mean | 53.32 | 145.92 | 186.39 | 219.30 |
| | Std. Deviation | 144.90 | 104.92 | 135.75 | 170.06 |
| | Significance | B,C[a] | | | |

[a] the hypothesis of non-significant differences between groups could be rejected with a probability of >= 99 % according to Mann-Whitney U test.
[b] the hypothesis of non significant differences between groups could be rejected with a probability of >= 95 % according to Mann-Whitney U test.
[c] the hypothesis of non significant differences between groups could be rejected with a probability of >= 90 % according to Mann-Whitney U test.

between the performance groups includes the complete cattle production, which consists of beef, milk and sales of young stock. Even when all these products are considered, the lowest performers do not recuperate their losses from the dry season during the rest of the year. A tendency of a more efficient use per unit of land is noticeable among those farms who win, but differences are comparatively small and the within group variation is high.

The performance per unit of land does not show to be as distinctive as the performance per cow in milk in the dry season. Only when all farm products are considered (all annual and perennial crops, milk, beef and young stock sales), the lowest performers make a small benefit in total farm income per unit of land. This means that the lowest performers are better in crop production than in livestock production. Low performers are better in livestock production per ha than in crops, while overall income per area of land rises slightly between medium and top performers.

**Milk prices and milk market in performance groups:** In Olancho, the majority of the farmers sell to intermediates that collect the milk on the farm and resell it to artesian milk processing plants, where it is processed into the popular fresh cheese. In 1999, there were an estimated 600 artesian milk processing plants in Honduras. The difference of the dry and wet season price for milk is between .05 and .086 US$ per liter (Table 84). The higher milk price in the dry season is a measure of the dual increase in demand and scarcity of fresh milk during this period. The milk shortage that occurs during the dry season leads to a market potential for additional milk to be produced.

**Table 84.** Dry and wet season milk price in $US per liter, Olancho.

| | | Lowest N = 24 | Low N = 13 | Medium N = 23 | Top N = 16 |
|---|---|---|---|---|---|
| | | A | B | C | D |
| Dry season milk price | Mean | 0.2614 | 0.2506 | 0.2570 | 0.2776 |
| | Std. Deviation | 0.0248 | 0.0349 | 0.0274 | 0.0263 |
| | Significance | | D** | D** | |
| Wet season milk price | Mean | 0.1919 | 0.2000 | 0.1805 | 0.1911 |
| | Std. Deviation | 0.0380 | 0.0374 | 0.0294 | 0.0468 |

The highest dry season and wet season amplitude of milk price per liter was found among the top performers. Their dry-season milk price is significantly higher than the one of low and medium performers. Some farms with higher production volumes sell to milk collection centers at a stable price. The dry season milk price of lowest performers was also higher than the one of the low and medium performers categories, but this difference was not significant. Yet, the trend of a higher product price among lowest performers can be attributed to a low volume of milk production, which is often sold locally as fresh milk in the village, especially among small farmers. Opportunities to sell milk were available for all farms sampled. For 95 % of the farms, it was always possible to sell the milk. Those with stagnation of sales in some periods during the wet season (typically around Christmas and Easter) processed their milk to curd cheese, which sells easily in the villages.

**Milk production costs in different performance groups:** During the wet season, when pasture feed is abundant, only 18.9% of the farms purchased feed supplements. For the low and medium performers, this results in a comparatively low milk production cost and higher income per cow. Lowest performers still produce at considerably higher costs. The supplement use changes in the dry season, when 57.9 % of all farms use purchased supplements and the production cost per liter of milk rises.

The production cost per liter of milk in the dry season differs significantly between all success groups (Table 85). In the case of the lowest performers, the production cost per liter is the highest and exceeds the milk price per liter. The smallest margin of profit of 0.0812 $US per liter produced is found among the low performers, which is less than half the profit than the top performers (0.1918 $US/liter). The margin of the Medium performers is 0.1329 $US per liter. Top performers have the lowest production costs and highest selling prices. With the exception of top performers, who spend more on supplements, there are no big differences in the dry season expenses of purchased supplements per animal between the performance groups (Figure 54). In all groups, average milk yield per cow drops in the dry season. Dry season milk yield per cow of lowest and low performers is considerably lower than the one of medium and top performers (Table 85). The expenses for forage production rise from the lowest to the medium performers, while the expenses for supplements fall. Lowest performers spend very little on forage production and a lot on supplements, while producing little milk. The spending of the top performers is concentrated on supplements. Their expenses for forages are comparable to those of the low performers. Top performers have the highest milk production per cow throughout the year. The structure of the expenses and the management of dry season feeding are made up of different components within the performance groups. In Table 86, dry season practices are summarized and are presented as frequencies among the performance groups.

Lowest and low performers show the highest dependency on purchased supplements, while pure farm feed is more widespread between medium and top performers. Although roughly 26% of the medium performers do nothing specific for dry season feeding, their situation is different. Their relative success is a result of favorable conditions available on these farms that provide more feed in the dry season, e.g., improved grasses and high quantities of crop residues. Mixing farm and purchased feed is a common practice among those groups who make profit from milk production in the dry season (Table 87). For a deeper interpretation of the production parameters and production conditions the following sections treat the performance groups separately, referring to Figures 54 and 55 and to Tables 85 and 86. To complete the picture of dry season milk production, farms in the performance groups were summarized to characteristic subgroups according to similar strategies.

**Milk production of the lowest performers:** About 17 % of the lowest performers do not use any purchased feed or farm supplements. Their usual dry season feed consists of pasture. This

**Table 85.** Dry and wet season milk production and costs in US$ of different performance groups, Olancho.

| | | Lowest N = 24 | Low N = 13 | Medium N = 23 | Top N = 16 |
|---|---|---|---|---|---|
| | | A | B | C | D |
| Production cost per liter dry season | Mean | 0.4941 | 0.1694 | 0.1241 | 0.0858 |
| | Std. Deviation | 0.3427 | 0.0601 | 0.0495 | 0.0381 |
| | Significance | B,C,D[a] | C[b],D[a] | D[a] | |
| Production cost per liter wet season | Mean | 0.2171 | 0.0586 | 0.0581 | 0.0561 |
| | Std. Deviation | 0.2124 | 0.0412 | 0.0347 | 0.0394 |
| | Significance | B,C,D[a] | | | |
| Monthly supplementation cost per cow dry season | Mean | 4.81 | 4.67 | 3.50 | 7.33 |
| | Std. Deviation | 9.26 | 4.61 | 5.95 | 11.08 |
| | Significance | B[c] | | | |
| Monthly forage production cost per cow dry season | Mean | 0.28 | 1.78 | 2.42 | 1.84 |
| | Std. Deviation | 1.39 | 3.92 | 4.00 | 2.46 |
| | Significance | B,C,D[a] | | | |
| Dry season daily milk yield per cow liters | Mean | 1.77 | 2.52 | 3.98 | 5.88 |
| | Std. Deviation | 2.10 | 0.80 | 1.42 | 2.87 |
| | Significance | C[b],D[a] | C,D[a] | D[a] | |
| Wet season daily milk yield per cow liters | Mean | 4.12 | 4.48 | 5.10 | 6.80 |
| | Std. Deviation | 2.08 | 1.93 | 1.52 | 3.35 |
| | Significance | C[b], D[a] | D[b] | D[b] | |

Note: All income figures are net income
Monetary units $US
[a] the hypothesis of non-significant differences between groups could be rejected with a probability of >= 99 % according to Mann-Whitney U test.
[b] the hypothesis of non significant differences between groups could be rejected with a probability of >= 95 % according to Mann-Whitney U test.
[c] the hypothesis of non significant differences between groups could be rejected with a probability of >= 90 % according to Mann-Whitney U test.

results in a low production of milk, because lowest performers have the smallest share of improved pastures and those who rely on pasture alone do not possess extraordinary favorable conditions, e.g., low groundwater surfaces on

**Table 86.** Frequencies of dry season feed sources in performance groups.

| | Lowest | Low | Medium | Top |
|---|---|---|---|---|
| Nothing specific | 17.39 | 7.69 | 26.09 | 12.50 |
| Pure purchased feed | 26.09 | 23.08 | 0.00 | 12.50 |
| Pure farm feed | 43.48 | 23.08 | 30.43 | 31.25 |
| Mixture of purchased and farm feed | 13.04 | 46.15 | 43.48 | 43.75 |

**Table 87.** Average number of dry season feed sources per farm in performance groups.

| | Lowest | Low | Medium | Top |
|---|---|---|---|---|
| Total feed | 1.22 | 2.23 | 2.39 | 2.81 |
| Purchased feed | 0.48 | 0.92 | 0.70 | 0.81 |
| Low quality farm feed | 0.52 | 0.62 | 0.74 | 0.88 |
| High quality farm feed | 0.22 | 0.69 | 0.96 | 1.13 |

Note:
Purchased feed: Commercial concentrate and molasses.
Low quality farm feed: dry pasture if fertilized, Maize and Bean straw.
High quality farm feed: Cut and carry grasses, Fresh maize and Sorghum, Hay, Silage, Legumes.

pastures. For the most part, lowest performers possess low quality natural pasture (Table 86). A phenomenon, which is introduced here as the "concentrate trap", describes those farmers who spend on purchased supplements without recuperating these expenses in milk production. About 39.1% of the lowest performers fall into this category. Supplementing concentrate, which is the most expensive form of supplementation, as the sole supplement is common practice for nearly 17.4 % of the lowest performers. Another 8.6% rely only on feeding concentrate and molasses. The rest of the lowest performers who fall into the supplement trap (13.1%) use farm feed of low quality combined with the purchased supplements. Only 17.3 % of the lowest performers dispose of cut and carry forages, a forage of better quality, but in limited quantity. The lowest performers with pure farm feed (43.4 %) mostly rely on maize stover of low quality. Only 4.3 % had cut and carry forages. With this poor feed base, 42 % of the lowest performers do not milk their cows in the dry season. The most important reason for not milking in this time is scarcity of feed for the herd. Cows are put to grazing on dry pastures, where they cannot get enough feed to produce. In some cases herd sizes are small and the milking period of the cows falls into the wet season, a good strategy for those farms with insufficient farm feed resources.

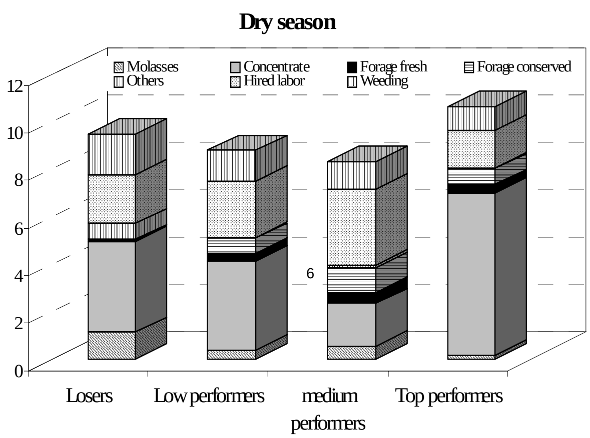


**Figure 54.** Monthly expenses for milk production per cow in milk in $US, dry season.

For 90 % of the lowest performers who did not milk in the dry season, it is characteristic that they do not spend on dry season feeding. Weight losses are characteristic for such a practice. Approximately 58 %, or 14 farms, of the lowest performers produce milk in the dry season. With the exception of one case, which has a comparatively high dry season milk production, lowest performers had an average milk yield of 2.6 liters per cow per day. This corresponds to the low price per milking cow, which indicated a low genetic potential for milk production. Dry season feeding of lowest performers who milk:

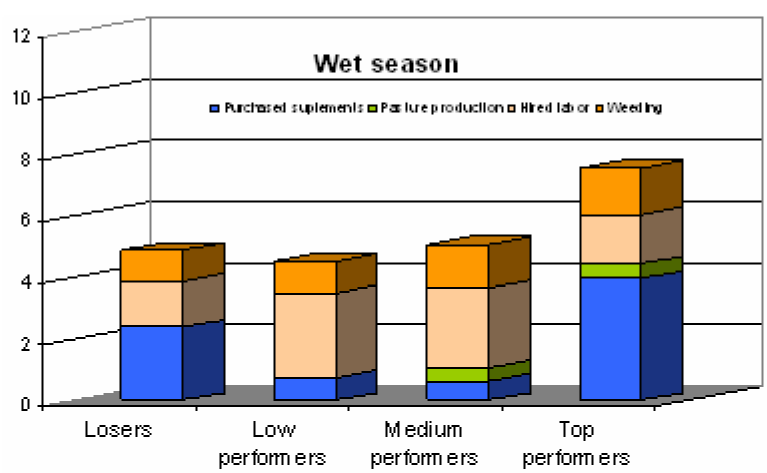


**Figure 55.** Monthly expenses for milk production per cow in milk in $US, wet season.

1. Limited quantity of farm supplements without use of purchased supplements, (one case).
2. No dry season supplementation was found in 4 cases. This results in a low production, which is not sufficient to recuperate the costs of animal husbandry (labor and vaccinations).
3. Seven farms purely relied on purchased supplements and dry pastures. Concentrates are most frequently used.
4. In two cases, farm and purchased supplements were combined. Quantities of farm feed were insufficient and expenses for purchased inputs turned out too high to recuperate costs.

