Tropical Grasses and Legumes: Optimizing genetic diversity for multipurpose use

Summary
Annual Report 2003
Project IP-5
PROJECT IP-5
Tropical Grasses and Legumes:
Optimizing genetic diversity for
multipurpose use
1.0 Project Overview: IP5: Tropical Grasses and Legumes: Optimizing Genetic Diversity for Multipurpose use

Objective: To develop and utilize superior gene pools of grasses and legumes for sustainable agricultural systems in subhumid and humid tropics.

Outputs
1. Optimized genetic diversity for quality attributes, for host-parasite-symbiont interactions, and for adaptation to edaphic and climatic constraints, for legumes and selected grasses.
2. Selected grasses and a range of herbaceous and woody legumes evaluated with partners, and made available to farmers for livestock production and for soil conservation and improvement.

Gains: Defined genetic diversity in selected grass and legume species for key quality attributes, disease and pest resistance, and environmental adaptation. Known utility in production systems of elite grass and legume germplasm. New grasses and legumes will contribute to increased milk supply to children, cash flow for small livestock and non- livestock farmers, while conserving and enhancing the natural resource base.

Milestones
2004 Defined utility of Flemingia, and Lablab hay as feed resources for dairy cows. Opportunities identified in Africa to promote the utilization of forages developed by CIAT.
2005 Methods and tools available to enhance targeting and adoption of multipurpose forage germplasm in smallholder production systems in Central America. A new Brachiaria hybrid with better adaptation to dry season and with higher seed yield available for release in the dry tropics.
2006 Widespread adoption of improved forage technologies in the subhumid and humid tropics (e.g. Central America and SE Asia). A Brachiaria hybrid with multiple stress resistance (different spittlebug species, Rhizoctonia and aluminum), with high forage quality and high seed production available as a commercial cultivar to farmers in the tropics.

Users: Governmental, nongovernmental, and farmer organizations throughout the subhumid and humid tropics who need additional grass and legume genetic resources with enhanced potential to intensify and sustain productivity of agricultural and livestock systems.

Collaborators: National, governmental, and nongovernmental agricultural research and/or development organizations; SROs (Universities of Hohenheim and Göttingen, CSIRO, JIRCAS, ETHZ); private sector (e.g. Papalotla).

CGIAR system linkages: Enhancement & Breeding (30%); Livestock Production Systems (15%); Protecting the Environment (5%); Saving Biodiversity (40%); Strengthening NARS (10%). Participates in the Systemwide Livestock Program (ILRI) through the Tropileche Consortium.

CIAT project linkages: Genetic resources conserved in the Genetic Resources Unit will be used to develop superior gene pools, using where necessary molecular techniques (SB-2). Selected grasses and legumes will be evaluated in different production systems of LAC, Asia and Africa using participatory methods (SN-3) to target forages (PE-4, SN-2) and to assess their impact (BP-1) for improving rural livelihoods and conserving natural resources (PE-2, PE-3).
### 2.0 Revised Project Log-Frame, 2003

**CIAT**

**Area:** Genetic Resources Research  
**Project:** IP-5 Tropical Grasses and Legumes: Optimizing Genetic Diversity for Multipurpose Use  
**Project Manager:** Carlos E. Lascano

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<th>Narrative Summary</th>
<th>Measurable Indicators</th>
<th>Means of Verification</th>
<th>Important Assumptions</th>
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<td><strong>Goal</strong></td>
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| To contribute to the improved welfare of small farmers and urban poor by increasing milk and beef production while conserving and enhancing the natural resource base. | • New cultivars of grasses and legumes used by farmers.  
• Raised productivity of livestock and crops while protecting biodiversity and land in savannas, forest margins and hillsides. | Statistics and case studies on socio-economic benefits and natural resource conservation in smallholder livestock farms in the subhumid and humid tropics. | Policies are put in place by governments to favor sustainable livestock and forage development in marginal areas occupied by small farmers. |
| **Purpose**       |                       |                       |                       |
| To identify and deliver to farmers superior gene pools of grasses and legumes for sustainable agriculture systems in subhumid and humid tropics. | • Demonstrated economical and ecological benefits of multipurpose grasses and legumes to livestock and crop farmers in tropical regions of Latin America, Africa and South East Asia. | Demonstrated differences under field conditions  
Performance of forage components in systems. | Support from traditional and nontraditional donors.  
Effective collaboration:  
CIAT’s Projects  
ARO’s, partners and farmers, NGOs. |
| **Outputs**       |                       |                       |                       |
| 1. Grass and legume genotypes with high forage quality are developed. | • Defined utility of *Flemingia* and *Lablab* hay as a feed resource for dairy cows by 2004.  
• Determined utility of legume mixtures for increasing protein supply in ruminants while reducing methane emissions by 2005  
• New *Brachiaria* genotypes with superior forage quality for improved animal performance characterized by 2006. | Demonstrated differences under field conditions  
Scientific publications  
Annual Reports  
Theses. | Effective collaboration with CIAT Projects (PE-2), AROs, partners and farmer groups. |
| 2. Grass and legume genotypes with known reaction to pests and diseases and interaction with symbiont organisms are developed. | • Efficient screening method to assess *Rhizoctonia* resistance in *Brachiaria* developed by 2004.  
• Role of endophytes on drought tolerance determined under field conditions by 2004.  
• QTL’s for resistance to spittlebug and high aluminum in the soil in *Brachiaria* are available for marker-assisted selection by 2005  
• *Brachiaria* genetic recombinants with combined resistance to different species of spittlebug are available by 2006. | Demonstrated differences under field conditions  
Scientific publications  
Annual Reports  
Theses. | Effective collaboration with CIAT Projects (SB-1, SB-2), AROs, partners and farmer groups. |
| 3. Grass and legume genotypes with superior adaptation to edaphic and climatic constraints are developed. | • Improved accessions of *Vigna* and *Lablab* with adaptation and known value to farmers in hillsides of Central America are available to partners by 2004.  
• Defined variability for nitrification inhibition in *Brachiaria* genotypes by 2005.  
• *Brachiaria* genetic recombinants with resistance to low P and high aluminum in the soil and with drought tolerance are available by 2006. | Demonstrated differences under field conditions  
Scientific publications  
Annual Reports  
Theses. | Effective collaboration with CIAT Projects (SB-1, PE-2, PE-4), AROs, partners, NGOs and farmer groups. |
| 4. Superior and diverse grasses and legumes delivered to NARS partners are evaluated and released to farmers | • Scaling process of *Vigna*, *Lablab* and *Cratylia* and improved *Brachiaria* are in place in Central America by 2004.  
• New market opportunities in Central America for processed forages assessed by 2006.  
• A Decision Support Tool for targeting forages to different environments and production systems in Central America is available by 2005  
• Opportunities identified in Africa to promote the utilization of forages developed by CIAT by 2004  
• An information network on forages and an effective forage multiplication systems are established in benchmark sites in SE Asia by 2004.  
• Improved multipurpose grasses and legumes result in increased on-farm milk, meat, and crop production, and reduced labor requirements in benchmark sites in SE Asia by 2005.  
• Widespread adoption of forage technologies in the subhumid and humid tropics by 2006.  
• Improved processes for scaling-out the impacts of forage technologies on farms in SE Asia. | Promotional publication  
– Newsletters  
– Journal  
– Extension booklets  
Surveys on adoption  
impact of new grasses and legumes:  
– Seed sold  
– Area planted  
– Production parameters  
Environmental/socioeconomic indicators. | Effective collaboration with CIAT Projects (PE-2, SN-1, SN-2, SN-3, BP-1 and Ecoregional Program), partners, NGOs and farmer groups. |
3.0 Summary of Annual Report, 2003

