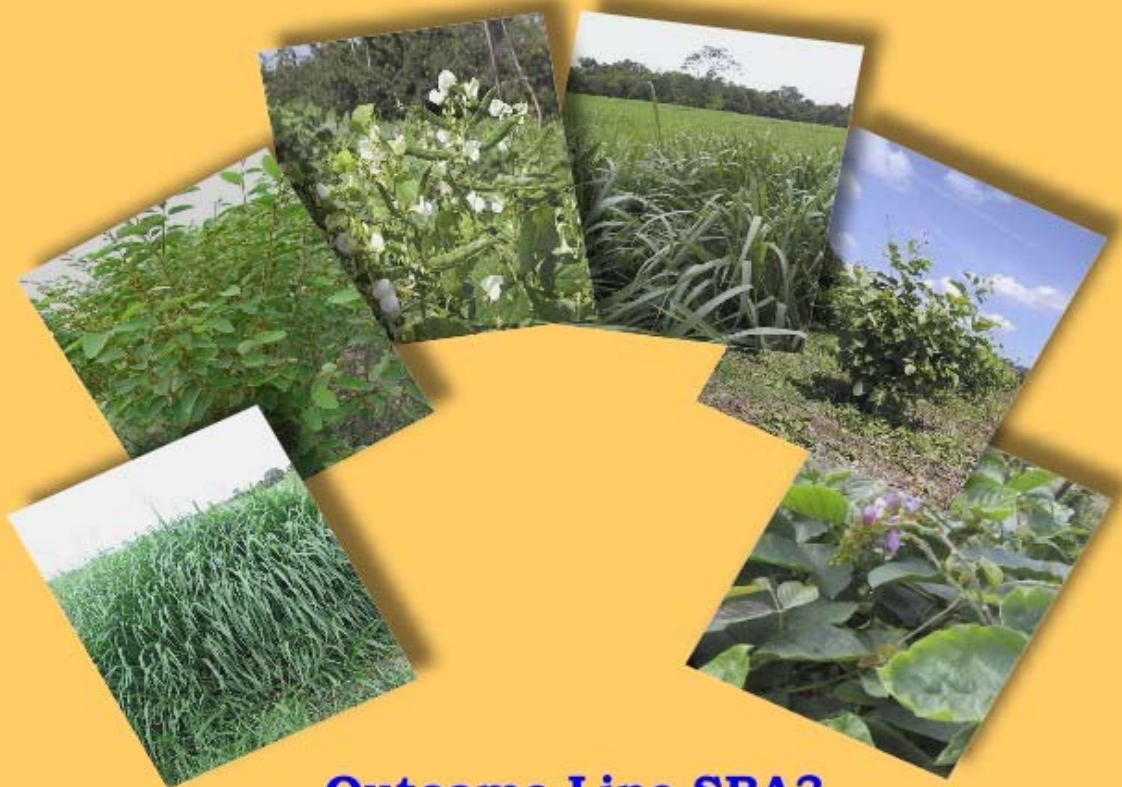


# Improved Multipurpose Forages for the Developing World

Summary  
Annual Report  
2007



Outcome Line SBA3

**SUMMARY  
ANNUAL REPORT  
2007**

**Improved Multipurpose Forages for  
the Developing World**

**Outcome Line SBA3**

**Before**

**CIAT Project IP5: Tropical Grasses and Legumes: Optimizing  
Genetic Diversity for Multipurpose Use**



# Improved Multipurpose Forages for the Developing World

## Product Line SBA3

### Before

#### CIAT Project IP5: Tropical Grasses and Legumes: Optimizing Genetic Diversity for Multipurpose Use

#### 1. Narrative Product Line Description

##### *Rationale & Changes*

##### **Rationale**

Livestock development is recognized as a key element for increasing the income of poor smallholders given the increased demand for animal products that is being experienced in developing countries. Recent analysis indicates evolving market opportunities for forages as prices for alternative, mostly grain-based feeds are increasing and consumers request higher quality products. However, a high proportion of smallholder crop/livestock systems are located in areas with prolonged dry seasons and with land in different stages of degradation, which leads to an inadequate supply of high quality feed for livestock throughout the year. In addition, in many cases smallholders with livestock and limited land (i.e., Southeast Asia) do not have easy access to fodder and have to walk long distances to harvest forages. On the other hand forages are one of the few opportunities available to a large number of smallholder farmers to produce high value or added value products, due to the fact that forages can be cultivated not only under favorable conditions but also in marginal environments. Improved forages could play a key role in maintaining and improving agricultural productivity through their effects on soil fertility, restoring degraded lands, reducing deforestation and mitigating the effects of climate change. Thus, development and expansion of high yielding and high quality forages, particularly at the livestock – crop interface can enable smallholders to be more competitive, with positive effects on poverty alleviation; improved food security and related effects on health are an additional benefit. At the same time forages contribute to nutrient cycling via animal manure, resource conservation and reversing land degradation, with an additional potential in the area of environmental services (e.g., carbon sequestration, biological nitrification inhibition).

To address the issues of scarcity of feed resources for livestock encountered by small producers and to capture emerging opportunities, the research portfolio of CIAT includes the Product Line entitled ‘Multipurpose Forages for Improving Livelihoods of Smallholder Farmers’ which is housed in the Sharing the Benefits of Agrobiodiversity Research for Development Challenge Program. The goal of the work on forages is to conserve and exploit the genetic diversity – either through breeding or natural variation - of tropical grasses and legumes to improve the livelihoods of poor rural livestock producers through linkages to traditional and emerging markets and to contribute to greater access of poor urban consumers to high quality animal products that are safe, while taking advantage of the potential of forages to enhance natural resource base and provide environmental services.