With the lowest dry season milk yield per cow the lowest performers spend more on purchased supplements than low and medium performers. The high production cost per liter of milk and the low return per cow can be explained by a combination of traps in which these farmers repeatedly fall, i.e., the comparatively high use of purchased supplements, the low use and availability of farm-produced forages, and the low genetic potential of the cows. Even in the rainy season lowest performers have the highest costs per liter of milk. On average lowest performers used more purchased supplements and spent much more on purchased supplements than the low and medium performers. In the wet season 16.6 % of the lowest performers still fall into the concentrate trap. Family labor force is an under utilized resource among lowest performers. Although their herd sizes are small, the expenses for hired labor force per cow are comparable, to those of the top performers. The number of animals in milk and the total volume of production are low, family labor can only be accounted for those animals the family works or is supposed to work for. In the dry season, when few animals are in milk, the average opportunity cost for family labor is 20.52 $US per cow per month, while the rest of the costs sum up to 9.47 $US per cow. Average gross income per cow is only 13.96 $US per month. The family labor force is under exploited.

**Milk production of the low performers:** All 13 low performers produced at least some milk during the dry season. The monthly dry season net income from milk per cow is about 5.62 $US, and thus less than half of what medium performers generate. Gross income from dry season milk production among low performers is only about 5 $US per cow higher than that of the lowest performers. Moreover, low performers spend less on animal nutrition, and labor per cow is used more efficiently than among lowest performers, because low performers have more cows in milk.

Dry season feeding strategies among the low performers:

1. Two cases of the low input low output system, in which 1 case did neither use purchased nor produced forage and the other case only used crop residues (maize stover).
2. Three cases worked with purchased supplements exclusively.
3. Two cases worked with conserved forage. These farms had only recently adopted silage and the forage ensiled was not sufficient for the whole dry season.
4. Four farms work with a mixture of farm feed of low and high quality, among which low quality farm feed is more available, plus purchased inputs.
5. The remaining 2 cases combine farm grown forages with purchased inputs. One case has a better farm forage base than the other.

The average dry season milk yield of the low performers is 2.5 liters per cow per day, a very low milk yield to produce efficiently. Lowest performers milk 1.77 liters per cow per day. Such production levels can be reached without any purchased supplement, just by farm-produced forage, if made available. The wet season milk yield and the price per milking cow of the low and medium performers are comparable. Thus the genetic potential to produce more in the dry season is available among the low performers as well. In the dry season, all low performers who use purchased supplements fall into the supplement trap (69.2%) because they could do

better without it by changing their feed production strategy. The concentrate trap catches 46 % of the medium performers, but they do not fall as deeply as the lowest performers.
In the wet season low performers and medium performers spend a similar amount on purchased feed, but do not apply fertilizers to their improved pastures. Wet season net income per cow is nearly equal between low and medium performers.

**Milk production of the medium performers:** All medium performers produce milk during the dry season. Their average milk yield per cow in the dry season is lower than the one of the top performers, but greater than that of the low performers and the lowest performers. In the cases of top and medium performers, the gross income from milk in the dry season exceeds the one of the rainy season. For the medium performers, this difference is small, but the trend to exploit the herd more intensively in periods of high prices is noticeable.

Dry season feeding strategies of medium performers:

- Nine cases did not use purchased or produced forage. These farms have more favorable site conditions than others,. such as dry season pastures made up of improved pastures, or pastures near rivers, which stay green during the dry season and some crop residues.
- One case had high quality farm feed, such as conserved forage.
- Four cases feed conserved forage and purchased supplements.
- The remaining nine (9) cases apply strategies, including the use of fresh Maize and dry Sorghum forage and cut and carry forage, which is usually complemented with commercial concentrate.

Differences in management let the production cost per liter of milk fall below the one of the low and lowest performers. There is not a single case among medium performers that relied on purchased inputs alone. Medium performers show the highest percentage of improved pastures (Table 82).

Medium performers are marked by a comparatively low use of purchased supplements and by the use of a variety of farm produced dry season feed. Costs of production for farm-produced forages are higher than in the other groups. In the dry season feed of medium performers forages are used in various ways, including supplementation of fresh and conserved forages. This makes the cost for hired labor per production unit rise.

**Milk production of the top performers:** The situation among the top performers is twofold and needs to be interpreted separately. Some top performers generate a high income per cow without purchasing supplements, while others have huge expenses for purchased supplements. Among the top performers, the average monthly dry season income from milk per cow (Table 78) is $32.49, which is even higher than in the rainy season (27.90 $). On average, this can be explained by the higher milk price in the dry season. Typically, the milk production per cow drops is a little in the dry season. There are also farmers whose milk production rises in the dry season. They state that this is the result of a better care and alimentation during the dry season. Thus dry season feed is of better quality than rainy season feed, which usually consists of pasture and less concentrate. The top performers are made up of farms from all sizes with a high share of medium size farms and positive deviances (37.5 % for both).

The variety of dry season feeding strategies is the highest among top performers:

1. There are 2 cases, which do not use feed supplements or produce forage on the farm. These farms have favorable site and climatic conditions.
2. Three more farms of the top performers have favorable climatic conditions, but they supplement with molasses during the dry months.

3. Frequent strategies among top performers include feeding of cut and carry grasses, cut forage Maize and Sorghum in sufficient quantities. Grazing of crop residues, accompanied with the previously mentioned feed items, enables them to produce milk comparatively cheap. Concentrate is always a part of the diet.
4. Six of the top performers belong to the positive deviances, which use between 3 and 6 sources of feed in adequate quantities. These feeds include conserved forage (hay and silage), cut and carry grasses, Maize and Sorghum for forage, crop residues, and the purchased inputs in considerable quantities.

**Milk production of the positive deviances among performance groups:** Knowing that the positive deviances apply forage technologies in a more advanced way than the rest of the farms lets the expectation that they all should belong to the top performers group rise. The sample of positive deviances consists of normal farms that have adopted some forage technology. The economic valuation of these farms does not necessarily demonstrate what can be achieved with an appropriate use of forage technology. For such questions, controlled field trials or farmer field experiments would be more appropriate. The socio/economic assessment of positive deviances shows how these farmers work.

The positive deviances were selected to assess examples of technology adopters. Technologies included the more advanced technologies of livestock production systems and of forage production. Positive deviances were defined by outstanding use of forage options, such as silage, hay, improved grasses, and legumes. The expectation that the application of forage technology makes all those farms perform better could not be met because more factors have a great influence on the economic success of dairy production and those factors, such as e.g. the quality of the milking cows and to which costs forages are produced could not be eliminated during sampling.

Comparatively few farms could be identified that qualified as positive deviances. Thus we had to sample each farm and were not able to choose only farms that had applied the same forage technology.

The positive deviances that are top performers use over 4 times more money for purchased supplements than the medium performers (Figure 56). They seem to use purchased supplements in an exaggerated amount. The success of farms in milk production depends greatly on the volume of milk produced per production unit. Gross income from milk in the dry season depends on the value of the cow and the number of cows in milk in the dry season (Table 80).

The success or failure among positive deviances is explainable through the value, and thus the quality, of the milking cows (Table 88). The top performers have the most expensive cows. About 69 % of the cows from these farms are crossbreeds, with more than 50% being European breeds. These crossbreeds are able to transform concentrate into milk in a profitable way. Low performers among positive deviances feed good forage to inefficient dairy cows, which is obviously not as profitable as with good dairy cows.

## General Discussion

The reduction of the number of cows in milk during the dry season is a common strategy which can be clearly observed among the lowest performers. Insufficient availability of farm fed lets the feeding costs rise and the income decline.

Considering their scarce feed sources, low performers do not respond by reducing the number of cows in milk. They have a slightly higher proportion of cows in milk during the dry season than the others. But their benefit is small because their production per cow is significantly lower than among the other winning categories, and they spend more on purchased inputs than the medium performers. Without changing the feed base, better timing of insemination to get cows to calving during the period of feed

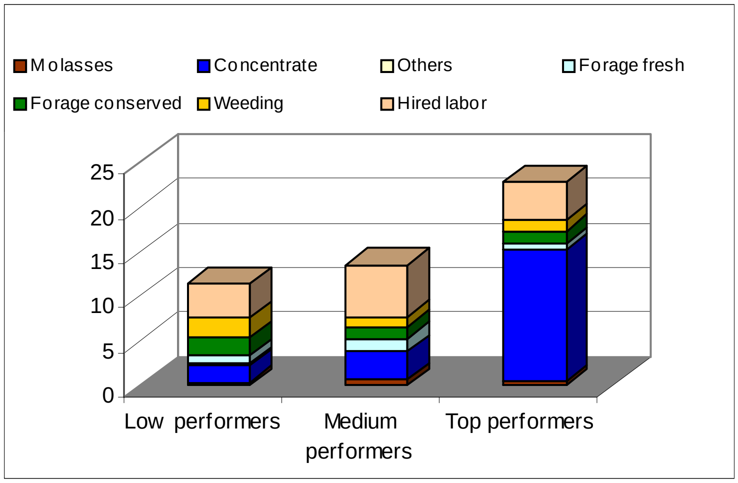


**Figure 56.** Monthly expenses of positive deviances in performance groups

**Table 88.** Average Value and breed composition of dairy herds among positive deviances in performance groups.

| Category | Average value per dairy cow $US | | Cattle cross breeds percentage of the dairy herds | |
|---|---|---|---|---|
| Low performers | Mean<br>Std. Deviation | 513.16<br>187.93 | 75 % Brahman 25 % Pardo | 62.50 |
| | | | 50 % Brahman 50 % Pardo | 25.00 |
| | | | 25 % Brahman 75 % Pardo | 12.50 |
| Medium performers | Mean<br>Std. Deviation | 789.47<br>157.89 | 75 % Brahman 25% Holstein | 26.67 |
| | | | 50 % Brahman 50 % Holstein | 16.67 |
| | | | 50 % Brahman 50 % Pardo | 56.67 |
| Top performers | Mean<br>Std. Deviation | 956.14<br>395.85 | 75 % Brahman 25 % Holstein | 30.83 |
| | | | 50 % Brahman 50 % Holstein | 39.17 |
| | | | 50 % Jersey 50 % Holstein | 1.67 |
| | | | 75% Holstein 25 % Brahman | 28.33 |

abundance, would make the use of their actual feed resources more profitable.

The decision of top performers to milk cows with an adequate provision of feed is a strategy that pays off well because efforts are concentrated on animals of good quality, which produce more per unit of feed.

Although fed in various intensities, purchased supplement are shown to be the most important cost driver in the dry season and are applied on 62 % of the farms.