List of Researchers in the IP-5 Project

Lascano Carlos E, Project Manager and Animal Nutritionist; Headquarters
Argel Pedro, Forage Agronomist: 60% CIAT and 40% Papalotla, San José, Costa Rica
Cardona Cesar, Entomologist (Host Plant –Resistance): 50% in IP-5 and 50% in IP-1; Headquarters
Holmann Federico, Animal Production Systems/Economics: 50% CIAT and 50% ILRI; Headquarters
Horne Peter M., Forage Agronomist: 40% IP5, 40% PE3 and 20% CIAT in Asia
Kelemu Segenet, Pathologist: 70% in IP-5 and 30% PE-1; Headquarters
Miles John, Plant Breeder: 100% in IP-5; Headquarters
Peters Michael, Forage Biologist: 100% in IP-5; Headquarters
Rao Idupulapati, Plant Nutritionist/Physiologist: 30% in IP-5, 30% in IP-1 and 40% in PE-2; Headquarters
Roothaert Ralph, Animal Scientist/Participatory Research; 50% CIAT (IP-5 and PRGA) and 50% ILRI; Addis Ababa, Ethiopia
Schmidt Axel, Forage Agronomist (Systems): 100% IP-5, Managua, Nicaragua

List of Partners

Main collaborators in CIAT

<p>| | |</p>
<table>
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<tr>
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<tbody>
<tr>
<td>Debouck Daniel, SB-1</td>
<td>White Douglas, PE-4</td>
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<td>Tohme Joe, SB-2</td>
<td>Thomas Oberthur, PE-4</td>
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<td>Barrios Edmundo, PE-2</td>
<td>Jones Peter, PE-4</td>
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<tr>
<td>Lefroy Rod, (SE Asia: Regional Coordinator, Laos)</td>
<td>Hernández Luis Alfredo, SN-3</td>
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<tr>
<td>Ayarza Miguel (CA: Regional Coordinator, Honduras)</td>
<td>Posada Rafael, BP-1</td>
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<tr>
<td>Kirby Roger (Africa: Regional Coordinator, Uganda)</td>
<td>Rivas Libardo, BP-1</td>
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<tr>
<td>Sanz José I, PE-3</td>
<td>Rondon Marco, PE-6</td>
</tr>
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Main collaborators outside CIAT

Forage Quality: Rolando Barahona, CORPOICA, Colombia; Juan Carulla, U. Nacional, Colombia; Kreuzer Michael and Hess Dieter, ETH, Zurich, Switzerland.
Genetic Improvement of Brachiaria: do Valle Cacilda B., EMBRAPA, Brazil
Pests (spittlebug): Corpoica Macagual and Escuela de Graduados de Chapingo, Mexico.
Diseases (anthracnose): Chakraborty Sukumar, CSIRO, Australia
Endophytes: Schardl Christopher, Department of Plant Pathology, University of Kentucky, USA; Dongyi Huang CATAS, The People’s Republic of China; Sakai Tomoko, JICA, Japan.
Adaptation to abiotic stress factors: Claassen N., University of Göttingen, Germany; R. Albert and Heberle-Bors E., University of Vienna, Austria; Mayer J. E. and Wenzl, P., CAMBIA, Canberra, Australia; Oberson A. and Frossard E., ETH, Zurich, Switzerland; Osaki M., and Tadano T, Hokkaido University, Sapporo, Japan; Ishikawa T. and Subbarao, G.V., JIRCAS, Japan; Escobar C.J., CORPOICA, Macagual, Colombia
On-station and on-farm evaluation of forages: Restrepo Jose y Villeda Daniel, FIDAR, Colombia; Velásquez Jaime, U de la Amazonia, Colombia; Medrano Jorge y Parra Fredy, CORPOICA, Colombia; Hidalgo Carlos, Lobo Marco, and Sánchez William, Beatriz Sandoval and
Financial Resources

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<tr>
<td>Restricted Core</td>
<td>522,597</td>
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<td>Carry Over from 2002</td>
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<td><strong>Sub –Total</strong></td>
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<td>Special Projects</td>
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<td><strong>Total Project</strong></td>
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Research Highlights

- **Mixtures of forage legumes with different tannin types offer the possibility to manipulate methane production in ruminants fed with low quality diets**

We have made progress in defining the potential of tropical saponin-rich fruits to reduce methane emission from rumen fermentation and enhance N utilization by sheep. Results from in vitro and in vivo experiments carried out during the last two years showed that supplementation of fruits of *Sapindus saponaria* improve duodenal microbial protein flow and efficiency of rumen fermentation, and reduces ruminal methane release. This year we confirmed that the inclusion of tannin-rich legumes such as *Calliandra calothyrsus* and *Flemingia macrophylla* in forage-based diets significantly reduces methane release but also negatively affects nutrient degradation and N turnover.

