Tropical Grasses and Legumes:

Optimizing genetic diversity for multipurpose use

Summary Annual Report 2003

Project IP-5

CIAT
Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture

SUMMARY
ANNUAL REPORT
2003

PROJECT IP-5
Tropical Grasses and Legumes: Optimizing genetic diversity for multipurpose use

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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**

Narrative Summary	Measurable Indicators	Means of Verification	Important Assumptions
Goal 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	• Range of genetic variation in desirable plant traits • 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 tropicis 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

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

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

María Mesén, MAG, Costa Rica; Bustamante Julio, ECOTRÓPICA, Costa Rica; Burgos Conrado, DICTA, Honduras; Uebelhor Konrad, Leitz Jochen, Muller Peter, gtz, Honduras; Ibrahim Muhammad, CATIE, Costa Rica; Posas Marlen Iveth, SERTEDESO, Honduras; Mena Martin, INTA, Nicaragua; Schultze-Kraft Rainer, University of Hohenheim, Germany; Hoffmann Volker, University of Hohenheim, Germany; Kexian, CATAS, Hainan, China; Le Hoa Binh, NIAH, Vietnam; Ed Magboo, PCARRD, Philippines; Ibrahim and Yakob Pangendongan, Dinas Peternakan Samarinda, Indonesia; Chaisang Phaikaew and Ganda Nakamanee, DLD, Thailand; Viengsavanh Phimphachanhvongsod and Bounthavong Kounnavongsa, NAFRI, Laos; Viengxay Photakoun NAFES, Laos; Sorn San, NAHPIC, Cambodia; Eduardo Stern, Papalotla, Mexico

Financial Resources

Source	Amount (US Dollars)	Proportion (%)
Unrestricted Core	248,590	13
Restricted Core	522,597	27
Carry Over from 2002	25,480	1
Sub –Total	796,667	41
Special Projects	1,128,640	59
Total Project	1,925,307	100

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 permatins 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 pI) 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 m^2 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

TRAINING EVENT	TIMING	LOCATION	PARTICIPANTS
Workshop to develop cross visit methodology	08-13 December 2002	Luang Phabang	20
Workshop to develop cross visit methodology	16-19 December 2002	Xieng Khouang	13
Workshop to review case studies of impacts	13-14 January 2003	Vientiane	8
Training workshop on Cross Visit and Case Study Methods	10-14 February	Luang Phabang	27
Staff Cross visit to another participatory R&D project	16-20 February 2003	Sayaboury	27
Village planning workshop methodology	25-29 March 2003	Luang Phabang	20
Village planning workshop methodology	31 March – 02 April 2003	Xieng Khouang	13
Technical training workshop	01-03 May 2003	Luang Phabang	23
Technical training workshop	05-08 May 2003	Xieng Khouang	17
Adoption of Participatory Approaches by Institutions	14-16 August 2003	Vientiane	19
Cross visit to Forage Sites in Tuyen Quang, Vietnam	18-23 August 2003	Vietnam	19
Development of whole village case studies of impacts	08-12 September 2003	Luang Phabang	23
Development of whole village case studies of impacts	15-19 September 2003	Xieng Khouang	20