Low and lowest performers do not benefit adequately from their herd. They are in a situation in which they use purchased feed supplements in order to keep the herd alive/ in a good condition, while other farms with a better feed base are producing milk. This situation of using purchased concentrate to replace farm feed or to maintain the herd can be described as the bottom of the concentrate trap. Expenses are high and few returns are generated, if any. Ideally, concentrate should be fed as an additional protein source to enrich the diet, and not as a substitute for forages.

With the exception of the top performers, as the expenses and variety of farm feed rise, the expenses for purchased supplements decline. The rising income per cow and per unit of land is a logical consequence of the more adequate use of farm resources for production and the purchase of inputs.

Lowest performers combine the disadvantages of resource-poor farms with deficiencies in management. Obstacles for the adoption of multi-purpose forage options are related to cash scarcity and the experience that the cows do not bring much. The lowest performers gain this experience, because the genetic potential for milk production of their cows is low and because their feed base is insufficient. The gross production of milk in the dry season is low and continuous cash flow is not available in these farms. Milk is thus "purchased", paid for with supplements. They are at the bottom end of the concentrate trap.

Their situation is not likely to change without intervention. Possibilities for policy and development interventions in these systems should aim at a consequent improvement of the forage feed base for the dry and the wet season and in the improvement of the genetic potential for milk production of the herds. The objective of such a development strategy should be to facilitate a continuous cash flow through year-round milk production, which is based on as much as possible farm feed. Recommendations for the development of losers include the subsidized promotion of well-adapted improved grasses (e.g. *B. brizantha cv* Toledo) and their conservation. Cut and carry grasses could also be promoted where appropriate land is available. Low quality farm feed in the form of maize stover is the most accessible dry season low cost feed for losers. This low quality feed resource can be improved by using *Lablab purpureus* as an intercrop species with maize to provide better legume/ stover feed and at the same time increase maize yield, as experiences from Olancho have demonstrated. Parallel to these forage based measures which aim at creating a good feed base, farms of poor communities should be enabled to improve the genetic potential of the milking cows by provision of adequate (milk cross breed) bulls to farmer groups. Technical assistance in pasture management and rearing of heifers would complement the package.

In the case of the low performers the low returns can be attributed to, inadequate feeding in the dry season with high share of purchased supplements and a low availability and use of high quality farm feed, such as fresh forage and conserved forage. The genetic potential for higher milk production in the dry season is generally available on the farms of low performers. Lack of forage and excessive supplement use causes them to fall behind the medium performers. Although to a smaller degree than the losers, these farms also fall into the concentrate trap because they substitute forage with concentrate to fill the cows stomach.

Possibilities for intervention lie in the improvement of the farm feed base by promoting a more adequate pasture management (rotation pasture and fertilization including organic and chemical fertilizers), the restoration of degraded unproductive pasture land and the improvement of maize stovers with legume intercrops. As long as the improvement of the feed base is in process and unreached, low performers should follow the example of medium performers, which keep the share of milking cows a little lower in the dry season, and thus corresponding to their feed availability. This could mitigate the effects of the concentrate trap.

The variety of feeding strategies rises for the dry season among medium performers because there is more farm feed available. Medium performers did not show any dominance of a specific herd size. The important message of this distribution is that milk production can be profitable irrespective of the size of the herd. What inhibits better performance among the medium performers is that they lack sufficient quantities of cheap forage and of high quality supplements. Limitations For higher volumes of dry season milk production and possibilities for the reduction of costs are related to the dry season forage shortage, which makes farmers reduce the number of cows in milk.

Most dry season feeding strategies are used among top performers, but expenses for purchased supplements are clearly higher than in the other groups. Top performers spend on average 7.33 $US per cow on purchased supplements. This is about the double of the medium performers. But they use the purchased input for production and not to fill the cows, as it is the case on many farms that perform low and medium. The genetic potential of their cows is considerably better than in the rest of the farms. Top performers should rethink their dry season feed strategy and make efficient use of high quality forages in conserved form or in the form of self or locally made concentrates.

Although top performers do not fall into the concentrate trap, they base their milk production on high levels of commercial concentrate. This dependency could possibly change by a sound use of legumes and enhanced use of conserved forage. Nevertheless, there is room for more intensive use of farm resources among top performers and among medium performers. The high use of purchased supplements (top performers) shows, that there is a need to improve the dry season feed base with conserved forage.

Milk production in Olancho is highly dependent on commercial concentrates. Although legumes provide high quality protein feed, they are rarely used. Adoption of such technologies is most probable among top and medium performers because they have some financial reserves, which could be used to test new technologies. Moreover, top performers possess good cows, which have the potential to respond to high quality feed. Once technology has sufficiently spread between top and medium performers, the message that it is possible to work more profitably with forages will probably reach and convince low and lowest performers and is likely to take over to low performers.

### 4.5.3 Diversified production systems for the Colombian Llanos: An economical assessment

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

Colombia's Ministry of Agriculture and Rural Development (MADR, its Spanish acronym) has launched an all-inclusive "Rebirth of Colombia's Upper Orinoquia" mega-project proposal. The main objective of this project is to generate environmental services associated with carbon (C) fixation or sequestration in an attempt to mitigate the effects of progressive global warming. The project will involve the large-scale planting of plant species that fix C in their aerial parts (foliage) and roots as a commercial product for the international market.

The proposal contemplates the establishment of 6.3 million hectares of trees species over a 20-year period. Upon termination of the project, the region's population is expected to have reached 5 million inhabitants, with 1.5 million jobs generated. The total cost of the agricultural component of the megaproject is estimated at US$15,000 million, in addition to the investments required in physical and social infrastructure and in public utilities. This initiative is encompassed within the national policy on productive forest development, which considers Forestry Incentive Certificates, known as CIFs, as one of the main incentive tools for the sector. The policy aims to stimulate the use and offer of forest products in Colombia, while generating environmental benefits such as erosion control, conservation of water sources, C fixation, reduced felling, and less pressure on natural forests. Using an economic, social and environmental approach, the present study evaluated, within the aforementioned global framework, new farming models that include various livestock, agricultural, and forest components for the production of food crops, raw materials for industrial use, and environmental products, such as C sequestration.

This *ex ante* evaluation aims to generate pertinent information as a way of supporting decision-making about investment in the public and private sectors, allowing a sustainable and competitive development scheme to be implemented in the region, with a high economic, social, and environmental impact. The techniques, based on linear programming, are used to address the major economic problem of efficient allocation of limited resources among multiple alternative uses. The theoretical model proposed is as follows: maximize $Z = CX$, subject to: $AX \leq b$; $X_1, X_2 ......X_n \geq 0$; $Z$ being the target function, which in the present case is defined as the total net profit resulting from the implementation of several production options at the farm level. The $C$ row vector corresponds to the coefficients of net profit per unit of product generated and the $X$ column vector includes the latter.

The modified model used in the study extends the evaluation period to 19 years and is limited to the analysis of livestock, agricultural, and forest alternatives and carbon sequestration by different types of plant coverage.

The following variables are included: (1) decision options—also known as activities—whose level is directly controlled by the producer and are part of the production plan of any given farm and may include pasture-crop rotations, sale and purchase of products and inputs, access to credit, and use of cash over time and (2) internal (endogenous) and restrictive variables that include all those variables resulting from the internal operation of the model as well as economic, technical, and environmental restrictions. Production activities feasible of being carried out in Colombia's Orinoquia region include: (1) different alternative uses of land resources and how their efficient use can generate social, economic, and environmental benefits; (2) potential land use in livestock production, agricultural crops, and activities involving reforestation or natural forests; (3) alternatives that generate commercial products such as meat, milk, and wood, and environmental services such as Ca sequestration by pastures and forest coverage; (4) economic, social, and environmental benefits derived from land use occurring at the farm, region, and national levels.

Two types of livestock systems were evaluated. The first, dual-purpose systems, involve the production of both beef and milk on the same farm, with emphasis on milk production. The productive capacity of cows is improved by incorporating genes of dairy breeds and by offering a better quality diet to the bovine herd. The second, the cow-calf operation is a basic livestock production phase aimed at the raising of cattle for livestock farms specialized in cattle fattening.

The forage on offer for livestock comes from the following alternatives (Table 89): (1) pastures of native savanna alone, improved *Brachiaria*, and *B. decumbens*-legumes in association, and (2) pastures resulting from three different crop rotations. Rotation 1 starts with a period of 7 years of native savanna, followed by a 4-year cycle of semiannual crops rice-soybean and maize-soybeans in rotation, and ends with a pasture of *B. decumbens*-*D. ovalifolium* in association that remains productive over an 8-year period. Rotations 2 and 3 are similar, and begin and end with crop cycles of 6 years each, including an improved pasture in the intermediate phase, which, in the case of Rotation 2, is improved *Brachiaria* and, in Rotation 3, an improved pasture of *B. decumbens*-*D. ovalifolium*. The pastures alone were evaluated over the entire 19-year period, including renewals in years 8 and 15. The forest component is represented by the planting of Caribbean pine, which produces wood as well as environmental services in the form of Ca sequestration. To improve the soil's physical and chemical conditions, an improved grass was initially planted that remains productive for 4 years, before the pine plantation was established.

Several sequential scenarios were constructed to simulate the gradual incorporation of new technological components into existing livestock systems (Table 90). The livestock production model used, whether cattle-raising or dual-purpose, is based on the extensive use of pastures alone. During the following phase, the model adds a component of pasture-crop rotation in a process oriented to gradually improve soils by building arable layers.

**Table 89.** Farm model with dual-purpose livestock production system: livestock production, with availability of adapted crop germplasm, soil improvement practices, forest options, and payment for environmental services (sale of carbon) at different levels of working capital.

| Initial availability of capital ($x\ 10^3$US$) | | Land use (ha) | | | | Cows at final evaluation (no.) | Net generation of employment (no. workdays)[a] | Value target objective ($x10^3$ US$) |
|---|---|---|---|---|---|---|---|---|
| Total ($x\ 10^3$ US$) | Per ha (US$) | Caribbean pine | Crop-pasture rotation R1 | Crop-pasture rotation R2 | Brachiaria *cv. Toledo* | | | |
| 300 | 600 | 414.1 | 37.8 | 0.6 | 47.5 | 162 | 709 | 7851 |
| 200 | 400 | 287.0 | 117.7 | 47.6 | 47.7 | 312 | 873 | 6850 |
| 100 | 200 | 160.0 | 190.4 | 101.9 | 47.7 | 443 | 1062 | 5840 |
| 50 | 100 | 96.6 | 226.7 | 129.1 | 47.6 | 509 | 1156 | 5334 |
| 25 | 50 | 48.0 | 274.9 | 127.0 | 50.1 | 601 | 1147 | 5080 |
| 10 | 20 | 15.3 | 310.0 | 122.6 | 52.1 | 668 | 1129 | 4927 |
| 5 | 10 | 4.4 | 321.7 | 121.1 | 52.8 | 691 | 1123 | 4876 |

a. Annual average. Total area available: 500 ha.

The incorporation of trees and the offer of environmental services in the form of Ca sequestration represent the following stage in the process of transforming production systems. Finally, to evaluate the impact of the economic policy on production systems and land use, scenarios are built in which the production systems are supported by promotional policies such as the CIFs or prepayment of environmental services, rather than by including new technological components. The model considers a 500-hectare farm that operates with costs considered average for the region and with a working capital that can vary, alternatively, between US$5000 and US$300,000. Results showed the following possibilities for the region, among others:

(1) The incorporation of new technological components into traditional livestock production systems of the Llanos of Colombia results in a significant growth of net farm income, employment, production, and productivity. As can be expected, the use of improved pastures in the traditional livestock production system is conditioned by the availability of funds. The appearance of pasture-crop rotations excludes native savannas from the optimal solution and improved of cash flow facilitates the expansion of improved pastures on farms with lower availability of funds.