We had hypothesized that to take advantage of the methane suppressing effect of tannin-rich legumes without affecting nutrient degradation and N turnover it was necessary to combine them with legumes low or free of tannin. Our results indicate that *C. calothyrsus* and *F. macrophylla* with high tannin content had similar chemical composition and tannin contents. However, the nutritional value of *F. macrophylla* was higher than that of *C. calothyrsus* when used in combination with a legume of low tannin content as *C. argentea*, but less effective in suppressing methane emission than *C. calothyrsus*. 
Future work will concentrate in defining the optimal type and proportion of tannin rich legumes in mixtures to take advantage of their methane suppressing potential without affecting nutrient degradation.

- **Brachiaria** hybrids with combined resistance to multiple stress factors selected for the first time

A major objective of the *Brachiaria* Improvement Program is to develop commercial cultivars that combine high level of resistance to abiotic and biotic stress factors. We have for the first time identified apomictic hybrids that combine adaptation to low fertility soils and high aluminum (Al), tolerance to drought and resistance to certain species of spittlebug. These new hybrids are now candidates for further field evaluation as potential cultivars for release.

**Hybrid- FM9503-S046-024--- Tolerant to low nutrient supply, resistant to drought and to spittlebug and of high forage quality:** Previous results from the entomology group had indicated the *Brachiaria* hybrid FM9503-S046-024 had antibiosis resistance to several spittlebug species (*Zulia carbonaria*, *Z. pubescens*, *Aenolamia reducta* and *Manaharva trifissa*) and tolerance to other species (*A. varia*). This year results from field studies in the Matazul Farm in the Llanos of Colombia indicated that after 3 years the *Brachiaria* hybrid FM9503-S046-024 was not only rapid in its establishment but that it also performed well over time in a low fertility-acid soil with low initial fertilizer application (kg/ha of 20P, 20K, 33Ca, 14 Mg, 10S). Its superior performance in leaf biomass production was associated with its ability to acquire greater amounts of nutrients, particularly Ca and Mg from the soil solution. This hybrid was also very responsive to higher fertilizer application as revealed by live shoot biomass and total forage yield. Results after three years also indicate that under field conditions (Matazul, Llanos of Colombia) the *Brachiaria* hybrid FM9503-S046-024 has had an outstanding performance in the dry season (4 months dry) as indicated by a high proportion of green leaves as a result of its ability to acquire nutrients under water deficit conditions. Finally, results from grazing trials indicate that milk with Brachiaria hybrid FM9503-S046-024 is similar to the milk yield recorded in cv Mulato, which is known to have high forage quality.

**Hybrid - BR02NO1372--- Tolerant to low nutrient -high Al and resistant to some species of spittlebug:** For the last two years, we have implemented screening procedure to identify Al-resistant *Brachiaria* hybrids that were preselected for spittlebug resistance. Last year, we identified 2 sexual hybrids (SX 01NO3178 and SX01NO7249) and one apomictic hybrid (BR99NO/4132) with greater level of Al resistance than that of the sexual parent, BRUZ/44-02. This year we evaluated Al resistance of the most promising *Brachiaria* hybrids that are resistant/tolerant to spittlebug and found that BR02NO1372, with antibiosis resistance to *A. reducta* and tolerant to *Z. carbonaria*, had the lowest root mean diameter with and without Al in the solution. This hybrid has a superior total root length and fineness of roots than *B. decumbens* cv Basilisk (most widely planted commercial *Brachiaria* cultivar), which is well adapted to soils with low fertility and high Al but susceptible to spittlebug.

- **An antifungal protein was isolated from the seeds of a tropical forage legume**

An array of plant defense mechanisms can be triggered upon wounding or perception of microorganisms, including the synthesis of proteins and peptides that have antifungal activity. Various antifungal and/or antibacterial proteins such as chitinases, thionis, ribosome-inactivating proteins and permatsins have been detected in seeds. In the last 4 years we have been examining a
number of tropical forage legumes for antifungal properties. Among these examined, seeds of *Clitoria ternatea* exhibited a strong *in vitro* antifungal activity on the test fungus *Rhizoctocnia solani*. The crude extract from seed of *C. ternatea* with high antifungal activity could be eliminated with Pronase E indicating that the active compound is a protein. A new protocol was developed to facilitate the identification of the protein, which turned out to be highly basic (alkaline pl) named Finotin. This protein was active against a number of fungi and bacteria pathogenic on common beans, rice, forage grasses and legumes. The protein was also shown to be very toxic to first instar larvae of bruchid species.

The wide range of effects of Finotin against fungi, bacteria and insects seems to be an important component of the natural defense system of *C. ternatea* known to be free of major pests and diseases. The potential utility of Fenotin will be better defined when the gene coding for the protein is isolated. These results point out once again that tropical grasses and legumes can be an important source of useful genes for many tropical crops.

- **Results from on-farm trials demonstrate the benefits and limitations of *Brachiaria* hybrid cv Mulato**

On-farm evaluation of new forage options offers the opportunity to expose new forage cultivars to different abiotic and biotic constraints, production systems and management strategies. During this year, with financial support from Papalotla, on-farm trials have been established in Colombia and in different countries of Central America and Southeast Asia to validate the utility of *Brachiaria* hybrid cv. Mulato in different cattle systems.

Results confirm high plant vigor at establishment tolerance to certain species of spittlebug and to drought. However, results confirm that cv Mulato does not tolerate poorly drained soils and that in sites with high rainfall *Rhizoctonia solani* heavily attacks it. In sites with low fertility soils cv Mulato has shown symptoms of nutrient deficiencies (e.g., N) after one year indicating that it should be targeted to moderately fertile to fertile soils, in intensive livestock systems or in crop/pasture rotations that are economically profitable for use of fertilizer inputs.

In most locations milk yield of cows grazing cv Mulato increased from 1.0 to 2.0 liters per day. Observations carried out in Honduras also indicate liveweight gains of steers of 900 g/an/day with cv. Mulato in contrast to 600 g/an/day with *B. decumbens* cv. Basilisk. In addition, stocking rate has also increased with cv. Mulato in relation to other *Brachiaria* grasses, which translates in more milk and beef per unit of land.