LAC

Event	Timing	Country/Location
Diffusion of Cratylia		
• Field day- La Isla farm	March 28	Colombia/Villavicencio
• Meeting to form a Cratylia network in Colombia	May 8 and 9 May 16	Colombia/Villavicencio Colombia/ Casanare
• Conference: Establishment and management of Cratylia	May 28 and 29	Colombia/Villavicencio
• Conference: The role of legumes in cattle production: Cratylia	May 30	Colombia/Villavicencio
• Conference: Different uses of Cratylia • Conference: Grass and legume species for the Llanos piedmont	June 7	Colombia/Granada
Presentation of technical information on *Brachiaria* hybrid cv Mulato	June 17 and 18	Colombia/ Puerto Lopez and Monteria
Workshop: Advances in the *Brachiaria* improvement program: CORPOICA- Turipana	May 22 to 23	Colombia/ Monteria
Workshop: Advances in the development and management of new forage options for the llanos of Colombia: CORPOICA- La Libertad	June 16 to 20	Colombia/ Villavicencio
Curso Nacional de Forrajes	October 2-3	Colombia/ Medellin
Annual planning meeting of the CFC project on beef cattle led by ILRI	July 7 and 9	Costa Rica/San José
Annual meeting of the Technical Committee of the BMZ Project on participatory evaluation of forages in CA	March 27-29	Honduras/Yoro and Tela
Training course “Farmer seed production” – FONDEAGRO	March 16- 22	Honduras
Training course “Participatory monitoring and evaluation” – FONDEAGRO	February 24 -27	Nicaragua
Improved forages – field day in San Dionisio for milk farmer associations from Chontales	March 10-11	Nicaragua
Training course “Pasture Management” – FONDEAGRO	April 28-30	Nicaragua
Field day for technicians of EU projects in Nicaragua	May 20	Nicaragua
Training course “CIAT’s new forage options” – FONDEAGRO	May 30	Nicaragua
Brachiaria hybrid “Mulato”- field days (4)	June 25, 26, 27 and July 1	Nicaragua/Managua, Matiguas, Santo Tomas, Chinandega
Presentation of *Brachiaria* hybrid cv Mulato Conference: Utilization of Brachiaria cv Mulato	May 9	Panama/David
Presentation of *Brachiaria* hybrid cv Mulato in the Annual Livestock and Agriculture Exhibition of Central American countries	June 12-14 May 21	Panama/David Guatemala/ Guatemala City
Presentation of *Brachiaria* hybrid cv Mulato	July31- August 15	Mexico/Tampico, Villahermosa, Acayucan, Tuxtla Gutierrez, Morelia and Torreon

Thesis Students

BS thesis students:

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

Chavez Quiroz, Carlos A. Calidad y consumo de mezclas de *Cratylia argentea* y sorgo forrajero con y sin melaza ensiladas en bolsas plásticas. Universidad de Costa Rica. Facultad de Ciencias Agropecuarias. Escuela de Zootecnia (in progress)

Fores, Zenelia – "Determinación del potencial de la carga animal en los potreros establecidos con pastos *Brachiaria* en asociación con *Arachis pintoi* en la comunidad Wibuse, San Dionisio, Nicaragua". Universidad Nacional Autonoma de Nicaragua – UNAN CUR Matagalpa, Nicaragua, 2003 (finishes Dec 2003).

López, Erwin and Alejandro Vargas. 2003 – "Evaluación de los métodos de alimentación de ganado bovino utilizados por los productores del municipio de San Dionisio en la época seca" Universidad Nacional Autonoma de Nicaragua – UNAN CUR Matagalpa, Nicaragua, (completed).

Mera, Mónica Lorena. Efecto de reducción de taninos en leguminosas forrajeras tropicales en producción de metano en un sistema de fermentación in vitro. Universidad Nacional de Colombia, Facultad de Ciencias Agropecuarias-Zootecnia (in progress).

Monsalve C., Lina Maria. 2002. Suplementación de una gramínea tropical con leguminosas y *Sapindus saponaria*: Efecto sobre la fermentación ruminal y la metanogénesis in vitro. Universidad de Santa Rosa de Cabal, Facultad de Zootecnia, Pereira, Colombia. p. 93.

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

Ramón Iván Bertrand – "Estudio sobre alimentación de ganado doble propósito en época de verano en comunidades aledañas al municipio de Somoto, Madriz – Nicaragua". Universidad Católica Agropecuaria del Trópico Seco, Esteli, Nicaragua, (finishes Feb 2004).

Sotelo, Paola. "Efectos subletales de antibiosis de genotipos de *Brachiaria* en adultos de *Aeneolamia varia*. Universidad del Valle, Facultad de Ciencia. (ends August 2004).

MS Thesis students:

Abreu S., Andrés. 2003. Utilización del fruto de *Sapindus saponaria* como fuente de saponinas para reducir la metanogénesis y mejorar la utilización del alimento en rumiantes con dietas tropicales. Universidad Nacional de Colombia, Facultad de Medicina Veterinaria, Postgrado- Linea de Nutición Animal. 114p (completed).

Arango, Adriana. 2003. Identification of candidate genes for aluminum resistance in *Brachiaria*. Universidad Nacional de Colombia (in progress).

Castro, Ulises. Mecanismos de resistencia de *Brachiaria* spp. a tres especies Mexicanas de salivazo. Colegio de Postgraduados, Chapingo, Mexico. (started in January, 2003).

Genio-Samson, J.N., 2002. Participatory interactive research on the evaluation of soil conservation options in San Migara, Malitbog, Bukidnon, Philippines. University of the Philippines Los Banos, Los Baños (completed).