(2) The level of technology development in cattle-raising systems was lower as compared with dual-purpose systems. Therefore the economic effect of introducing

**Table 90.** Structure of the net present value of income according to degree of intensification of livestock systems in the Colombian *altillanura*[a].

| Activities and products | Production system | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Cattle-raising | | | | Dual-purpose | | | |
| | Based on native savanna | | Intensified[b] | | Based on native savanna | | Intensified[b] | |
| | PVGI[c] (x$10^3$ US$) | % total | PVGI[c] (x$10^3$ US$) | % total | PVGI (x$10^3$ US$) | % total | PVGI (x$10^3$ US$) | % total |
| Livestock | | | | | | | | |
| Beef | 174.4 | 78.7 | 143.0 | 9.2 | 221.2 | 44.2 | 1262.1 | 41.7 |
| Milk | — | — | | | 246.4 | 49.3 | 1405.4 | 46.4 |
| Crops | — | — | 457.0 | 29.3 | — | — | 237.4 | 7.8 |
| Forest | | | | | | | | |
| Wood | — | — | 932.0 | 59.8 | — | — | 101.8 | 3.5 |
| Sale of C | | | 18.0 | 1.2 | — | — | 19.0 | 0.6 |
| Sale of workdays | 47.3 | 21.3 | 8.0 | 0.5 | 32.9 | 6.5 | 1.2 | 0.0 |
| Total gross income | 221.7 | 100.0 | 1558.0 | 100.0 | 500.5 | 100.0 | 3026.9 | 100.0 |

a. Working capital: US$10,000.
b. Includes improved pastures, pasture-crop rotations, forest species, and sale of C.
c. PVGI: present value of gross income, for example 5%.

improved technologies was greater in the former.

(3) The establishment of forest plantations for sale of wood and C sequestration has greater possibilities of being adopted in cattle-raising systems. The simulation exercise showed that trees would enter this system at all levels of available capital, being a promising alternative to cattle-raising systems, which are usually relegated to isolated areas far from the markets. The above can occur if the government invests in road infrastructure and transportation, in tandem with the development of complementary services, especially those related to the processing, management, and marketing of forest products.

(4) Technical advances significantly improve net farm income—the target objective of the model—but especially on farms with less available capital. For example, the implementation of pasture-crop rotations in cattle-raising systems increased net farm income by 1.8 with high capital availability and by 6 in farms facing greater financial restrictions.

(5) The intensification of production systems increases the capacity to generate employment, which has an important impact on the achievement of the social goals of equity and reduction of poverty.

(6) Forest development policies, for example the CIFs, have greater impact on production units with more working capital because it allows them to expand their area under forest. When capital is below US$25,000, the impact is null.

(7) Current prices of carbon are low on the international market and, according to several experts, will remain stagnant through 2012.

On-farm research projects and ex ante economic studies have demonstrated the feasibility of new technological options. However, the adoption of new technologies in the region does not yet have the necessary dynamics to trigger a significant impact on production, productivity, employment, and prices.

Agriculture is risky in the Llanos because it faces numerous restrictions (technical, economical, physical, social infrastructure) as documented in surveys conducted by CIAT in 2004 and 2005. Many of the producers interviewed perceive the enforcement of NAFTA as threatening, increasing the risks faced by the region's crop production. This bilateral agreement, however, also opens significant opportunities for the production of beef, milk and dairy products, forest and fruit trees—all activities that can adjust to the resources found in the Llanos. In a scenario where the price of grains falls more than 10%, the net income contributed by the crops to the rotations would be negative. Despite this, Rotation 1 (native savanna–crops–improved grass) would continue to be profitable because of its solid livestock component.

The research conducted on current crops to improve their yields and the search for new options of adapted, high-yielding crops to establish rotations with grasses emerge as alternatives to face the economic risks posed by prices and NAFTA challenges. In a growth environment supported by policies on investment in physical and social infrastructure, official credit programs, and compensatory measures for sectors adversely affected by the bilateral treaty, grain production is expected to continue to be economically viable in the Colombian Llanos. To materialize the advantages of participating in a broad, high-value market and to take maximum advantage of the Llanos natural resource pool, the country must consider comprehensive development programs that, in addition to promoting the on-farm application of new technology alternatives, apply appropriate policies to overcome the constraints hindering technical advances.

## 4.6 Forages for Monogastrics

### Highlights

- Monogastric animal production is an integral component of many smallholder farms. Many farm families produce mostly chickens and pigs but other monogastric animals are common including duck, guinea pigs, rabbits and fish. Input and output opportunities restrict the earnings capacity of many farmers.

- Larger scale monogatric farmers face expensive feed costs. With cost of imported grain prices increasing, domestic production of grain and legumes may become more attractive. In addition, these alternative feed sources can be better adapted to specific production niches.

- Monogastric production is an important strategy to diversify household risk for many smallholder farmers. Occasional and/or informal sales of meat, eggs, and animals provide an additional income source, especially for women. A challenge for research and development is to foster enhanced market access and feed inputs according to local context.

### 4.6.1 Opportunities and constraints of smallholder farmer feed production for monogastric animals in Colombia, Honduras and Nicaragua

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#### Rationale

Demand for animal products is growing in developing countries. Pork and poultry rather than beef dominate consumption changes. These monogastric animals accounted for 76% of the increase in demand in developing countries between 1983 and 1997. Smallholder farmers, however, may not benefit from this opportunity. Trade liberalization and superior market access provide competitive advantages to larger-scale commercial operations.

A scarcity of high-quality feed restricts animal production and marketing of both small and large scale operations. A reliance on imported ingredients exposes concentrate companies to volatile prices and unreliable supplies. Difficulties in obtaining low-cost, high-quality feed ingredients may worsen; particularly since grain prices are anticipated to increase. Smallholder swine and poultry producers, without access to alternative feeds, may become even less competitive.

The aim of these diagnostic studies is to characterize areas with a high potential for smallholder production of monogastric animals and define opportunities and constraints. Objectives included poverty reduction and counteracting environmental degradation in specific areas in Honduras, Nicaragua and Colombia.

#### Materials and Methods

Three areas were selected for the diagnostic studies, Cauca, Colombia, Olancho, Honduras and Chinandega and Léon, Nicaragua. A quick diagnostic survey approach was employed to rapidly obtain in-depth knowledge of constraints and opportunities in specific social, economic, and natural environments. The objective was to understand smallholder monogastric production systems and identify the opportunities and constraints to substitute purchased (and imported) feeds with forage-based protein feed.

The following topics and questions were addressed:

General, monogastric systems

- General farm data such as area, crop and livestock enterprises;
- Livestock holdings and composition;
- Enterprise (crop and livestock) management and reasons for their selection;
- Livestock feeding systems (including on-farm production, purchases, pasture management);
- Use of outputs (i.e., household consumption, local market and/or commercial sales) and underlying reasons for end-use;
- Changes and trends in livestock composition and underlying reasons;
- Problems, difficulties, constraints, and opportunities;
- Animal health.

Markets

- Other on-farm commercial enterprises (besides monogastrics);
- How animals are sold, market competition;
- Seasonal demand and price variation;
- Price differentials according to product quality;
- Enterprise profit margins.

Feeds

- Feed use, composition, production and purchase;
- Feed sufficiency, critical times of the year;
- Strategies used to alleviate feed problems;
- Feed quality and quantities;
- Concentrate and supplement use.

Organization

- Participation in groups or associations;
- Technical support, sources and quality;
- Capital and credit availability.

## Results

### A) Cauca, Colombia.

The team visited small farms near the town of Pescador and Popayan. In Pescador (1200-1500 masl), most farmers had secure rights to land, as is the case throughout the Cauca region. Farmers with monogastrics generally relied on coffee and/or cattle as primary commercial activities. Approximately 70% of respondents raised chickens for household consumption that were fed household waste, some concentrates and, in some cases, farm-produced forages. Production of monogastrics was mostly a family activity, involving women, men and children. In most cases, women were responsible for the daily management of poultry; care of swine was more diverse.

Nearly 25% of farmers raising monogastric animals produced broilers, approximately 20% raised swine and 20% rabbits. A few raised guinea pigs (Table 91). Farmers producing poultry commercially had better access to technical support and to capital, the latter either through credit or earnings from coffee production.

Monogastric production was made possible by links with other farm activities. Earnings from coffee harvests were often invested in fattening poultry. A similar situation occurred with swine, Capital to obtain piglets came from coffee sales or credit provided by farmers' associations. For both commercial poultry and swine production, investments of returns from coffee into livestock production are a means to diversity production and to ensure cash flows over a greater part of the year. Nevertheless, investments were a greater priority than monogastric production. In some cases, farmers refrained from monogastric production due to limited available labor and fear of damage to the coffee crop by free roaming animals.

A lack of technical support and capital limited commercial production. Constraints to poultry production included animal diseases, insecure markets, price fluctuations, and resulting low profit margins. Lack of water, unfavorable prior experience and theft were also mentioned. Many farmers preferred either poultry or swine production. Lower market risk and higher profit margins were claimed for swine and guinea pigs, although the latter had a very limited market. The high cost of concentrates restricted profit margins.

In areas around the city of Popayan (1500-1700 masl), commercial production of monogastrics were dominant. As with farms near Pescador, coffee based systems provided capital for animals and feeds. Such an arrangement also limited monogastric production in peak coffee management and harvest times. Most farmers concentrated on animal fattening rather than egg production, thereby enhancing the flexibility for labor inputs. Fifty-six percent of respondents only fed their poultry purchased concentrates; while 40% mixed purchased and on-farm produced feeds. While nearly half of swine producers combined purchased feed with farm-produced feed, only 30% of poultry producers did the same. Less than 5% of producers completely relied on feed produced on-farm: these cases were mostly guinea pig producers.

Expansion of on-farm animal production in coffee based systems will depend on labor and capital availability. There was limited knowledge regarding on-farm feed production. A few farmers recognized the value of (forage based) on-farm feeds in reducing costs of concentrates and increasing product quality (e.g., texture and taste of meat and of egg yolk color). Forages

**Table 91.** Predominant monogastric systems and research priorities in northwestern Nicaragua.

| System | Strategy | Research Needs |
|---|---|---|
| 1. Small-scale swine fattening for 0 to 6 months or to 6 to 12 months of relatively poor farmers. Feed produced on farm and purchased | A | a) Introduction and testing of: i. Improved sorghum and (QPM) maize ii. Protein-rich germplasm (legumes--annuals and perennials) b) Participatory on-farm systems trials with attention paid to gender and to land and labor. c) Work with organized groups or with groups facilitated by project d) Improvement of animal breeds e) Facilitate relations with projects or programs providing credit, animal loans and/or training (e.g., on animal and human health relations). |
| 2. Fattening of 20-100 pigs reared in pens; feed purchased and produced on farm | A | |
| 3. Pigs produced using residues from peanut production | - | No research planned due to unique and inequitable system |
| 4. Swine fattening of 20 to 50 unpenned pigs, peanut residues not available | A | |
| 5. 20 to 50 pigs, with animals penned during crop production period | B | Some farmers interested in producing their own feed concentrates. Research to include model A with additional attention to production and formulation of feed concentrates including co-development of complementary feed ingredients. Organizational and business development for feed utilization and sale of feeds and livestock products. |
| 6. Small and medium 7. scale poultry production with and without confinement, for hh consumption and sale | A | Particular attention to be given to protein nutrition for more eggs and better weight gain |
| 8. Other monogastric animals solely for hh consumption | - | No research due to few or no incentives to improve production |

produced for monogastrics included *Axonopus*, *Pennisetum* hybr., *Saccharum officinarum*, *Manihot esculenta*, *Bohemia nivea*, *Tripsacum laxum*, *Arachis pintoi*, *Alocacia macorrhiza* and *Trichantherea gigantea*.

The tendency to combine purchased and on-farm produced feeds was greater in swine compared to poultry production. Profit margins for swine appeared to be relatively healthy; while poultry production operated on smaller margins. Guinea pig production margins were high but restricted to a very limited niche market. Rabbit production in the Cauca region appeared to be the least commercially attractive.