Results in Thailand indicate that cv. Mulato produced very high pure seed yields in small plots (13 kg from 288 m² equivalent to 450 kg pure seed/ha), which is considerably higher than yields recorded in Brazil and Mexico (150-200 kg/ha). Trials are being conducted in 2003 with smallholder forage seed producers to see if similar yields can be produced on-farm.

- **Livestock farmers in the llanos of Colombia are obtaining multiple benefits with the utilization of Cratylia as a dry season feed**

In February 2001 we started a 2-year project funded by PRONATTA (Programa Nacional de Transferencia de Tecnologia Agropecuaria) in the piedmont of the Llanos of Colombia to evaluate the utility of *Cratylia argentea* (Cratylia) in smallholder dairy farms. The original idea was for farmers to use Cratylia in a Cut & Carry system but some realized that this system was associated with high labor cost. The alternatives to Cut & Carry of Cratylia that some farmers implemented
were silage production and direct grazing all year round using electric fences. Grazing of Cratylia has not caused plant mortality and in some farms a very productive association of the legume with *Brachiaria decumbens* (the grass originally in the plots) was formed.

We had postulated that the main benefit for dairy farmers in the Piedmont would be increased milk production in the dry season and consequently more cash flow. It was interesting however, to learn that farmers saw other benefits when using Cratylia:

a) Possibility of having high quality forage for cows in the middle of the rainy season when pastures were difficult to graze due to high soil moisture
b) Replacement of purchased supplements in the dry season, which has economic implications
c) Possibility of milking cows in the dry season and get higher price for the milk sold
d) Improved body conditions of cows which has been associated with improved reproductive performance

The adoption of Cratylia in the Piedmont of the Llanos of Colombia is an ongoing process being promoted not only by extension people who received training from the Project but also by enthusiastic farmers who have experimented and seen the benefits of the legume in their farms. To enhance adoption of Cratylia we are promoting commercial seed production with farmer groups in different regions of Colombia.

**Problems encountered and their solutions**

**Main problem:** The general consensus among staff of the project continues to be that security in Colombia is the main problem affecting fieldwork. For example, some staff have had to postpone field trips to collect microbes and pathogens in the Amazon region because of security concerns. Field activities to evaluate *Brachiaria* hybrids under prolonged drought condition on the north coast of Colombia have also been postponed due to security risks.

**Solution:** Staff in headquarters are relying more and more on the use of greenhouse screens to select forage genotypes and those with field trial follow strictly the recommendations on local travel given by the Security Department.

Other problems affecting research of the Forage Team are:

1. High cost and limited agriculture machinery in the Santa Rosa Station in the Llanos to cope with demand from several programs (Soils, Maize, Forages) working at the Matazul farm.

   **Solution:** Rent agriculture machinery in the Llanos at times of high demand (planting season)

2. Lack of adequate maintenance service for laboratory equipment

   **Solution:** Hire technicians in Cali/Bogotá to provide maintenance to non-specialized laboratory equipment and make maintenance contracts with companies in Colombia that represent manufactures of specialized equipments in the laboratories

3. Limited capital budget for replacement of laboratory equipment

   **Solution:** Include as much as possible needed laboratory equipment (new or replacement) and computers in budgets of Special Projects
4. Assignment of capital budget for replacement of laboratory equipment by recommendations of a Research Committee to the Director of Research that is not necessarily based on priorities of the Projects that are responsible for delivering outputs.

**Solution:** Include at some point in the process of assigning capital to scientists in different competency areas, a consultation with the PM of the project that houses the staff making the capital request.

5. Difficulties to import forage germplasm into Nicaragua

**Solution:** Collaborate with the Seed Department of Agriculture Ministry (MAGFOR) to set-up a norm to regulate imports of forage seed to Nicaragua (a staff of CIAT in Nicaragua is working with MAGFOR officials on the norm).

**Proposed plans for next year**

New plans for next year for each major area of R & D in the Forage Project:

**Germplasm Evaluation**
- Evaluation of the collection of *Desmodium velutinum*
- Evaluation of the collection of *Canavalia* sp
- Evaluation of the collection of *Vigna umbellata* for green manure
- Multiplication of seed of selected accessions of Cowpea, LabLab and *Flemingia*

**Brachiaria Improvement**
- Preparation for full scale implementation (2005) of a breeding scheme for selecting on test-cross performance in the *Brachiaria* sexual population
- Initiate studies on mechanisms of resistance of *Brachiaria* genotypes to the spittlebug species, *Prosapia simulans*, in Colombia
- Initiate studies on mechanisms of resistance of *Brachiaria* genotypes to three major spittlebug species (*Aenolamia postica, A. albofasciata and Prosapia simulans*) present in Mexico and make arrangements to undertake similar work in Brazil
- Implement the new screening method for *Rhizoctonia* in *Brachiaria* hybrids
- Initiate screening for drought tolerance of *Brachiaria* hybrids in the greenhouse and make arrangements with partners to screen selected hybrids in the field at different sites (Atenas, Costa Rica, and Santa Elena, Mexico and North Coast, Colombia)
- Elaborate plan with Papalotla for the regional evaluation of the advanced *Brachiaria* hybrid FM 90503- S046-024

**Development and Diffusion of new Forage Technologies**
- Baseline study in selected livestock farms in Costa Rica, Nicaragua, Honduras and Guatemala for later assessment of the effect on farm productivity and income of the use of improved forage technologies
- Work with NARS partners to consolidate forage R&D work in Central America giving high priority to the evaluation of selected grasses and legume and to strengthening existing farmer-led seed enterprises and creation of new groups
- Co-organize workshop on adding value to forages in Africa (co-funding is being requested)
- Strengthen collaboration of staff in headquarters with staff in SE Asia on forage R & D
- Build collaboration in Africa on forage R&D through CIAT’s regional coordinator and the forage expert located in the region
4.0 Performance Indicators

Technologies, Methods and Tools:

Forage Cultivars Released: *Brachiaria* hybrid cv Mulato released by Semillano Seed Company in the Llanos and the North Coast of Colombia

Forage Accessions Distributed:

Seed Unit Palmira: Requests (354) of 15 species from 8 countries: Total Seed delivered: 1 Ton;
Seed Unit Atenas: Request (56) of 11 species from 6 countries: Total Seed delivered: 494 kg

Elite *Brachiaria* hybrids developed:

Resistance to spittlebug: 4 hybrids of *Brachiaria* (BR02NO/0419, BR02NO/0465, BR02NO/0756, and BR02NO/0812) showed high levels of antibiosis resistance (reduced nymph survival) to *A. varia*, *A. reducta*, and *Z. carbonaria*

Resistance to high Al in the soil: 2 hybrids (BR02NO/1372 and BR02NO/1621) of *Brachiaria* were identified with greater level of Al resistance as compared with other hybrids evaluated.