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.)

Phengsavanh, Phonepaseuth. 2003. Effects of *Stylosanthes guianensis* CIAT 184 as a supplement in the diet of growing goats in smallholder farming systems in Lao PDR. SLU, Uppsala, Sweeden (in revision).

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.)

Valencia, Francis Liliana. 2004. Determinación del efecto de la calidad de la dieta en relación con la presencia de taninos y emisiones de metano en un sistema in vitro. Universidad Nacional de Colombia, Postgrado Ciencias Agrarias con énfasis en Producción Animal (in preparation).

Vivas, Nelson. 2004. Evaluación agronómica de 144 accessiones de *Desmodium velutinum* como alternativa forrajera para las zonas de ladera del norte del departamento de Cauca, Universidad Nacional, Palmira (in progress).

Ph.D. Thesis Students:

Andersson Meike Stephanie. 2004. Genetic diversity and core collection approaches in the multipurpose shrub legumes *Flemingia macrophylla* and *Cratylia argentea.* University of Hohenheim, Germany (in preparation).

Castañeda, Nelson. 2004. Genotypic variation in phosphorus acquisition and utilization in *A. pintoi*. University of Goettingen, Germany (in progress).

Dongyi, Huang. 2003. Fungal endophytes in tropical forage grass *Brachiaria*, South China University of Tropical Agriculture, Department of Genetics and breeding for crops. Completed and degree awarded in 2003.

Hernández, Luis Alfredo. 2005. A participatory procedure applied to selection and development of forages with farmers (*PPSF)* University of Hohenheim, Germany (in progress).

O'Brien, Rachel. 2004. Incorporating socio-economic data and expert knowledge in complex spatial decision-making. Curtin University, Australia, (in preparation).

Rincón, Alvaro. 2005. Integration of maize with forages to recuperate degraded pastures in the Llanos of Colombia. Universidad Nacional de Colombia (in progress).

Tscherning, Karen Joanna. 2004. Development of methods for the simultaneous evaluation of forage legume for feed and for soil improvement. University of Hohenheim, Germany (in preparation).

Van der Hoek, Rein. 2004. Participatory research methods for forage- based technologies in Central-American hillsides. Thesis University of Hohenheim, Germany (in preparation).

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".

Fory, P. Sotelo, G., Cardona, C. Second best paper presented by a student in the XXIX Congreso Sociedad Colombiana de Entomología, 2002.

Sotelo, G., Cardona, C., Miles, J.: Honor Mention, Premio Hernán Alcaraz Viecco to the best paper presented by a professional in the XXIX Congreso Sociedad Colombiana de Entomología, 2002.

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

Planning Meeting for the HAP Project in Haiti: Port au Prince- 19 to 24 January, 2003.

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.

Second Nicaraguan Milk Congress, Rivas, Nicaragua – 7th-9th February, 2003.

Planning workshop for site selection for the DFID funded project. "Enhancing livelihoods of poor livestock keepers through increasing use of fodder", IITA, Ibadan, Nigeria, 26 - 28 February, 2003.

Workshop on biodiversity and production chains, GTZ, Managua, Nicaragua – 17-19th of March, 2003.

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

II Feria de Tecnologia productiva y Alimentos alternativos, San Dionisio, Nicaragua – 4th of April, 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): ILRI, Addis Ababa- 19-21 May, 2003.

Regional workshop on proposal writing (organized by CIAT). Esteli, Nicaragua - 9-12th of June, 2003.

Systemwide Program on Participatory Research and Gender Analysis (PRGA) Stakeholders Meeting, Cali, 30 June – 01 July, 2003.

National Workshop on Extension Methodologies: CIAT's experiences with methodologies for scaling out from locally successful impacts. National Agriculture and Forestry Extension, Vientiane- July 24, 2003.

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

American Phytopathological Society Annual Meeting Charlotte, North Carolina, USA 9-13 August, 2003.

Retreat for the Enabling Rural Innovations (ERI) program, Kampala, Uganda, 25-30 August 2003.

International Workshop: Meeting of experts to develop database on forages (Soft Project): CIAT-Palmira 25 - 28 August, 2003.

Workshop "Encuentro nacional silvopastoril – La forestería para la reconversión de la ganadería", Rivas, Nicaragua - 1-2nd of September, 2003.

III Regional conference on seeds, Jinotepe, Nicaragua – 12-13th of September, 2003.