## Conclusions

In the majority of cases, coffee and monogastric production co-existed, with coffee providing necessary capital and labor but also competing during certain periods. Impediments to on-farm feed production include:

- Competition for land by coffee and cattle (although recently renovated coffee parcels may be suited to feed production);
- Labor peaks in coffee production limit availability of labor for on-farm production of feed;
- Credit for purchase of concentrates is readily available;
- Technical support for monogastric production is often provided by feed companies
- Technical information on producing alternative feeds is not readily available.
- Many farms are managed by caretakers who have little if any incentive to increase their labor inputs for on-farm feed production.

Factors favoring on-farm feed production include:

- Forages that do not compete with coffee in terms of cash flow and labor;
- High demand for high-quality feed concentrates;
- Expensive concentrates exacerbate household cash flow problems;
- On-farm produced feeds can impart product qualities favored by consumers;
- Variable quality of purchased concentrates recognized by farmers but is not specified by manufacturers;
- Farmers have experience cultivating mixes of crops and could easily add forages;

Additional analysis is needed regarding the costs of on-farm feed production vs. purchased feeds and concentrates vs. local artesanal production of concentrates (using either purchased or on-farm produced ingredients). Forage-based feed would likely be used in combination with purchased concentrates.

Forage-based protein feeds appear particularly attractive given widespread lack of sufficient protein in livestock diets. Opportunities for tropical forage-based protein feeds appear to be greatest in areas of 1400-1600 masl, to diversify production in areas suboptimal for coffee production. Potential for artesanal production of raw materials for sale appears greatest at lower altitudes, where many tropical forages have their highest productivity. Further work would need to focus on owner-managers of farms. Quicker success is likely with farmers who are (1) already organized or who could easily be organized and (2) already engaged in commercial production of monogastrics. Willingness and feasibility of commercial production needs to be explored further.

Specific areas of further research include:

- Cost-benefit and household cash flow analyses of forage-based on-farm feed production;
- Feeding strategies including trade-offs amongst feed cost, quality, and quantity;
- Effectiveness of forage-based protein feeds in the diets of different monogastric animals;
- Locally available forage and feed materials and local practices;
- On-farm trials with the participation of farmer groups;
- Value chains of both monogastric feeds and products;
- A focus on swine and poultry, and possibly guinea pigs, is appropriate. Rabbits and fish production appeared to be less attractive in the Cauca region.

**B) Léon, Sauce and Chinandega el Viejo Nicaragua**

The diagnostic team worked in areas around Chinandega and Léon. Areas visited differed by agroecological conditions, wealth levels, access to market and importance of cash crops.

*Léon.* Most of the area around the town of *Léon* is characterized by poverty and small-scale livestock systems. Animals were for household consumption and some sales in local markets. Mean farm size was slightly above 10 mz. Main crops were maize and sorghum cultivated on an average area of 1-2 mz and used for household and animal consumption. Mango and plantain was a cash crop in limited areas. Farmers raised multiple types of livestock, with a few having a few cattle; and most having a few chickens and fewer pigs. Approximately half of the respondents considered mongastrics as a commercial activity. Broilers and eggs were consumed and sold; while pigs were raised mostly for sale. Sheep, turkeys, geese and other animals were found and raised for home consumption. Smallholders had a mean of 9 pigs and approximately 25 chickens, though differences among individuals were large.

Maize and sorghum were the basic feeds of monogastric animals, sometimes combined with residues of plantain, mango, cassava and squash. Where available, farmers used jicaro fruit. Concentrates or purchased feed were used for very young animals, during feed shortages, final fattening, and largely as a supplement rather than a complete feed ration. While concentrates for very young animals appeared to be formulated, concentrate composition for other animal stages was unclear. In some cases, farmers mixed feeds themselves using available ingredients such as maize and sorghum.

Approximately 2/3 of farmers purchased supplements such as concentrates, mixed feeds (i.e. composites of maize and sorghum), semolina (maize meal), or maize and sorghum itself. Only 1/3 of farmers bought commercial concentrates, some of which may be locally fabricated. Use of peanut residues was limited but of importance where encountered.

Expansion of swine production was limited by lack of capital and/or lack of access to water in some cases. For both chicken and swine, theft appeared to be a problem. Other risks were animal diseases and instability of rainfall.

**Sauce.** Farm size and level of monogastric production in the area around Sauce were similar to those around Léon. Production of monogastrics was a diversification strategy with various interactions among different types of animals and between animals and crop production. Farmers fed milk whey to pigs; and in rare cases, chicken manure was used as a protein supplement to swine. Good crop harvests allowed animal feeding to be based almost completely on feed produced on-farm, while poor harvests led to a need to purchase at least some feeds. Animal production also had monetary interactions. While chickens were used more for home consumption and some cash flow, swine were a 'bank account' for investment or emergencies. Pig sales served to purchase crop production inputs; while crop harvests allowed purchase of the next set of piglets. Some farmers aspire purchase cattle from the earnings realized from pig production.

Animal feeding was largely based on farm inputs and cheaper feeds such as semolina. Concentrates—although recognized as being of higher quality—were considered too costly for continual feeding.

Limitations to the expansion of swine (and to some extent chicken) production included the danger of crop damage by roaming animals. Construction and use of pens, however, was unattractive to farmers taking advantage of open access field crop residues in the off-season.

Although the production of different types of animals was generally viewed as favorable, a cultural preference for cattle was common. Nevertheless, cattle are not easily attained since they require a much higher initial investment. A major benefit of cattle is that they are considered more secure (e.g., less prone to diseases than either swine or poultry).

Animal production has gender implications. Cattle raising was more a men's activity; while poultry and swine at smaller scale (i.e. < 10 pigs and < 50 chickens) were mostly managed by women.

In some cases, off-farm work may prevent the raising of any animals. Feed availability was limited by crop yields and a lack of access to larger areas of land. Some farmers stated that local breeds of swine have low liveweight increases. Others recognized the robustness of such animals and saw liveweight gains because of feed quality. High mortality of young animals was a problem.

Almost all farmers had at least a few monogastrics. Swine and chicken production fulfilled different functions. Poultry provided a somewhat continuous household cash flow and food for home consumption. Small-scale poultry sales were often seasonal. Prices paid for poultry did not suffer price drops but increased seasonally and from year-to-year. Higher returns were realized during the Christmas period, for which some farmers planned accordingly. While demand/prices paid for cattle products rose 10-20%, swine increased20-40% over the last few years, making pig production relatively attractive. Farmers having to sell pigs in the face of personal emergencies possibly received lower prices from buyers.

Farmers employed different strategies for swine production. Most commonly, poor farmers with pigs kept one or two animals fed largely with farm-produced feed. Some farmers sold chickens to help pay for pig feed with pigs sold at 6 months. Others fattened pigs for up to 12 months to obtain higher weights and prices. A very small number of producers fattened up to 100 animals in pens. Other monogastrics, including ducks, geese, guinea fowl, sheep, or goats were raised by a few farmers. Crop outputs and earnings from crop sales supported animal production; animal sales helped to finance crop inputs; and crop residues supported pig production.

**Chinandega el Viejo**. Notably different in the Chinandega area was that pig production took advantage of crop residues from large-scale peanut production. Peanuts became an important cash crop when a processing plant opened in 2001. Rice is another major crop in the area and may have also inadvertently ended up supporting pig production. Farmers browse their pigs on previously harvested fields, some paying rent and others not. Crop residues are often sold at low prices. Peanut residues comprise the bulk of feed for farmers fattening pigs in the dry season (when there are no crops in the fields). The system based on peanut residues is highly attractive to fortunate locals who obtain high-quality feed at very low cost. One group of less-advantaged farmers was organizing itself to produce their own feed mixes and was interested in feed alternatives.

### Conclusions

- Nearly all households raised monogastric animals.
- Many poor smallholders worked off-farm.
- Feed, mostly maize and sorghum, was usually produced on-farm and was supplemented with purchased feed (mixtures of maize and sorghum, maize and rice meals) and concentrates.
- In some cases lack of land and labor limited on-farm feed production.
- High costs prevented the feeding of animals solely concentrates.
- A lack of protein from purchased and farm-produced feeds limited animal productivity.
- An exceptional case of a highly productive crop residue / animal feed system was based on use of underpriced peanut residues.
- Various interactions were common between crop and livestock production (crops and crop incomes supporting animal production and vice-versa) and among animal classes (the use of chicken manure or whey in pig production).
- Farmers maintained animal and crop mixtures as a risk reduction strategy.
- Demand for pigs was high and increasing.
- Price premiums were not paid for higher animal product quality.
- Monogastric production was more risky than cattle production due to diseases.
- With some exceptions, farmer organizational levels were low.
- In some cases, farmers were interested in producing their own feed concentrates and in forage alternatives.
- Further investigation is needed to assess the relation between human and animal health (e.g. trichinosis).

Table 91 provides a summary of monogastric systems encountered and the appropriate research and development strategy for each of the systems. Research and development strategy A addressed the needs of resource-poor smallholder farmers, while strategy B improves the competitiveness of medium-scale farmers.

### B) Olancho, Honduras

The diagnostic survey contrasted two focal groups: farmers with monogastrics for home consumption and farmers producing a higher volume for commercialization.

**Small scale production**. Thirty-eight small farms around Catacamas (La Pita, El Pescador) at about 400 masl were visited. Families rely on livestock, annual crops, off-farm employment and remittances. Although many farmers mentioned land availability as a problem, land rights were generally secure. About 73% of the group had poultry, mostly layers and some broilers. Chickens were kept unpenned around the house and in the gardens. About 43% had chickens for exclusively for subsistence, while 57% also sold some of their poultry products. No farmers exclusively produced eggs for sale. All fed their chickens maize, with 46% producing the maize on-farm. Ten percent purchased concentrates, and 25% purchased rice derivates like rice bran (3%) and broken rice (21%).

Approximately 60% of small-scale producers raised pigs. More than half had both chicken and pigs. Reasons for having pigs and chickens differed with 65% producing pigs for sale, 18% for consumption, and 13% for both purposes. With small-scale production, pigs were sold to passing buyers or were slaughtered at home and sold by section. Passing buyers fixed prices based on estimated live weight. Pigs were fed whey (78%) from milk processing plants. Whether farmers bought (52%) or received whey at no cost (26%) depended on relations with plant owners. Rice bran was purchased by 48%. Use of concentrates was moderate (43%). Concentrates were purchased, with the exception of one farmer who mixed his own. Pigs were also fed kitchen scraps, sweet potato, plantains and sugar cane.

Reasons for not having monogastrics or not having more monogastrics fell into four groups: (a) *social*— the smell of pigs, lack of space, and accidents with cars, (b) *experience*—animal diseases and associated knowledge, and (c) *economic*—lack of financial resources for concentrates and pens , and (d) *market bias*– purchases of chicks for broiler production in small quantities was not possible without futures obligation to buy concentrates.

**Commercial production**. Medium to large farms around Catacamas and Juticalpa were visited. The Universidad Nacional de Agricultura (UNA) in Catacamas has a donor-supported breeding program that sells breeding pigs and provides limited technical assistance in hygiene, breeding and feeding. Many of the farmers interviewed were in contact with the university and some had adopted recommended technologies: pen construction, concentrate mixes and improved pig breed. A similar program in Comayagua financed by Chinese donors is selling breeding pigs over a larger area.

Commercial pig producers typically had various income sources, and land and financial resources. Pig, poultry, and fish producers with limited access to land specialized in one product. Pig farmers with sufficient land usually had cattle as their main source of income.

Approximately 92% of commercial pig producers used concentrates. Nearly 40% purchased from four major producers and from stores in Catacamas and Juticalpa. Concentrate purchased from producers was delivered, paid for directly, and accompanied by technical assistance that also promoted the product. Concentrate prices were reportedly stable. Although packaging did not in all cases indicate the percentage of proteins, farmers were generally satisfied with quality and quality consistency.

Over half of farmers mixed their own concentrates. In 38% of cases, all raw materials were purchased, while 17% used purchased and farm-produced products like maize, sorghum, soya and semolina. Soy production was said to be impossible because machinery required for seeding and harvesting unavailability. This situation may favor alternative protein sources and smallholder production. An advantage of purchasing raw material was that its processed form of meal. Prices for raw material were not stable, with soya fluctuating 12% and maize 18%. Farmers were aware of the changes but were not able to store raw materials due to financial constraints.