To accomplish the objectives of the Forage Product Line, the research is organized around three major outcomes: 1) Improved *Brachiaria* grasses, 2) Forages as and for high value products developed to capture differentiated markets for smallholders, and 3) Benefits of multipurpose

grasses and legumes realized in crop/livestock systems through adaptation, innovation and adoption.

Partnerships are formed with private seed industry, ARIs, universities and NARS to carry out strategic research to: breed *Brachiaria* hybrids; develop screening methods based on improved knowledge of mechanisms of adaptation of forage species to biotic and abiotic stresses; develop targeting, processing and evaluation techniques and employ operational research principles to define forages for specific production and market niches; and develop improved crop/livestock and feeding systems using an innovation approach .

As an activity across products to target and deliver our research products we form partnerships with different groups to define environmental and market niches, document on-farm performance of released grass and legume cultivars, and quantify the impact of selected forages in improving livelihoods and protecting the environment.

Capacity building remains an important component of our agenda, to improve: a) our research capacity through pre- and post-graduate research and strengthening/benefiting from the research capacity of partners, and b) our capacity to deliver research products in different environments. Capacity building includes group and individual training and activities in the area of knowledge management.

### **CG System Priorities**

Among the CGIAR Research Priorities (2005-2015), livestock is recognized as being crucial to improve the livelihoods of many poor rural and peri-urban farmers in tropical regions. It is recognized, however, that for poor farmers to capitalize on evolving commodity markets, there is a need to improve the availability of improved feed resources in areas of both low and high potential. This implies the challenge of developing forages capable of producing high quality biomass to feed ruminant animals in environments characterized by having pest and disease pressures, low fertility soils, long dry seasons and/or poorly drained soils. Development of forage-based feeding systems for monogastric animals to complement existing home-grown feed resources and replace expensive commercial concentrates is also seen as an important research product to assure improved productivity and competitiveness of swine, poultry and fish in smallholder systems.