Resistance to drought: Field evaluation of most promising *Brachiaria* hybrids and accessions over 3 years in the Llanos of Colombia indicated that a germplasm accession *B. brizantha* CIAT 26110 (cv Toledo) and one *Brachiaria* hybrid, FM9503-S046-024, were superior in their adaptation to acid soil conditions and drought due to greater acquisition of nutrients from infertile soil conditions

Elite grass and legume genotypes being multiplied for regional testing:

*Brachiaria* hybrid FM 90503- S046-024 for drought tolerance and high forage quality (milk production higher than in commercial cultivars and as high as in the Hybrid cv Mulato).

*Brachiaria* accessions CIAT 26124, 26318 and 26990 continue to be under advance stage of evaluation (pre-release) in farms of the llanos of Colombia. Seed of these accessions is being multiplied in Mexico for distribution in Colombia

*Cratylia argentea* CIAT 18674 and 22406 were selected for high dry matter yields relative to the control

*Flemingia macrophylla* CIAT 21090, 21083 and 18437 (erect and semierect types) were selected based on higher dry matter yield (> 200 g DM/ plant) and higher digestibility (>48%) as compared to the control

*Lablab purpureus* CPI 34777, CPI 106471 and CPI 52535 were selected for high yield in acid and neutral soils

*Panicum maximum* cv Mombaza and *Brachiaria brizantha* cv Toledo for cut and carry and for erosion control as barriers in hillsides of Haiti

*Vigna unguiculata* IITA No: IT 86D-715, IT89KD-288, IT6D-733, IT89KD-391, and IT95K-1088/4 for acid soils and IT95K-1088/4, IT86D-719, IT95K-1088/2, IT93K-637/1 and IT96D-740
for neutral soils were selected. Farmers in Haiti selected the accession IT86D-716, which is in the cluster for neutral soils

**Methodologies:**

Fast inoculation method to screen *Brachiaria* hybrids for *Rhizoctonia*.

Method for participatory selection of forages (with IPRA)

**Mechanisms:**

Showed that the resistance of 4 *Brachiaria* hybrids (BR02NO/0419, BR02NO/0465, BR02NO/0756, and BR02NO/0812) to different spittlebug species (*A. varia, A. reducta, and Z. carbonaria*) functioned as antibiosis (reduced nymph survival)

Showed that tolerance of low P in the *Brachiaria* hybrid cv. Mulato involved two major strategies: (1) increasing the ability to use P efficiently by inducing phosphohydrolases (APase and RNase) in shoots with P deficiency; and (2) enhancing sugar catabolism and subsequent synthesis of amino acids and organic acids in leaves under P deficiency.