A total of 44% used specific concentrate mixtures matched to growth stages. Concentrate firms offered five different products. Farmers mixing their own concentrates elaborated up to four different mixes. Table 92 compares prices of purchased and farm-mixed concentrates using purchased inputs.

Most farmers sold slaughtered pigs to middlemen. Other market channels were meat-processing plants in Catacamas and Tegucigalpa, the local market, and consumers. Prices paid were US $ 0.63/lb liveweight and US$ 0.79-0.95/ lb for meat. Farmers claimed that a higher quality did not increase price. The local market for pigs is saturated; and many producers ceased production due to market constraints.

Poultry was not as widespread as pig production and was differentiated between layer and broiler production: i.e., farms producing chickens specialized in one product. Broiler producers tended to purchase rather than mix concentrates; while farms with layers tended to mix their concentrate. Of all poultry producers, 70% used different concentrates for specific fattening steps or age periods. Sources of commercial concentrate were the same as for pigs. Prices for concentrates did not vary. Farmers who bought concentrate reported that changes from one brand to another changed production efficiencies. Farmers who mixed their own concentrate reported that sometimes protein content would be insufficient (Table 93).

Supply of chicks differed among farms and depended on the quantity purchased at a time. Large producers are able to order chicks from large firms without conditions. Medium size producers bought chicks from stores in Catacamas with the condition to use specific concentrates. One producer self prepared concentrates from purchased raw materials to avoid this dependency and purchases chicks delivered from El Salvador.

Eggs are marketed in the towns of Juticalpa, Catacamas, and San Francisco de la Paz). Some farmers sell to middlemen, others to small local stores. Eggs sold to the market and to resellers are paid for in cash. Food stores pay with a delay of seven days. Three large national producers regulate egg and broiler prices. A box of 320 eggs is worth US $27. Large broiler producers had more market channels than small ones. The most important channels for eggs were supermarkets, food stores and sales consumers or restaurants. Higher quality did not earn higher prices.

Chicken meat is worth US $0.73-0.89/ lb. A premium was paid for delivery to stores, restaurants and consumers. Some farmers provided delivery, built good relations with

**Table 92.** Purchased and self-mixed concentrates.

| | Purchased ready n = 2 | | Farm mixed n = 1 | |
|---|---|---|---|---|
| Concentrate | US$/100 lb | % Protein | USD/100 lb | % Protein |
| Pre starter | 28.15 | | | |
| Starter 1 | 19.78 | 22 | 12.63 | 22 |
| Starter 2 | 15.26 | 15 | 11.57 | 18 |
| Development | 12.10 | 16 | 10.79 | 14 |
| Final | 11.44 | | | |
| Pregnancy | | 13 | 10.26 | 13 |

**Table 93.** Sources of feed for monogastrics, Olancho, 2006

| | Pigs | | Layers | | Broilers | | Fish | |
|---|---|---|---|---|---|---|---|---|
| | Observations | % of total | Observations | % of total | Observations | % of total | Observations | % of total |
| Bought concentrate | 8 | 33 | 2 | 40 | 4 | 80 | 8 | 89 |
| Bought concentrate plus feed from farm | 1 | 4 | | 0 | | 0 | | 0 |
| Feed from farm | 2 | 8 | | 0 | | 0 | | 0 |

costumers, and provided flexible short-term credits (7-20 days).

Prices rose around Christmas due to high demand. Small and medium producers were not able to increase production to take advantage of the high price because the large producers do not sell chicks to them in this period. Large producers said that they produced more broilers for the high price periods.

Fish production depended on availability of permanent water sources and was found on both specialized and diversified farms. All but one farmer purchased commercial concentrate for fish production. The one farmer mixed concentrates using purchased raw material. Different feeds for different fish growing stages are commercially available and were used by 2 out of 9 farmers. People typically did not mix their own fish concentrates because it was not easy to produce a product that floats on water. Only one farmer fed fish with cut-and-carry grass as a supplement to concentrates.

Fingerlings were purchased and transported from places like Campamento about 100 km away or from Comayagua about 300 km away.

Marketing of fish was not seen as problematic; there is not much production in the area, and fried tilapia is a typical dish. Market channels included direct sales to consumers (US $1.47/lb), restaurants (US $1.26/lb) and local markets. Some producers have restaurants where they sell fried fish for US $3.40-4.20. Fish producers respond to high price/demand periods like Easter week or the time around Christmas. They either stop selling fish before the high price period or produce more fish for the period.

Monogastrics producers mentioned the following reasons for not producing concentrates:

- Lack of machinery for mixing
- Less expensive to purchase concentrate (a large scale producer with 560 pigs)
- Obligation to purchase concentrates (medium broiler producers)
- Credit availability with concentrate purchase (laying hens)
- Not possible to produce floating concentrate for fish
- Lack of knowledge of concentrate composition
- Monogastrics are often an activity of secondary priority

Producers who mixed their own concentrate mentioned reasons for not producing raw material:

- High opportunity cost of land
- Lack of interest and knowledge
- Lack of machinery for crop production
- High production cost of maize and sorghum
- Specialization on egg production
- Scarcity of land
- Insufficient time or financial means for diversification

The most frequently mentioned market problems were:

- Not possible to sell large quantities at once (pigs and broilers)
- Quality does not fetch a premium
- Difficult to respond to price fluctuations
- The end consumer prefers to purchase known brands
- Transport problems to reach the national market

### Conclusions

- Cost of producing raw materials on-farm should be further analyzed and compared with imported soy prices.
- Lack of knowledge of alternative high value protein sources may limit monogastric production.
- Monopoly power of concentrate companies can be challenged with alternative sources of chicks and feed.
- For all monogastrics products, quality is not awarded a price premium. Marketing initiatives would require consumer awareness.
- Although many medium-scale pig producers do not have land available for raw material production, opportunities exist for the production of forage-based protein feeds for others who already mix their own concentrates and who have sufficient land.
- Locally available materials and local practices need further diagnosis and analysis.
- Value chains of both monogastric feeds and products need further analysis and development.

### General conclusions

Farming contexts differ greatly within and amongst countries of Latin America. Monogastric animal production is an integral component of many smallholder farms. Many farm families produce mostly chickens and pigs but other monogastric animals are common per region including duck, guinea pigs, rabbits and fish. Input and output opportunities restrict the earnings capacity of many farmers.

Larger scale monogatric farmers face expensive feed costs. With imported grain prices increasing, domestic production of grain and legumes may become more attractive. In addition, these alternative feed sources can be better adapted to specific production niches.

As ample feed for animals constrains production, markets are rarely formal or fair for smallholder producers. In Honduras, chick purchases require the purchasing of feed in the future. Enhanced farmer organization can help overcome policy and institutional barriers.

Monogastric production is an important strategy to diversify household risk for many smallholder farmers. Occasional and/or informal sales of meat, eggs, and animals provide an additional income source, especially for women. A challenge for research and development is to foster enhanced market access and feed inputs according to local context.

## 4.7 Promotion of artisanal seed multiplication and scaling of forage technologies in Central America

### Highlights

- In Honduras the pilot farmer led seed enterprise EMPRASEFOR (Empresa de Producción artesanal de Semilla Forrajera) was regognized as an enterprise in early January, giving access to formal seed markets.

- In Nicaragua, various farmer group are initiating the production of legume seeds such as *Lablab purpureus*, *Cratylia argentea*, *Canavalia brasiliensis* and *Vigna unguiculata.*

### 4.7.1 Promotion of farmer led forage seed multiplication enterprises in Honduras

**Collaborators:** P. Lentes, H. Cruz, M. Posas (SERTEDESO), M. Peters, C. Lascano and C. Burgos (DICTA)

#### Rationale

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

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 locations.In 2001, production of loosely organized farmers in Honduras began with 286 kg of seed of *Brachiaria brizantha* cv. Toledo. During 2002 the 13 members now organized in EMPRASEFOR produced a total of 720 kg of Toledo on 10.4 ha, doubling the cultivated area of the year before. In 2003, production volume and area rose to nearly 1.5 tons, produced on 18.5 ha, 8 ha more than in 2002. For 2004, the production target of 1.6 tons was over shot by 300 kg, meanwhile increasing the area by only 2 ha. As the production volume of 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 (Table 94).

The limited local market was the entry point for linking the seed producers to a large company and export market opportunities. Thus, in April 2005, CIAT facilitated the contact of EMPRASEFOR with the Mexican seed producer and distributor PAPALOTLA, a partner of CIAT for several years. Once the core points of the alliance were agreed upon, PAPALOTLA ensured to buy the entire harvest of EMPRASEFOR, with defined minimum quality parameters to be met. To meet Honduran legal requirements EMPRASEFOR registered as certified seed producer with SENSASA, the Government body for Agricultural Health and is formally recognized as an enterprise since January 2006.

The group extended the area of cultivation to a total of 37.4 ha, 71 % more than in 2004. PAPALOTLA provided a credit and organized the delivery of fertilizers and agrochemicals for production through their local reseller.

**Table 94.** Development of seed production, EMPRASEFOR.

| Year | area (ha) | Production (kg) | Production / ha | Increased production area (%) |
|---|---|---|---|---|
| 2001 | 5.25 | 286 | 54.5 | |
| 2002 | 10.4 | 720 | 68.8 | 99.3 |
| 2003 | 18.5 | 1465 | 79.0 | 77.3 |
| 2004 | 21.8 | 1915 | 87.5 | 17.9 |
| 2005 | 37.4 | 954 | 25.4 | 71.2 |
| 2006 | 7 | 345 | 49.3 | |

Farmers prepared themselves to meet a production target of 4 tons of seed and during flowering, the Toledo plots were in perfect condition. Between October and December 2005, several hurricanes hit Central America. Due to the unfavorable weather conditions, the Toledo seed harvest of EMPRASEFOR was much below the expectations in quantity and quality, a severe backstroke for the recently founded enterprise. Total production was about 954 kg and thus only 23.85 % of what was expected. Since volume and quality were not sufficient for the export by PAPALOTLA, the partners agreed to continue selling the seed locally at a price of 10 $ per kg. Farmers have gained the experience that high volume production, is necessary to compete on the international seed market. However, the secure market offered by the alliance with the PAPALOTLA was paid for with a lower sale price per kg (6.50 $US) of seed.

For small farmers, like the members EMPRASEFOR, the investment and the associated individual risk of an expansion of seed production were comparatively high and met adverse environmental conditions. As a consequence of the negative experience in 2005 the area of seed production shrank to 7 ha in the following year. Farmers changed their priorities of land use, by using the established plots of Toledo as pasture and for the production of conserved forage. Farmers were refocused for the 2006 season and, despite the losses incurred during 2005 honored the credit provided by PAPALOTLA. As long as the local market for seed is good enough to sell for around 10 $US per kg, farmers meanwhile opted for a lower individual risk of production. Under the present context it appears to be more secure for them to use the area under Toledo liberated through the decline of seed production for milk and beef production, capitalizing on higher productivity of the improved pastures.

Another effort of Toledo seed production has been undertaken by CIAT´s national partner DICTA. Activities were related to training of individual farmers in Olancho, who just started to produce seed. In 2006, 6 farmers and 2 DICTA field technicians were trained in seed production. On nine farms in Olancho approximately 700 kg of seed were harvested. The area under seed production was 15.75 ha. This seed was produced for individual use of the producers and for local sales. Similar efforts are underway with the production of *Vigna unguiculata* (cowpea) seed.

The support of farmer led seed supply system producing forages in the process of adoption is supported by production of basic seed of pipeline materials for further experimentation, testing and technology adaptation, so that this seed is available in the country in time for semi-commercial evaluation and scaling.