To address the priorities of the CGIAR on livestock, the Forage Product Line of CIAT has the global mandate of developing forage-based technologies suitable for extensive and intensive crop/livestock systems in contrasting environments. Selected forages are expected to perform well in infertile soils and to contribute to reduce seasonal variation in both feed quality and quantity and as a result reduce livestock mortality and increase productivity. In addition, grasses and legumes with broad adaptation to soils and climate in sub-humid and humid environments can contribute to better use of family labor (especially women) and to recuperate degraded soil/pastures in pastoral and crop/livestock systems through the enhanced capacity of grasses with deep root systems to improve physical structure of soils and of legumes to improve soil fertility through their contribution via biological N<sub>2</sub> fixation. Furthermore, improved forages contribute to a) soil improvement through improved soil organic matter quality thereby enhancing soil biological activity and below-ground biodiversity and b) nutrient cycling via improved manure quality thereby increasing productivity of subsequent crops.

The benefits of multipurpose forages are captured by forming strong research linkages with the Research for Development Challenge (RDC) dealing with People and Agroecosystems, and with TSBF (Tropical Soil Biology and Fertility) Institute of CIAT. These strong internal linkages

together with external partnerships will contribute to better targeting of research products to environments and clients thus facilitating improved and more equitable linkages of farmers to markets.

Specific activities carried out by the Forage Product Line to contribute to the CGIAR System Priorities (SP) are:

- Characterization of the genetic diversity in legume collections from the Gene Bank of CIAT, other CG Centers and research institutions to select new alternatives with superior forage quality, yield and resistance to biotic and abiotic stress factors (SP 1b, 2b, 3b);
- Development of methodologies for screening forages for quality and for major abiotic and biotic constraints (SP 2b);
- Breeding to develop superior grasses (*Brachiaria*) that combine quality attributes with adaptation to major abiotic and biotic constraints (SP 2b, 2c, 2d, 3b);
- Development of molecular map of *Brachiaria* and discovery of genes associated with adaptation to abiotic stresses (SP 2b, 2d, 3b).
- Development of methods for evaluating forages in different production systems with farmer participation ( SP 5b);
- Development of Data Bases and Decision Support Tools to help target forages to different environments and production systems (SP 5a);
- Income generation from livestock through improved forages for feeding ruminants and monogastric animals and improved equity in value chains (SP 3b, also 2c and 5b, and spillover effects on 3c);
- Analysis of trade-offs between use of legumes for soil enhancement or as animal feed resource on crop/livestock productivity and environmental quality (SP 4b); and
- Capacity building consisting of individuals for short term and long term training, group training and knowledge management (SP 5a)

### **Changes**

To capture emerging market and research opportunities targeted to smallholder farmers CIAT has refocused its forage research into the Forage Product Line entitled ‘Multipurpose Forages for Improving Livelihoods of Smallholder Farmers’. As reflected in the attached logframe this is an evolutionary change building on past experiences and competencies while responding to a changing external context. The products and outcomes described in the former Mega Project entitled ‘Tropical Grasses and Legumes: Optimizing Genetic Diversity for Multipurpose Use’ presented in the MTP 2007 - 2009 are maintained. However, they are reorganized under the newly defined products; products and outcomes from 2010 onwards will follow the new product line structure. The most significant change is the inclusion of targeting and delivery of research products, as integral parts across the new products and more concretely addressing emerging market opportunities for forage-based high value and added value products. To achieve the more focused targeting and delivery of research results, research work will integrate more strongly with the ‘People and Agroecosystems’ RDC and emphasize current and new partnerships with the private sector and NGOs.

Following on changes in the last MTP (2007-2009) more emphasis is placed on livestock other than cattle (such as monogastrics), stronger market orientation addressing the demand for higher value products and other kinds of benefits (such as freeing up labor) that improve poor farmers’ welfare.

With these changes in objectives we will contribute more effectively to income generation and the improvement of livelihoods of poor rural communities that depend on livestock and also to improve access to safe, high quality animal products for poor urban consumers.