The Second National Review Workshop on Food and Forage Legumes, Addis Ababa, Ethiopia -22-26 September 2003.

Deutscher Tropentag 'Technological and Institutional Innovations for Sustainable Rural Development' Göttingen - 8th to 10th October, 2003.

Meeting of representatives of centers (LPG) in the System Wide Livestock Group (SLP), Nairobi, Kenya - November 1- 2, 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.

Potential utility of Mulato in smallholder livestock systems of northern Laos: Papalotla and Forages and Livestock Systems Project: NAFRI, Laos.

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.

Validation and promotion of *Brachiaria* hybrid cv Mulato seed production in SE Asia. The Pakchong Animal Nutrition Research Center in Thailand, The Khonkaen Nutrition Research Center, Thailand 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.

Improving Livelihoods of Upland Farmers Using Participatory Approaches to Develop More Efficient Livestock Systems: Cambodia, China, Indonesia, Laos, Philippines, Thailand and Vietnam; Asian Development Bank, 1 Jan 2003 – 31 Dec 2005.

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.

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

Genetic Exploitation of Nitrification Inhibition in Crops and Pastures – A Novel Strategy to Minimize Nitrate Leaching and Nitrous Oxide Emissions from Agricultural Systems. Donor: New Energy and Industrial Technology Development Organization (NEDO), Japan. 3 years Project. 90 million Japanese Yens.

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:

Country	Seed Sold [1] (kg)	Planted Area (estimated) [2] (ha)
Colombia	9,800	2,450
Costa Rica	1,400	350
Ecuador	2,500	625
Florida, US	2,222	555
Guatemala	4,660	1,165
Honduras	8,000	2,000
Mexico	20,000	5,000
Nicaragua	1,700	425
Panama	10,000	2,500

[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.

Philippines and Vietnam: The documentation of impact of the forage work in the Philippines and Vietnam was published in: Bosma, R.H., Roothaert, R.L., Asis, P., Saguinhon, J., Binh, L.H., Yen, V.H., 2003. Financial and social benefits of new forage technologies in Mindanao, Philippines and Tuyen Quang, Vietnam. CIAT Working Document No. 191. Centro Internacional de Agricultura Tropical, Los Baños, Philippines, pp. 92.

Annex

List of Publications

Refereed Journal (published, in press and submitted):

Barahona Rolando, Lascano Carlos E., Narvaez Nelmy, Owen Emir, Morris Phillip and Theodorou mike. 2003. In vitro degradability of mature and immature leaves of tropical forage legumes differing in condensed tannin and non-starch polysaccharide content and composition. Journal of the Science and Food and Agriculture 83:1256-1266.

Begum, H. H., M. Osaki, M. Nanamori, T. Watanabe, T. Shinano and I. M. Rao. 2003. Role of phosphoenolpyruvate carboxylase in the adaptation of a tropical forage grass, *Brachiaria* hybrid, to low phosphorus acid soils. Journal of Plant Nutrition (in review).

Cardona, C., P. Fory, G. Sotelo, A. Pabon, G. Díaz and J. W. Miles. 2003. Antibiosis and tolerance to five species of spittlebug (Homoptera: Cercopidae) in *Brachiaria* spp.: Implications for breeding for resistance. J. Econ. Entomol. (accepted with minor revisions September 25, 2003).

Chakraborty, S., Ghosh, R., Mukherjee, M., Fernandes, C. D., Charchar, M. J. and Kelemu, S**.** 2003. A comparison of artificial neural network and multiple regression analysis for weather-based prediction of anthracnose. (submitted).

Hess, H.D., Kreuzer, M., Nösberger, J., Wenk, C., Lascano, C.E., 2002. Effect of sward attributes on legume selection by oesophageal-fistulated and non-fistulated steers grazing a tropical grass-legume pasture. Tropical Grasslands 36:227-238.

Hess, H.D., M. Kreuzer, T.E. Díaz, C.E. Lascano, J.E. Carulla, C.R. Soliva and Andrea Machmüller. (2003). Saponin rich tropical fruits affect fermentation and methanogenesis in faunated and defaunated rumen fluid. Animal Feed Science and Technology, 109:79-94.

Hess, H.D., Monsalve, L.M., Lascano, C.E., Carulla, J.E., Díaz, T.E. and M. Kreuzer. 2003. Supplementation of a tropical grass diet with forage legumes and *Sapindus saponaria* fruits: effects on in vitro ruminal nitrogen turnover and methanogenesis. Australian Journal of Agricultural Research, 54:703-713.