**Forage Database, Decision Support Tools and Web page:**

Released all published volumes of Pasturas Tropicales in a CD

New CIAT- Asia web site developed

Spanish version of web site launched

**Publications (see Annex for List of Publications)**

**Journal Papers**

Published: 11
Accepted (in press): 5
Submitted: 6

**Conference and Workshop Proceedings:** 29

**Working Documents and Technical Bulletins:** 11

**Invited Book Chapters (published and in press):** 9

**Other Publications:** 3
Strengthening NARS

Training Courses/Workshops /Field Days

South East Asia

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<th>TRAINING EVENT</th>
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<td>08-13 December 2002</td>
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<td>Workshop to review case studies of impacts</td>
<td>13-14 January 2003</td>
<td>Vientiane</td>
<td>8</td>
</tr>
<tr>
<td>Training workshop on Cross Visit and Case Study Methods</td>
<td>10-14 February</td>
<td>Luang Phabang</td>
<td>27</td>
</tr>
<tr>
<td>Staff Cross visit to another participatory R&amp;D project</td>
<td>16-20 February 2003</td>
<td>Sayaboury</td>
<td>27</td>
</tr>
<tr>
<td>Village planning workshop methodology</td>
<td>25-29 March 2003</td>
<td>Luang Phabang</td>
<td>20</td>
</tr>
<tr>
<td>Village planning workshop methodology</td>
<td>31 March – 02 April 2003</td>
<td>Xieng Khouang</td>
<td>13</td>
</tr>
<tr>
<td>Technical training workshop</td>
<td>01-03 May 2003</td>
<td>Luang Phabang</td>
<td>23</td>
</tr>
<tr>
<td>Technical training workshop</td>
<td>05-08 May 2003</td>
<td>Xieng Khouang</td>
<td>17</td>
</tr>
<tr>
<td>Adoption of Participatory Approaches by Institutions</td>
<td>14-16 August 2003</td>
<td>Vientiane</td>
<td>19</td>
</tr>
<tr>
<td>Cross visit to Forage Sites in Tuyen Quang, Vietnam</td>
<td>18-23 August 2003</td>
<td>Vietnam</td>
<td>19</td>
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<tr>
<td>Development of whole village case studies of impacts</td>
<td>08-12 September 2003</td>
<td>Luang Phabang</td>
<td>23</td>
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<tr>
<td>Development of whole village case studies of impacts</td>
<td>15-19 September 2003</td>
<td>Xieng Khouang</td>
<td>20</td>
</tr>
<tr>
<td>Event</td>
<td>Timing</td>
<td>Country/Location</td>
<td></td>
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<tr>
<td>----------------------------------------------------------------------</td>
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<td></td>
</tr>
<tr>
<td>Diffusion of Cratylia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Field day- La Isla farm</td>
<td>March 28</td>
<td>Colombia/Villavicencio</td>
<td></td>
</tr>
<tr>
<td>• Meeting to form a Cratylia network in Colombia</td>
<td>May 8 and 9</td>
<td>Colombia/Villavicencio</td>
<td></td>
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<tr>
<td></td>
<td>May 16</td>
<td>Colombia/Casanare</td>
<td></td>
</tr>
<tr>
<td>• Conference: Establishment and management of Cratylia</td>
<td>May 28 and 29</td>
<td>Colombia/Villavicencio</td>
<td></td>
</tr>
<tr>
<td>• Conference: The role of legumes in cattle production: Cratylia</td>
<td>May 30</td>
<td>Colombia/Villavicencio</td>
<td></td>
</tr>
<tr>
<td>• Conference: Different uses of Cratylia</td>
<td>June 7</td>
<td>Colombia/Granada</td>
<td></td>
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<tr>
<td>• Conference: Grass and legume species for the Llanos piedmont</td>
<td></td>
<td></td>
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<tr>
<td>Presentation of technical information on Brachiaria hybrid cv Mulato</td>
<td>June 17 and 18</td>
<td>Colombia/ Puerto Lopez and Monteria</td>
<td></td>
</tr>
<tr>
<td>Workshop: Advances in the Brachiaria improvement program: CORPOICA- Turipana</td>
<td>May 22 to 23</td>
<td>Colombia/ Monteria</td>
<td></td>
</tr>
<tr>
<td>Workshop: Advances in the development and management of new forage options for the llanos of Colombia: CORPOICA- La Libertad Curso Nacional de Forrajes</td>
<td>June 16 to 20</td>
<td>Colombia/ Villavicencio</td>
<td></td>
</tr>
<tr>
<td>Annual planning meeting of the CFC project on beef cattle led by ILRI</td>
<td>October 2-3</td>
<td>Colombia/ Medellin</td>
<td></td>
</tr>
<tr>
<td>Annual meeting of the Technical Committee of the BMZ Project on participatory evaluation of forages in CA</td>
<td>July 7 and 9</td>
<td>Costa Rica/San José</td>
<td></td>
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<tr>
<td>Training course “Farmer seed production” – FONDEAGRO</td>
<td>March 16- 22</td>
<td>Honduras</td>
<td></td>
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<tr>
<td>Training course “Participatory monitoring and evaluation” – FONDEAGRO</td>
<td>February 24 -27</td>
<td>Nicaragua</td>
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<tr>
<td>Improved forages – field day in San Dionisio for milk farmer associations from Chontales</td>
<td>March 10-11</td>
<td>Nicaragua</td>
<td></td>
</tr>
<tr>
<td>Training course “Pasture Management” – FONDEAGRO</td>
<td>April 28-30</td>
<td>Nicaragua</td>
<td></td>
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<tr>
<td>Field day for technicians of EU projects in Nicaragua</td>
<td>May 20</td>
<td>Nicaragua</td>
<td></td>
</tr>
<tr>
<td>Training course “CIAT’s new forage options” – FONDEAGRO</td>
<td>May 30</td>
<td>Nicaragua</td>
<td></td>
</tr>
<tr>
<td>Brachiaria hybrid “Mulato”- field days (4)</td>
<td>June 25, 26, 27 and July 1</td>
<td>Nicaragua/Managua, Matiguas, Santo Tomas, Chinandega Panama/David</td>
<td></td>
</tr>
<tr>
<td>Presentation of Brachiaria hybrid cv Mulato Conference: Utilization of Brachiaria cv Mulato</td>
<td>May 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presentation of Brachiaria hybrid cv Mulato in the Annual Livestock and Agriculture Exhibition of Central American countries</td>
<td>June 12-14</td>
<td>Panama/David</td>
<td></td>
</tr>
<tr>
<td>Presentation of Brachiaria hybrid cv Mulato</td>
<td>May 21</td>
<td>Guatemala/ Guatemala City</td>
<td></td>
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<td></td>
<td>July 31- August 15</td>
<td>Mexico/Tampico, Villahermosa, Acayucan, Tuxtla Gutierrez, Morelia and Torreon</td>
<td></td>
</tr>
</tbody>
</table>
Thesis Students

BS thesis students:

Buitrago, Maria E. Screening of Brachiaria hybrids for aluminum resistance. Universidad del Valle, Cali, Colombia, (in progress).


Pabón, Alejandro. "Resistencia de genotipos de Brachiaria spp. al ataque combinado de especies de salivazo (Homoptera: Cercopidae)". Universidad Nacional, Facultad de Agronomía de Palmira. (Ends November, 2003).


MS Thesis students:


Nieto Betancur, Juan C. Caracterización productive y nutricional de material fresco y ensilado de Maní forrajero (Arachis pintoi CIAT 17434) cultivado en asocio con Maíz (Zea mays) a diferentes edades de siembra. Tesis para optar al grado de Magíster Scientiae en Nutrición Animal. Universidad de Costa Rica. Sistemas de Estudios de Posgrado (in progress.)


Reiber, Christoph. 2004. Perspectives of different Vigna unguiculata accessions in Honduran hillsides: potential and constraints in different farming systems and their assessment by farmers, University: Hohenheim, Germany (in progress.)


**Ph.D. Thesis Students:**


**Awards to Staff in the Project:**

J.W. Miles: Outstanding Principal Staff Achievement award (December 2002).

Best presentation in Animal Production section at the PCCMCA (Programa Cooperativo Centroamericano para el Mejoramiento de Cultivos y Animales) conference. H. Cruz, C. Burgos, G. Giraldo, M. Peters and P. Argel. Intensificacion y Diversificacion Agropecuaria a traves del uso de especies forrajeras multipropositos: Caso Finca La Laguna, Yorito, Yoro”.


**Workshops/Conferences/Meetings (attendance by one or more staff of the Forage Project):**


Inception Meeting, Improving Livelihoods of Upland Farmers Using Participatory Approaches to Develop More Efficient Livestock Systems, 26 - 31 Jan. 2003, Hainan, China. ADB funded project convened by CIAT for 3 years.