The annual budget of the Forage-related work in CIAT has again been cut substantially in 2007. However, with the refocused strategy it is hoped that new funding opportunities can be realized and that through synergies with other CIAT research areas and strengthening partnerships most of the negative effects of the cut can be mitigated. The joint appointment with ILRI on forages for Eastern and Southern Africa has not been renewed. However, as a high priority together with ILRI we are elaborating a research and funding strategy: limited donor funded work in Rwanda is supervised jointly by ILRI and CIAT. This strategy will rely on close collaboration with TSBF Institute and the People and Agroecosystems RDC to integrate forages into production systems and to realize their economic and environmental benefits.

With the departure of our experienced animal nutritionist we are phasing out work on antinutritional factors as a separate strategic research area. However, we were able to secure external funding to contract a junior career animal nutritionist with an initial research emphasis on forages for monogastric animals, contributing to study on trade-offs in the use of forages between feed resource and soil improvement and continuing to support the *Brachiaria* breeding program; delays on delivering our donor commitment on research on the trade-offs between use of forages as feed or green manure have been addressed in a revised research plan which has been consolidated with partners. Stronger linkage with partners in Australia, Laos and Colombia and the People and Agroecosystems RDC within CIAT have allowed us to maintain the research focus on forages for monogastrics but additional partners and funding have been sought through additional proposals for donors. The loss of our in-house capacity in statistical analysis is a concern.

Stability of core resources at the current level will be needed to deliver the products stated in this document and additional resources to expand our contribution to forage-related work in Sub-Saharan Africa.

### **Impact Pathways**

To contribute to the improvement of livelihoods of poor rural livestock owners through high quality forages (outcome 1 and 2) adapted to major biotic and abiotic constraints, forage researchers rely on natural genetic diversity from core germplasm collections housed in the Genetic Resources Unit of CIAT and other international and national centers. Artificial hybridization to create novel genetic variation is used when major limitations in successful commercial cultivars have been identified and where evaluation of large germplasm collections has failed to identify the required character combinations (e.g., spittlebug resistance and acid soil tolerance in *Brachiaria*). Screening methods and selected genotypes with superior forage quality, with resistance to major pests and diseases and with adaptation to acid, low fertility soils, to poorly drained soils and to drought are the product targets to be used by different partners engaged in research and development activities. To improve the efficiency of partners to better target forages to diverse environments, production systems and market niches, the forage team collaborates with the RDC on People and Agroecosystems to develop methods of participatory evaluation of forages, decision support tools and more effective and equitable market interactions. Selected forage genotypes are evaluated and disseminated with and by partners in different environments and production systems. The superior grass and legume genotypes are released and promoted by NARS and private seed companies and adapted and adopted by farmers to intensify and diversify their production systems.

For its work in Sub-Saharan Africa, Southeast Asia and Latin America and the Caribbean CIAT has developed a joint strategy with ILRI, with complementary research priorities and expertise to include forages in diverse crop/livestock systems, particularly in Sub-Saharan Africa and Southeast Asia. This partnership and the interaction with the private sector have allowed us to amplify networks for delivery of research products. Information sharing through knowledge tools such as SoFT ([www.tropicalforages.info](http://www.tropicalforages.info)) reaches a wide audience ranging from researchers and development practitioners to educational institutions and complements our continued efforts of individual and group training. A particular objective for the revision of SoFT is the linkage of SoFT with forage germplasm distribution.

Adoption of new forage varieties results in more income to livestock farmers through more efficient use of land and labor, and more animal products for urban consumers, with impacts demonstrated in Latin America and the Caribbean and Southeast Asia.

### **International Public Goods**

In the past there were a number of strong organizations in developed countries (e.g., Australia, USA) involved in development of forages for sub-tropical and tropical environments. However, currently there are only a few suppliers of improved forages with an international mandate as is the case for CIAT, ILRI and ICARDA. The forage work carried out by the CGIAR Centers is complementary. For example, forages developed at ICARDA are mostly for the arid and semi-arid regions, and ILRI is concentrating its work on developing forages for cooler environments and the assessment of food-feed crops, while forages developed by CIAT are for tropical lowlands to mid-altitudes. With ILRI we are discussing a joint strategy. An additional important participant in tropical Forage R&D is EMBRAPA in Brazil, but with a national mandate.