### 4.7.2 Promotion of farmer led forage seed multiplication enterprises in Nicaragua

**Contributors:** A. Schmidt, M. Mena (INTA), R. van der Hoek, C. Davies and M. Peters (CIAT)

In Nicaragua farmer led seed production commenced later than in Honduras and hence the process of enterprise formation is still on going. However in San Dinisio in the Matagalpa department three farmers produced resp. 38, 38 and 9 kg seed of *Cratylia argentea* while seven farmers are producing seed of *Canavalia brasiliensis*. One of the farmers has extended his area to 0.3 ha and is likely to produce more than 200 kg this year. The other farmers all planted 0.15 ha and the total estimated production for this year is 700-800 kg (Table 95).

**Table 95.** Seed production of *Canavalia brasiliensis*.

| Community | Farmer | Area (ha) | Projected production (kg) | Observations |
|---|---|---|---|---|
| Susuli Central | Matilde Zamora | 0.15 | 130 | |
| El Chile | Agustín Escoto | 0.15 | 25 | Drought |
| Susuli | Juan Hernandez | 0.3 | 200 | |
| San Ramón | Clark Davies | 0.15 | 140 | |
| San Cayetano | Yuri Lopez | 0.15 | 0 | Drought |
| El Zarzal | Salome Zeledon | 0.15 | 120 | |
| Los Limones | Migdonio Campos | 0.15 | 140 | |
| Total | | 1.2 | 755 | |

In 2006 in Las Segovias, three farmers produced a total of 650 kg seed of *Vigna unguiculata*. This was an important increase compared to 2005, during which 135 kg of *Vigna unguiculata* and 45 kg of *Lablab purpureus* was produced. Apart from this, one farmer is expected to produce a considerable quantity (50-100 kg) of seed of *Cratylia argentea*.

As a result of the collaboration between CIAT (providing seed and technical support) and the national agricultural research instute in Nicaragua (INTA), the latter institution produced 400 kg seed of Cratylia argentea in a plot of 0.4 ha in the valley of Sébaco, Matagalpa department. In the South Pacific zone a similar plot was established, and some individual farmers also started to produce Cratylia seed.

Cratylia seed was released for use by farmers in Nicaragua (registered as INTA Cratylia). INTA plans to enhance seed production by establishing 5 plots of 2 ha each in its five intervention zones (Las Segovias, Centro-Norte, Centro-Sur, Pacifico-Norte, Pacifico-Sur).

## 4.8 Forage seeds: Multiplication and delivery of experimental and basic seed

### Highlights

- The Seed Unit at Atenas Costa Rica continued to produce, procure and deliver under request experimental and basic seed of promising forage germplasm. This year 505 kg of seed were delivered in response to 52 requests from 11 countries; the bulk of the seed was formed by *C. argentea* (124.3 kg) and *Brachiaria* spp. (314.1 kg).

- A total of over 800 kg of seed was produced in the Seed Unit of Palmira during 2006. This total included seed of 44 different accessions representing 17 grass and legume species. Six hundred seventy kg of seed were dispatched. This included 329 seed samples of 16 genera. Seed was shipped to 13 different countries.

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

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

Seed multiplication activities of promising forage germplasm continued during 2006 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 2005 through August 2006 a total of 245 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* (95 kg), *Brachiaria* spp. (11kg), *Brachiaria* hybrids cv. Mulato and cv. Mulato II (12 kg), *Arachis pintoi* (46 kg), *Leucaena* spp. (5 kg), *Stylosanthes guianensis* AFT 3308 (26.7 kg), *Vigna* spp. (21.2 kg), *Panicum maximum* (6 kg), *Paspalum* spp. (5 kg) and 18 kg of other forage species.

During the period August 2005-November 2006 a total of 504.9 kg of experimental and basic seed was delivered by the Seed Unit of Atenas (Costa Rica).

Table 96 shows that 52 seed requests were received from 11 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 (95.5 kg) and Panama (82.5 kg), followed by Nicaragua.

A total of 314 kg of basic seed of promising *Brachiaria* specie, particularly of cvv. Mulato and Mulato II, were also delivered this year.

**Future of the Atenas Seed Unit**

In December 2006 the CIAT´s Tropical Forage Project ended activities in Costa Rica and the office that supported the activities for the last 19 years was closed. However, given the importance of the Seed Unit in producing and delivering experimental and basic seed of promising forage germplasm for the region an agreement that is its final stages of negotiation allows national institutions of Costa Rica to continue the activities of the Seed Unit for the coming years.

The main supporters of the seed unit in the agreement are Corporación de Fomento Ganadero (CORFOGA), that will cover salaries and related expenses of one technician and two field labor; the Escuela Centro Americana de Ganadería (ECAG) and Cámara de Ganaderos del Sur (CEGUS) will cover office and field expenses.

On the other hand, CIAT will continue to supply promising forage germplasm to the seed unit based on demand. An international expert on forage seed will be contracted by CORFOGA to supervise the technical aspects of the seed unit.

It was agreed by the representatives of the institutions that will run the seed unit that the

**Table 96.** Countries, number of requests and amount of experimental/basic forage seed delivered by the Seed Unit of Atenas (Costa Rica) during the period August 2005-November 2006.

| Country | No. of Requests | Forage species (kg) | | | | Total |
|---|---|---|---|---|---|---|
| | | *Brachiaria* spp. | *A. pintoi* | *C. argentea* | Other species | |
| Costa Rica | 30 | 172.80 | 0.50 | 63.50 | 14.40 | 251.20 |
| Dominican Republic | 1 | | | | 4.00 | 4.00 |
| Guatemala | 2 | 52.00 | | 29.00 | 14.50 | 95.50 |
| México | 1 | | 0.25 | 0.25 | 0.54 | 1.03 |
| Honduras | 2 | | | 2.00 | | 2.00 |
| Alemania | 1 | 0.10 | 0.10 | 0.10 | 1.00 | 1.30 |
| Nicaragua | 5 | 31.00 | 4.00 | 15.00 | 8.00 | 58.00 |
| Uruguay | 1 | 5.00 | | | | 5.00 |
| Venezuela | 3 | 1.20 | 0.30 | 0.90 | 1.00 | 3.40 |
| Antillas | 1 | | | 1.00 | | 1.00 |
| Panama | 5 | 52.00 | 8.00 | 12.50 | 10.00 | 82.50 |
| **Total** | **52** | **314.10** | **13.15** | **124.25** | **53.44** | **504.93** |

**Table 97.** Activities programmed for the Seed Unit of Atenas with promising forage germplasm likely to become new forage cultivars during the next 6 years.

| Year/Species | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|
| *Panicum maximum* CIAT 16051 | Seed multiplication | Seed multiplication On-farm validation | Seed multiplication On-farm validation | Basic seed production | Cultivar release | |
| *Panicum maximum* CIAT 6799 | Seed multiplication | Seed multiplication On-farm validation | Seed multiplication On-farm validation | Basic seed production | Cultivar release | |
| *Brachiaria brizantha* CIAT 26124 | Seed multiplication | Seed multiplication On-farm validation | Seed multiplication On-farm validation | Basic seed production | Cultivar release | |
| *Vigna radiata* | Seed multiplication On-farm validation | Seed multiplication On-farm validation | Basic seed production | Cultivar release | | |
| *Cratylia argentea* CIAT 22386 | Seed multiplication | Seed multiplication | Seed multiplication On-farm validation | Seed multiplication On-farm validation | Basic seed production | Cultivar release |
| *Cratylia argentea* (Yacapani) | Seed multiplication | Seed multiplication | Seed multiplication On-farm validation | Seed multiplication On-farm validation | Basic seed production | Cultivar release |
| *Stylosanthes guianensis* (Multilínea) | Seed multiplication On-farm validation | Seed multiplication On-farm validation | Basic seed production | Cultivar release | | |

immediate activities on seed multiplication would concentrate on forge species listed in Table 97. The expectations are to multiply seed of selected accessions for on-farm demonstrations and eventual cultivar release. These forage germplasm are under advanced stage of evaluation and have seed available is a key for supporting research and promoting them at the farm level.

### 4.8.2 Multiplication and delivery of selected grasses and legumes in the Seed Unit of Palmira

**Contributors:** J.W. Miles (CIAT) A. Betancourt (CIAT) E. Pizarro (PAPALOTLA)

Diffusion of new forage genetic technology is generally through the vehicle of seeds. For novel plants, no commercial seed supply exists. In order to meet experimental (including participatory research) needs, CIAT maintains a small seed multiplication capacity at headquarters in Palmira. Seeds are multiplied in field plots established at CIAT-Popayán, CIAT-Quilichao, and CIAT-Palmira. A total of over 800 kg of seed was produced during 2006 (Table 98).

**Table 98.** CIAT Forage Seed Unit. Seed produced during 2006.

| Species | Number of accessions | Weight (kg) |
|---|---|---|
| *Brachiaria brizantha* | 7 | 33.50 |
| *Brachiaria humidicola* | 2 | 0.35 |
| *Brachiaria lachnantha* | 1 | 0.40 |
| *Brachiaria ruzizienzis* | 1 | 4.50 |
| *Brachiaria* sp. | 1 | 10.00 |
| *Cajanus cajan* | 3 | 66.00 |
| *Cannavalia brasiliensis* | 1 | 32.00 |
| *Centrosema macrocarpon* | 1 | 10.00 |
| *Centrosema molle* | 1 | 19.00 |
| *Cratylia argentea* | 2 | 322.70 |
| *Desmodium heterocarpon* | 2 | 16.80 |
| *Desmodium velutinum* | 7 | 23.36 |
| *Flemingia macrophylla* | 1 | 1.00 |
| *Lablab purpureus* | 4 | 62.50 |
| *leucaena diversifolia* | 1 | 0.40 |
| *Leucaena leucocephala* | 1 | 40.00 |
| *Vigna unguiculata* | 8 | 171.00 |
| Total | 44 | 813.51 |

This total included seed of 44 different accessions representing 17 grass and legume species. Six hundred seventy kg of seed were distributed. This included 329 seed samples of 16 genera (Table 99). Seed was shipped to 13 different countries (Table 100).

**Table 99.** CIAT Forage Seed Unit. Dispatches 2006, by genus.

| Genus | Number of samples | Weight (kg) |
|---|---|---|
| *Arachis* | 11 | 1.12 |
| *Brachiaria* | 91 | 67.46 |
| *Cajanus* | 3 | 0.30 |
| *Calliandra* | 4 | 0.08 |
| *Cannavalia* | 19 | 7.06 |
| *Centrosema* | 11 | 5.33 |
| *Clitoria* | 4 | 5.10 |
| *Cratylia* | 94 | 310.52 |
| *Desmodium* | 12 | 3.65 |
| *Flemingia* | 6 | 0.51 |
| *Lablab* | 12 | 5.86 |
| *leucaena* | 17 | 24.92 |
| *Mucuna* | 3 | 1.12 |
| *Pueraria* | 3 | 0.19 |
| *Stylosanthes* | 6 | 11.48 |
| *Vigna* | 33 | 225.38 |
| Total | 329 | 670.07 |

**Table 100.** CIAT Forage Seed Unit. Dispatches 2006, by recipient country.

| Country | Number of samples | Weight (kg) |
|---|---|---|
| Colombia | 247 | 628.82 |
| Costa Rica | 1 | 3.00 |
| Germany | 3 | 0.45 |
| Guatemala | 1 | 10.00 |
| Honduras | 8 | 6.35 |
| Japan | 21 | 3.37 |
| Malawi | 8 | 1.06 |
| Nicaragua | 21 | 7.66 |
| Ruanda | 8 | 1.06 |
| Switzerland | 1 | 0.50 |
| Vietnam | 6 | 0.60 |
| Zimbabwe | 3 | 7.00 |
| Mauritius | 1 | 0.20 |
| **Total** | **329** | **670.07** |

## 4.9 Tools to target forages

### Highlights

- SoFT has been well accepted by the international community as a useful tool compiling information on tropical forages.
- More than 1000 CD copies of SoFT have been distributed and almost 100.000 visits have been recorded to the web site mostly from Research and Development institutions working in tropical and subtropical and environments. Another not foreseen group of users include educational institutions not only in tropical countries and the private seed sector.