Meeting of the Technical Committee of the Project of the BMZ project in Central America: Yoro and Tela, Honduras- 24- 29 March, 2003.


Programa Cooperativo Centroamericano para el Mejoramiento de Cultivos y Animales, La Ceiba, Honduras, April 2003.


International Workshop: Meeting of experts to develop database on forages (SoFT Project): University of Hohenheim, Germany - 4 to 8 August, 2003.


Partnerships with NARS, Universities, NGO's and Producer Associations:

Enhancing beef productivity, quality, safety and trade in central America (led by ILRI and funded by CFC): MAGA and ASOBRAHMAN, Guatemala; DICTA, FENAGH and SENASA, Honduras; MAG-FOR, IDR and FAGANIC, Nicaragua; CORFOGA, Costa Rica.

Livelihoods and Livestock Systems Project. Tropical Pasture Research Center (CATAS), Hainan, China; Dinas Peternakan, Samarinda and Directorate General of Livestock Services (DGLS), Jakarta, Indonesia; National Agriculture and Forestry Research Institute, NAFRI, Vientiane, Lao PDR; Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD), Los Baños, Philippines; Visayas State College of Agriculture (ViSCA) and Department of Agriculture, Region 10, Philippines; Department of Livestock Development, Ministry of Agriculture and Cooperatives, Bangkok, Thailand; National Institute of Animal Husbandry (NIAH), Ministry of Agriculture and Rural Development(MARD), Hanoi, Vietnam; National Animal Health and Production Investigation Centre, Department of Animal Health and Production, Phnom Peng, Cambodia.
Participatory evaluation improved forages in hillsides of Central America: DICTA, Honduras; INTA, and FONDEAGRO, Campos Verde, Nicaragua; MAG, Fundacion Ecotropica, Costa Rica; SERTEDESO, Honduras.

Potential utility of Mulato in intensive dairy systems in SE Asia: Papalotla and Participatory evaluation improved forages in Asia: Department of livestock development, Ministry of Agriculture, Bangkok, Thailand.


Validation and promotion of Brachiaria hybrid cv Mulato in LAC: CORPOICA, Colombia, IDIAP, Panama; MAG, Costa Rica; INTA and MAG-FOR, Nicaragua; and IDIAF, Dominican Republic, and Semillas Papalotla.


Partnerships with ARO’s:

CSIRO and QDPI, Australia and ILRI, Kenya: Development of a database and retrieval system for the selection of tropical forages for farming systems in the tropics and subtropics (SoFT).

ETH, Zurich, Switzerland: Adaptation of Brachiaria to low P and the forage potential of tanniniferous legumes.

Hokkaido University, Japan: Mechanisms of plant adaptation to acid soils.

New Zealand Ag Research, New Zealand: Endophytes in tropical grasses.

U of Goettingen, Germany: Genotypic variation in Arachis pintoi for tolerance to low phosphorus.

U of Hohenheim, Germany: Participatory evaluation of forages in hillsides of Central America; Evaluation of Cratylia argentea, Flemingia macrophylla and Desmodium velutinum.

University of Kentucky, USA, Dept of Plant Pathology, Identification of alkaloid profiles in endophyte-infected Brachiaria tissues as well as in pure cultures.

JIRCAS, Japan: Nitrification inhibition in tropical grasses.

Resource Mobilization

Proposals being funded or approved:

Accelerating the impacts of participatory research and extension on shifting cultivation farming systems in Lao PDR. Project between the Lao National Agriculture and Forestry Extension Service (NAFES) and Charles Sturt University, Australia with CIAT as a collaborating agency (no funds come directly to CIAT)- 4 year Project.
Adaptation of *Brachiaria* grasses to low P soils (with ETHZ): Donor: SDC- ZIL, Switzerland -- 3 years-- $US 231,000 -- ($US 47,000 for CIAT).

**Brachiaria Improvement Program:** Donor: Papalotla Seed Company, Mexico - 5 years. Contribution increased in 2003 from $US 211,000/year to US $ 326,000/ year).

Development of a database and retrieval system for the selection of tropical forages for farming systems in the tropics and subtropics, SoFT (with CSIRO, ILRI and QDPI): Donor: ACIAR- Australia, BMZ- Germany, DFID-UK --- 3 year project-- $AUS 837,000 (CIAT will receive $US 99,000).

Enhancing beef productivity, quality, safety and trade in central America: Donor: CFC- Lead Center ILRI—4 year project-- $US 3,500,000 (CIAT will receive $US 200,000/year for each of 4 years).

**Full time researcher funded by SDC** to be attached to CIAT working on livestock systems in uplands in Lao PDR (initially one year).

Genetic diversity and core collection approaches in the multipurpose shrub legumes *Flemingia macrophylla* and *Cratylia argentea*. (with the University of Hohenheim) Donors: Eiselen foundation, Ulm, Germany EUR 14800. -, University of Hohenheim ($US 8,000).

Improved diagnostic and control methodologies for major livestock diseases in Lao PDR. Project between the Lao department of Livestock and Fisheries (DLF) and the CSIRO Australian Animal Health Laboratory (AAHL) with CIAT as a collaborating agency (no funds come directly to CIAT)- 4 year Project.


**Introducción de forrajes mejorados en sistemas de producción de leche de pequeños productores en Matagalpa, Nicaragua:** Donor: FONDEAGRO, Nicaragua - 20 month project-- $US 110,000.

Perspectives of different cowpea (*Vigna unguiculata*) accessions in Honduran hillsides: potential and constraints in different farming systems and their assessment by farmers; stipend for MSc student C. Reiber. Donor: Eiselen foundation, Ulm, Germany.

**The forage potential of tanniniferous legumes: Search for sustainable ways to cope with nutritional limitations in smallholder Livestock Systems** (with ETH, ILRI and U Nacional de Colombia): Donor: SDC- ZIL, Switzerland -- 3 years-- $US 221,000 ---($US 30,000/year for CIAT).

**Validación de sistemas de cultivos con introducción de leguminosas como abonos verdes y coberturas sobre la sostenibilidad de sistemas de producción tradicionales en una microcuenca, San Dionisio, Nicaragua:** Donor: FUNICA, Nicaragua – 2 years – $US 10,000.