The research products of CIAT's Tropical Forage Product Line are in line with the mandate of the CGIAR of producing international public goods (IPGs). The IPGs of the research products of the Forage Product Line can be grouped into the following categories:

Defining mechanisms/Processes (to assist in the development of screening methods)

- Understanding how forage quality affects monogastric productivity and product quality
  - Understanding how grasses resist pests (spittlebug) and diseases (*Rhizoctonia*)
  - Understanding how forages adapt to acid soils with high levels of Al and low levels of P
  - Understanding how forages adapt to drought and waterlogging
  - Understanding how grasses inhibit biological nitrification in soil
1. Developing screening and evaluation methods (to select improved genotypes)
    - Forage quality (i.e., crude protein and *in vitro* digestibility) for ruminants and monogastrics
    - Biotic constraints (i.e., spittlebugs and *Rhizoctonia* foliar blight)
    - Abiotic constraints (i.e., adaptation of grasses to low soil nutrient status and high Al; adaptation to drought and to poorly drained soil conditions)
    - Selection of forages by farmers using participatory methods
  2. Developing superior grass and legume genotypes and cultivars (to contribute to increased livestock productivity)
    - Grasses and legumes selected from germplasm collections that have broad adaptation to environmental factors prevailing in target areas and with multiple uses in crop/livestock production systems

- Grasses with high forage quality and combined resistance to biotic and abiotic constraints
  - Accessing new forage genetic resources remains of high priority though it is severely constrained under the current writing of the International Treaty and the Convention on Biological Diversity
  - Understanding trade-offs between use of legumes for soil enhancement or as animal feed
3. Targeting and delivery of research results through dissemination of forage germplasm and decision support tools
    - Documented conservation and distribution of germplasm by the Genetic Resources Unit, with support for larger quantities of seed of selected materials from the forage seed unit.
    - Review of taxonomy of selected forage legume genera/species
    - Protocols for indexing diseases of quarantine importance that limit the flows of germplasm between LAC, Africa and South East Asia
    - Decision Support Tools with information on adaptation, uses and management of different forage species

### **Partners**

Through partnerships with different organizations from developed and developing countries, the Forage Product Line conducts research to develop improved grasses and legumes as feed resources. In what follows we present some key partnerships and the nature of the work being done as it relates to the four products of the Forage Product Line shown in parenthesis.

1. Colombia – CORPOICA and Universidad Nacional: Conservation, documentation and distribution of forage germplasm
2. Colombia- MADR – IICA- FEDEGAN. (Outcome 3) Desarrollo y uso de recursos forrajeros para mejorar la competitividad y productividad en sistemas sostenibles de producción bovina para el Departamento del Cauca.
3. Colombia – MADR. (Outcome 3) Implementation and transfer of technologies for restoration of degraded pastures for beef production systems Córdoba, Sucre and Atlantic departments”
4. Australia - CSIRO and QDPI; Germany- U of Hohenheim, ILRI and FAO: (Outcome 3) Development of a tool - Selection of Forages in the Tropics (SoFT). Funds from ACIAR, DFID and BMZ.
5. Costa Rica - SIDE; Guatemala – ICTA and MAGA; Honduras- DICTA; Nicaragua- IDR, IICA and ILRI: (Outcome 3). Analysis of the Beef Chain in Central America. Funds from CFC.
6. Colombia - CORPOICA and Mexico- PAPALOTLA -Seed Company: (Outcome 1) On-farm evaluation of selected *Brachiaria* hybrids. Funds from PAPALOTLA.
7. Colombia - CORPOICA-CVS-CARSUCRE-GANACOR-FEGASUCRE: (Outcome 3). Recuperation of degraded pastures. Funds from MADR.
8. France- ANR. Biodiversity and environmental services at landscape level in the Amazon.