Holmann, F., C. Lascano, and C. Plazas. 2002. Evaluación ex-ante de *Cratylia argentea* en sistemas de producción de doble propósito en el Piedemonte de los Llanos Orientales de Colombia. Pasturas Tropicales Vol. 24(2)2-11.

Holmann, F., L. Rivas, J. Carulla, L. Giraldo, S. Guzman, M. Martinez, B. Rivera, A. Medina, and A. Farrow. 2003 Evolution of Milk Production Systems in Tropical Latin America and its interrelationship with Markets: An Analysis of the Colombian Case. Journal of Livestock Research for Rural Development (15)9:2003.http://www.utafoundation.org/lrrd159/holm159.htm

Kelemu, S. and Dongyi, H. 2003. Endophytic fungus *Acremonium implicatum* is seed transmitted in *Brachiaria* spp. (Abstract). Phytopathology 93:S43.

Kelemu, S., Dongyi, H., Guixiu, H. and Takayama, Y. 2003. Detecting and differentiating *Acremonium implicatum*: developing a PCR-based method for an endophytic fungus associated with the genus *Brachiaria*. Molecular Plant Pathology 4(2): 115-118.

Kelemu, S., Mahuku, G.**,** Fregene, M., Pachico, D., Johnson, N., Calvert, L., Rao, I., Buruchara, R., Amede, T., Kimani, P., Kirkby, P., Kaaria, S., and Ampofo, K. 2003. Harmonizing the agricultural biotechnology debate for the benefit of African farmers. African Biotechnology Journal (submitted).

Lascano, C., P. Avila and J. Stewart. 2003. Intake, digestibility and nitrogen utilization by sheep fed with provenances of *Calliandra calothyrsus* Meissner with different tannin structure. Archivos Latinoamericanos Producción Animal, Vol. 11(1): 1-8.

Muhr, L., Tarawali, S.A., Peters, M. and Schultze-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.

Nanamori, M., T. Shinano, T. Yamamura, I. M. Rao and M. Osaki. 2003. Low phosphorus tolerance mechanisms: Phosphorus recycling and photosynthate partitioning in tropical forage grass, *Brachiaria* hybrid cultivar Mulato compared with rice. Plant Physiology (in review).

O'Brien, R., Peters, M., Schmidt, A., Cook, S. and Corner, R. (2003) Helping farmers select forage species in Central America: the case for a decision support system. Agricultural Systems.(Submitted)

Peters, M. and Lascano, C.E. 2003 Linking On-Station Research with Participatory Approaches: Forage Development as the Pathway to Forage Technology Adoption. Tropical Grasslands (In Press).

Peters, M., Lascano, C.E., Roothaert, R. and de Haan, N.C. 2003 Linking research on forage germplasm to farmers - the way to increased adoption. A CIAT, ILRI and IITA perspective. Field Crops Research. (In Press**)**

Pinzón, B. R.; Montenegro, R. y Argel, P. 2002. Evaluación agronómica de especies poco conocidas de *Leucaena.* Ciencia Agropecuaria (Panamá). No. 12, 165-176.

Roothaert, R., Franzel, S., and Kiura, M., 2003. On-farm evaluation of fodder trees and shrubs preferred by farmers in central Kenya. Experimental Agriculture. 39.

Watanabe, T., M. Osaki, H. Yano and I. M. Rao. 2003. Internal mechanisms of plant adaptation to aluminum toxicity and phosphorus starvation in three tropical forages. New Phytologist (in review).

Weeds, P.L., Chakraborty, S., Fernandes, C.D., Charchar, M. J. d'A., Ramesh, C.R., Kexian, Y. and Kelemu, S. 2003. Genetic Diversity in *Colletotrichum gloeosporioides* from *Stylosanthes* spp. at centers of origin and utilization. Phytopathology 93:176-185.

Wenzl, P., L. I. Mancilla, J. E. Mayer, R. Albert and I. M. Rao. 2003. Simulating infertile acid soils with nutrient solutions and the effects on *Brachiaria* species. Soil Sci. Soc. Am. J. 67: 1457-1469.

Wünscher, T., Schultze-Kraft, R., Peters, M. and Rivas, L. 2003. Early adoption of the tropical forage legume *Arachis pintoi* in Huetar Norte, Costa Rica. Experimental Agriculture (In Press)

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