**The role of endophytes in tropical grasses:** Donor: The Government of Japan: $US 250,000/year (restricted core).
Research and development of multipurpose forage legumes for smallholders crop-livestock systems in the hillsides of Latin America (with the U of Hohenheim and CORPOICA): Donor: Volkswagen Foundation- Germany -- 3 years-- $US 85,000.

Proposals and CN submitted

Analysis of market opportunities for value-added forages and forage seed systems in Nicaragua. Donor: FAITAN, Nicaragua. Lead center: CIAT. One-year project. $US 64,800.


Livestock Systems in the northern uplands of Laos. Donor: SDC, Switzerland. Lead Center: CIAT (concept note to be submitted October 2003).

Market driven use of forages in fragile environments of Central America to improve livelihoods of smallholders (led by CIAT): Donor: BMZ, Germany -- 3 years--- $ EUR 1, 300,000.

Visits to donor agencies (one or more staff of the Project).

ACIAR, Australia: Regular liaison with ACIAR throughout the year to develop two new ACIAR funded project attached to the FLSP led by CIAT.

Asian Development Bank (ADB): Negotiation to launch a livestock development project in Laos, starting in 2006.

BMZ, BEAF, GTZ, Germany: Regular liaison, presentation of seminar on forage work.

Swiss Agency for Development Cooperation (SDC): Development of TOR for and SDC- funded CIAT staff in livestock systems in Laos and pursue the possibility of an SDC funded livestock R&D project in Laos starting in 2005.

Impact Monitored

LAC

Honduras: Now more than 400 farmers are employing various forage options, sown on about 180 ha, indicating a steady increase over time. The largest areas are planted to Brachiaria hybrid cv. Mulato (CIAT 36061) and B. brizantha cv. Toledo; increase in area for the latter is driven by seed multiplication through the farmer- led seed enterprise PRASEFOR or purchase from commercial seed producers.

Nicaragua: Uptake of new forage options by farmers has gained speed, with now more than 150 farmers testing and employing different forage options. Preferred species are B. brizantha CIAT
26110 (cv. Toledo) and *Brachiaria* hybrid cv. Mulato. There is growing interest in testing *Calliandra calothyrsus* as fuel wood.

**Sales/planting of Brachiaria hybrid cv Mulato:** As a result of a vigorous promotion by Papalotla and partners the sales of seed of cv Mulato during 2003 are in the order of 60 tons, which is enough to plant 15,000 ha. The distribution of sales per country is show bellow:

<table>
<thead>
<tr>
<th>Country</th>
<th>Seed Sold (kg)</th>
<th>Planted Area (estimated) (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colombia</td>
<td>9,800</td>
<td>2,450</td>
</tr>
<tr>
<td>Costa Rica</td>
<td>1,400</td>
<td>350</td>
</tr>
<tr>
<td>Ecuador</td>
<td>2,500</td>
<td>625</td>
</tr>
<tr>
<td>Florida, US</td>
<td>2,222</td>
<td>555</td>
</tr>
<tr>
<td>Guatemala</td>
<td>4,660</td>
<td>1,165</td>
</tr>
<tr>
<td>Honduras</td>
<td>8,000</td>
<td>2,000</td>
</tr>
<tr>
<td>Mexico</td>
<td>20,000</td>
<td>5,000</td>
</tr>
<tr>
<td>Nicaragua</td>
<td>1,700</td>
<td>425</td>
</tr>
<tr>
<td>Panama</td>
<td>10,000</td>
<td>2,500</td>
</tr>
</tbody>
</table>

1 Source: Papalotla (Period: January 1- October 15, 2003)  
2 Assumes all seed planted at a rate of 4 kg/ha

**South East Asia**

**Laos:** The main activities of the FLSP this year in Laos have been to consolidate impacts - by identifying and documenting case studies and developing methods to use these cases to fuel extension. As a result of the work done by district, provincial and national staff during the second field season (June-October 2002), the total number of farmers planting forages increased from 247 in 2001, to 467 in 2002. By comparison, at the start of the third field season (June 2003), the total number of farmers planting forages had increased from 467 in 2002 to 803. This is almost a 4 fold increase in 3 years of the number of farmers that have adopted improved forages. The major effects on livestock systems and livelihoods of farmers adopting forages are:

1. **Forages change the dynamics of livestock systems:** In many areas where we work, farmers have traditionally kept livestock as an additional activity to cropping. They are a safety net, a bank. They were often let loose in the forests and grazing lands, with little management. Now, however, these grazing lands are becoming over-utilized. We are seeing that planted forages are allowing farmers, for the very first time, to start moving into livestock production as a livelihood systems not just as livelihood security. That is, they can start cranking up their livestock production to produce cash for buying staple foods rather than expending huge amounts of labor to grow these staple foods.

2. **Freeing up labor is a major impact of forages:** Many of the farmers we work with are keeping their families fed. In many cases they spend 2-4 hours per day looking for cut feed for their animals. Planting forages can reduce this time to less than one hour per day. Freeing up labor is a key factor in allowing farmers the 'breathing space' to start developing alternatives to their current farming systems in the steep uplands.

Annex

List of Publications

Refereed Journal (published, in press and submitted):


Muhr, L., Tarawali, S.A., Peters, M. and Schultzze-Kraft, R. 2002 Soil mineral N dynamics and maize grain yields following *Centrosema macrocarpum* and *Stylosanthes guianensis*: effects of different improved fallow notations and varying levels of fertilizer to maize. Field Crops Research, 78(2-2), 197-209.


**Conference and Workshop Proceedings:**


levante. Presentation PCCMCA, La Ceiba, Honduras, April 2003.


Rivas, L. and F. Holmann. 2003. Sistemas de doble propósito y su viabilidad en el contexto de los pequeños y medianos productores en América Latina Tropical. Paper presented at the electronic conference “Sistemas pecuarios diversificados para el alivio de la pobreza rural en América Latina” organized by the Food and Agriculture Organization (FAO), Livestock and the Environment for Agricultural Development (LEAD), and CATIE.


Working Documents and Technical Bulletins:


Invited Book Chapters (published or in press):


Books and Monographs  (published or in press):


Other Publications