### 4.9.1 Expert systems for targeting forages and extension materials for promoting adoption of 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

The product itself has been described in previous annual reports. Here we will report on dissemination of the product and future needs.

In 2006 we recorded almost 100.000 visits to the www.tropicalforages.info web site and more than 1000 CD copies of the tool have been distributed. There continues to be a large number of visits from Australia, while we have an increase in visits from the CG, commercial institutions and networks. We also experience more

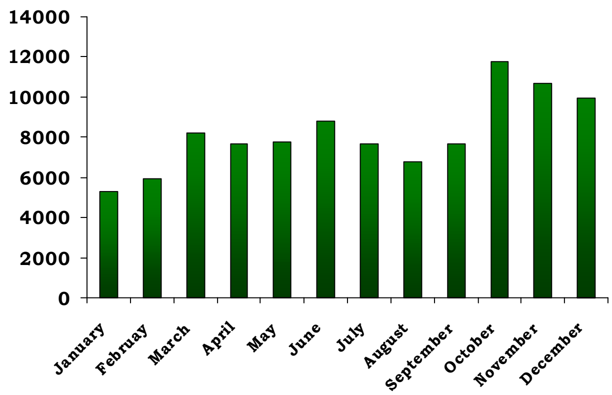


**Figure 57.** Number of visits to the forage web page in 2006: 98157

frequentation from LAC countries in particular Brazil, Mexico, Colombia, Argentina and European countries, the latter likely related to teaching. A number of Asian countries are regularly accessing the tool while use of the web site from African countries is comparatively low (though still recording a few thousand visits) (Figure 57).

**Outlook**

There is a need to include more recent information in the facts sheets and in some cases add new species. It is also necessary to translate the tool into other languages (i.e. Spanish and French, various Asian languages) to encourage its use and application in Latin America and the Caribbean, francophone Africa and Asia, respectively.

It is anticipated that the number of visits from Sub-Saharan Africa will increase over time as access to Internet will improve. Meanwhile it remains necessary to produce CD versions of the tool in particular in locations with limited internet access.

## 4.10 Facilitate Communication through journals, workshops and the Internet

### Highlights

- There has been a sharp increase in the use of the forage web page with close to 340,000 downloads in 2006.
- Pasturas Tropicales is increasingly accessed on line with about 130.000 downloads in 2006.
- A CIAT-ETH-CORPOICA-U. Nacional collaborative workshop on forage potential of tanniniferous legumes was held in Bogotá, with funding by ZIL-SDC.

### 4.10.1 Diffusion of research results: Pasturas Tropicales

**Contributors:** C. Lascano (CIAT) and A. Ramirez (Independent Publisher)

After 22 years (1985-2007) the Journal Pasturas Tropicales will no longer be published due to financial limitations of the Forage Project in CIAT. The last number will come out in March 2007. During its existence a total of 85 numbers were published distributed in 28 volumes which contained 610 scientific articles and research notes on tropical forages. Most of the papers published in Pasturas Tropicales were from researchers working in R&D institutions in LAC.

At the beginning Pasturas Tropicales was the vehicle for publishing results obtained by researchers from CIAT and by researchers from different institution participating in the CIAT- led international forage network (Red Internacional de Evaluación de Pastos Tropicales —RIEPT). However, it later evolved into a journal in great demand by researchers from many institutions in LAC to publish their work and by a wide range of subscribers. The Journal was particularly popular in University Libraries.

One of the most important contributions of Pasturas Tropicales was to stimulate forage researchers from different institutions in LAC to publish their work. The fact that the Journal had a process for reviewing papers submitted assured contributors that only relevant, high quality and original work would be published with an international distribution.

Finally, as members of the Editorial Board of Pasturas Tropicales we want to express our appreciation to all those institutions and researchers that in one way or another contributed to the success of Pasturas Tropicales as a specialized publication on tropical forages.

### 4.10.2 Training courses on utilization of improved forages in Central America

**Contributor:** P. J. Argel (CIAT)

As part of the ILRI/CFC project this year we carried out a number of training courses on utilization and management of improved forages, which were directed to mainly farmers.

In Costa Rica a group of 25 farmers from Panama members of the livestock association called ANAGAN attended a training course between October 31st and November 4. The training course included a field trip to visit a cattle auction in San Isidro and improved pastures in one of the projects small cattle farms that has a fattening system based on *B. brizantha* cv. Marandú supplemented with chicken manure and minerals. In each cycle the farmer fattens 10 steers with a mean animal live weight gain of 600 to 800 g per day.

The trip continued with visits to a milk processing plant called Dos Pinos and the slaughtering plant called Montecillos, and finished at the facilities of the Escuela Centramericana de Ganadería (ECAG), a livestock training school, were CIAT's Tropical Forage Project have experimental plots for evaluation and seed multiplication of selected forage germplasm. It is worth to mention that Panama is not part of the ILRI/CFC Project, but farmer associations in that country have shown considerable interest in the advances and on the results of the Project.

As part of the diffusion and training activities we organized the 1st of December a workshop directed to farmers and technicians of Santa Cruz cattle association. Twenty five participants assisted and the topics dealt with cattle phytosanitary aspects and pasture management practices. The group responded positively and showed high interest in the presentations. Technical documents were handed out to the group.

### 4.10.3 Workshop on Tannins in Ruminant Nutrition

**Contributors:** C. Lascano (CIAT) and D. Hess (ALP Posieux)

A workshop was carried out as part of a collaborative CIAT- ETH-CORPOICA-U. Nacional- Bogotá Project entitled "The forage potential of tanniniferous legumes: Search for sustainable ways to cope with nutritional limitations in smallholder systems" funded by ZIL- SDC. A total of 16 papers were presented in the two day workshop held in December 2006 in the National University in Bogotá with the participation of 63 persons.

The overall aim of the collaborative project was to develop efficient feeding systems based on tanniniferous shrub legumes in order to improve livestock productivity in smallholder systems in the tropics. To accomplish this objective a number in vitro and in vivo experiments were carried out by mostly graduate students from the UNAL- Palmira and UNAL- Bogotá to test the utility of mixtures of legumes with and without tannins as protein supplements to low quality grasses.

One of the most important conclusion that came out of the presentation and discussions of results during the workshop was that the feed value of high yielding shrub legumes with tannins could be significantly improved by mixing them with small quantities of high quality legumes with no tannins. Additional results showed that reduction in methane observed when feeding legumes with tannins was related to their low fiber quality rather than to a direct effect of tannins on methanogenic bacteria.

### 4.10.4 Dissemination and facilitation of communication through the forage web site

**Contributors:** Simone Staiger, M. Peters, C. Lascano and B.Hincapié (CIAT)

The web site of CIAT's Tropical Forages Project, is the result of teamwork between all Project members, under the general web site coordination of the Communications Unit and with the support of both the Systems and the Information and Documentation units. In view of the target users the web site is available both in English and Spanish. In 2007 the web site was redesigned to comply with CIAT new standard aiming to be more functional for the variety of users including universities, research institutes, collaborators, donors, and the scientific community in general (Photo 12).

Figure 58 shows the number of visits to the web site in the period from March 2006 to February 2007. 9242 and 21617 visits were recorded for the English and Spanish version, respectively, a substantial increase to the previous year.

**Downloads:** A total of 338927 documents have been downloaded form the forage web site in the period between March 2006 and February 2007 (Table 101). Of particular interest to users were downloads from the journal Pasturas Tropicales, with in average more than 10000 downloads per month (Figure 59).

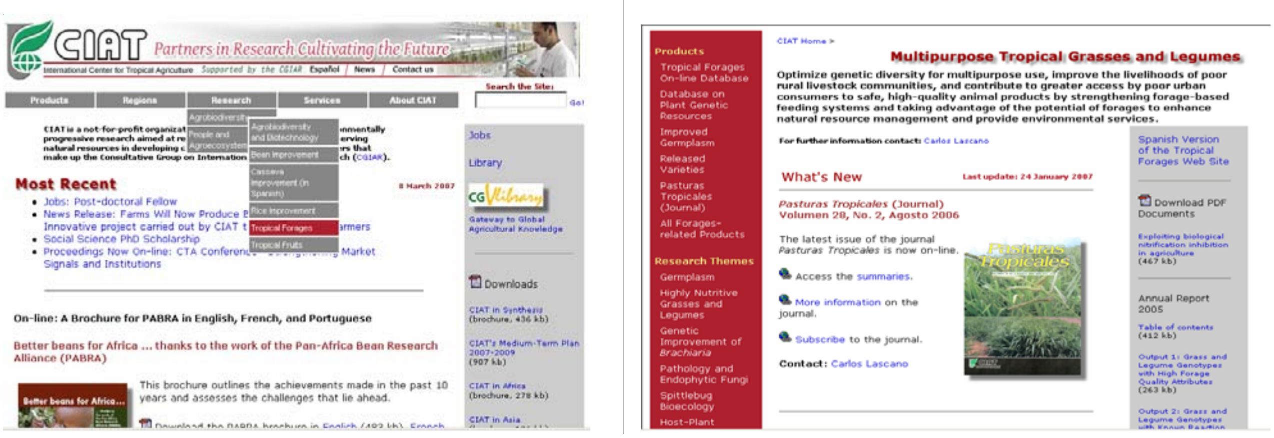


**Photo 12.** The site, accessible under the URL http://www.ciat.cgiar.org/forrajes/index.htm

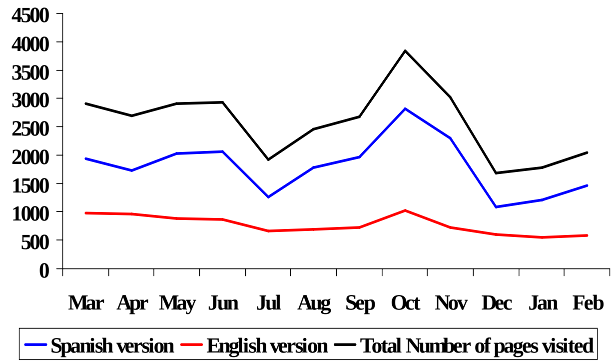


**Figure 58.** Number of visits to the forage web page

**Table 101.** Downloads from the forage web site in 2006

| Publication | Downloads |
|---|---|
| Pasturas Tropicales (Indices and summary) | 129840 |
| Annual Report 2005 | 34852 |
| *Brachiaria brizantha* cv. Toledo (Pasto Toledo) | 26292 |
| *Cratylia argentea* cv. Veranera | 18906 |
| Evaluación Pasturas | 15359 |
| Producción Artesanal de Semillas de Pasto Toledo | 13263 |
| *Desmodium heterocarpon* cv. Maquenque | 10421 |
| Producción Artesanal de Semillas de *Cratylia argentea* | 4467 |
| *Brachiaria* hibrido cv. Mulato | 1033 |
| Others | 84494 |
| Total | 338927 |

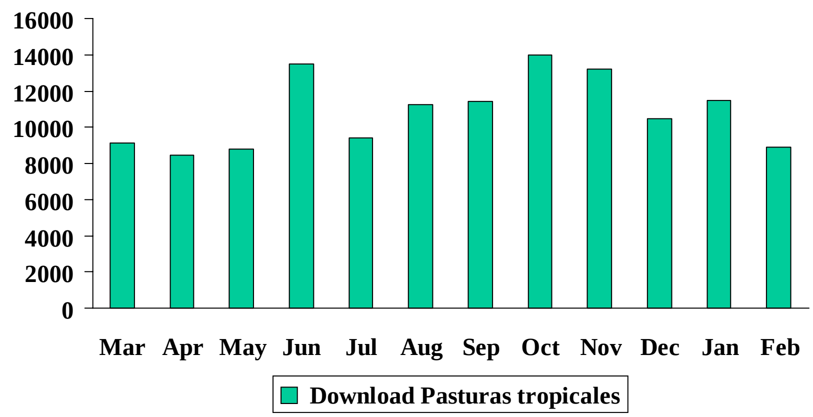


**Figure 59.** Downloads in the period March 2006 and February 2007 for the journal of Pasturas Tropicales.