9. Germany – CIM - Forage conservation and Feed Systems for Monogastrics. (Outcome 2).
10. Germany - U of Hohenheim; Colombia -CORPOICA and U del Cauca: (Outcome 2 and 3) Development of multipurpose forage legumes for smallholder crop/livestock systems in the hillsides of Latin America. Funds from Volkswagen Foundation
11. Germany -U of Hohenheim; Nicaragua- INTA; Honduras- DICTA: (Outcome 2 and 3) Demand-Driven Use of Forages in Fragile, Long Dry Season Environments of Central America to Improve Livelihoods of Smallholders. Funds from BMZ.
12. Germany - University of Hannover; Nicaragua-INTA: (Outcome 1): Developing *Brachiaria* hybrids with combined resistance to drought and aluminum toxicity. Funds from BMZ.
13. Lao PDR- National Agriculture and Forestry Research Institute, Australia- Department of Primary Industry and Forestry (DPI & F), Queensland and Canada- Nutrition Prairie Swine Centre, Saskatoon (Outcome 2) – Forage legumes for supplementing village pigs in Lao PDR. Funded by ACIAR
14. Switzerland - ETHZ; and Colombia- CORPOICA, Universidad Nacional de Colombia- Bogotá: (Outcome 2). The forage potential of tannineforus legumes. Funds from ZIL- SDC
15. Switzerland - ETHZ; and INTA- Nicaragua: (Outcome 3). Improved feeding systems for dairy cattle in tropical smallholder farms. Funds from ZIL-SDC
16. Switzerland -ETHZ; and INTA-Nicaragua: (Outcome 3). Realizing the benefits of cover crop legumes in smallholder crop/livestock systems. Funds from ZIL-SDC
17. Switzerland -ETHZ; INTA-Nicaragua; and ILRI-Colombia: (Outcome 3). Trade-off analysis of using legumes for soil enhancing or as animal feed resource. Funds from Systemwide Livestock Program (SLP)

**2. 2007 Output Targets CIAT Project IP5: Tropical Grasses and Legumes Optimizing Genetic Diversity for Multipurpose Use  
Logframe 2007 (MTP 2007-2009)**

<b>Targets</b>	<b>Outputs</b>	<b>Intended User</b>	<b>Outcome</b>	<b>Impact</b>	<b>Achieved 07 (yes or no)</b>	<b>Proof of achievement (list documentation)</b>
<b>Output 1</b>	Grasses and legumes with high forage quality attributes developed	CIAT and NARS researchers and seed companies	New cultivars of <i>Brachiaria</i> and legumes with high quality are released and adopted by farmers in LAC, Asia and Africa	Increased production of livestock through feeding high quality grasses and legumes		
<b>Output 1 Targets 2007</b>	Developed at least 5 <i>Brachiaria</i> sexual hybrids that combine resistance to 5 species of spittlebug with high leaf digestibility (>60%) and crude protein (>10%)	CIAT researchers	New genotypes incorporated into the <i>Brachiaria</i> breeding program to develop high quality cultivars		Yes	Annual Report Sections 1.1., 1.4. and 1.6
	Defined the effect of location and soil fertility on forage quality of 5 shrub legumes	CIAT and NARS researchers	Environmental niches to grow shrub legumes with tannins in LAC and Africa better defined		Yes	Annual Report Section 3.10. PhD. Thesis Tassilo Tiemann (2008) The forage potential of tanniniferous legumes: Search for sustainable ways to cope with nutritional limitations in smallholder livestock. Swiss Federal Institute of Technology (ETH), Zurich, Switzerland

Targets	Outputs	Intended User	Outcome	Impact	Achieved 07 (yes or no)	Proof of achievement (list documentation)
<b>Output 2</b>	Grasses and legumes with known reaction to pest and diseases and interactions with symbiont organisms developed	CIAT and NARS researchers, and seed companies	New cultivars of <i>Brachiaria</i> and legumes with resistance to prevalent pests and diseases are released and adopted by farmers in LAC	Increased profitability and sustainability of livestock production through planting grasses and legumes resistant to major pests and diseases		
<b>Output 2 Targets 2007</b>	Developed at least 5 apomictic <i>Brachiaria</i> hybrids that combine resistance to 3 species of spittlebug with tolerance to high levels of Al	NARS researchers	Selected <i>Brachiaria</i> hybrid with resistance to spittlebug and adaptation to acid, infertile soils tested in different regions in LAC		Yes	Annual Report Section 1.6
<b>Output 3</b>	Grasses and legumes with adaptation to edaphic and climatic constraints developed	CIAT, ARIs and NARS researchers, and seed companies	New cultivars of <i>Brachiaria</i> and legumes with adaptation to low fertility soils, drought and poorly drained soils released by partners and adopted by farmers in LAC, Asia and Africa	Increased livestock/crop production and improved NRM through planting multipurpose forage species adapted to low fertility soils, drought and waterlogged soils		
<b>Output 3 Targets 2007</b>	Developed a screening method for selecting <i>Brachiaria</i> hybrids for adaptation to poorly drained soils	CIAT researchers	New genotypes incorporated into the <i>Brachiaria</i> breeding program to develop cultivars with adaptation to poor soil drainage		Yes	Annual Report Section 1.8 Rao, I.M.; Rincon, J.; Garcia, R.; Ricaurte, J.; Miles, J. 2007. Screening for tolerance to waterlogging in <i>Brachiaria</i> hybrids. Poster paper presented at ASA-CSSA-SSSA International Annual Meeting, New Orleans, LA, USA. 4-8

Targets	Outputs	Intended User	Outcome	Impact	Achieved 07 (yes or no)	Proof of achievement (list documentation)
						November, 2007.
<b>Output 4</b>	Superior and diverse grasses and legumes evaluated in different production systems are disseminated	NARS researchers, development programs and farmers	New cultivars of grasses and legumes with adaptation to biotic and abiotic stresses are adopted by farmers in LAC, Africa and Asia	Livelihoods of small livestock farmers improved through adoption of forages that result in more efficient use of family labor and higher income from crop and animal products		
<b>Output 4 Targets 2007</b>	Elite accessions (4) of shrub legumes ( <i>Flemingia macrophylla</i> and <i>Desmodium velutinum</i> ) selected for high quality and yield in the wet and dry seasons.	NARS researchers and development programs	Researchers in LAC, Asia and Africa select new shrub legume alternatives for on-farm testing		Yes (partly)	Elite accessions defined, Genotype * Environment trials delayed due to adverse environmental conditions, trials re-established in 2008, Progress in Annual Report 2006, Section 3.5.

## Output Targets Improved Multipurpose Forages for the Developing World: Product Line SBA3 (2008-2010)

Targets	Products	Intended User	Outcome	Impact
<b>OUTCOME 1</b>	Improved <i>Brachiaria</i> grasses	CIAT and NARS researchers and seed companies	New cultivars of <i>Brachiaria</i> with high feed quality and resistance to major biotic and abiotic stress factors are released by partners and adopted by farmers in LAC, Asia and Africa	Increased efficiency of livestock production through feeding high quality grasses
<b>Outcome 1 Targets 2008</b>	<ul style="list-style-type: none"> <li>A reliable, high throughput screening methodology, based on artificial inoculation, for assessing <i>Rhizoctonia</i> foliar blight resistance is developed</li> <li>A screening method to assess waterlogging tolerance in <i>Brachiaria</i> hybrids streamlined in the breeding program</li> </ul>	<p>NARS researchers, CIAT researchers</p> <p>NARS researchers, CIAT researchers</p>	<p>Sexual tetraploid <i>Brachiaria</i> hybrids with high resistance to <i>Rhizoctonia</i> foliar blight identified and introgression of resistance into the tetraploid sexual breeding population initiated</p> <p>Selected <i>Brachiaria</i> hybrids tolerant to waterlogging tested in different regions in LAC and Asia</p>	
<b>Outcome 1 Targets 2009</b>	<ul style="list-style-type: none"> <li>At least 2 apomictic <i>Brachiaria</i> hybrids that combine high digestibility (&gt;60%) and crude protein (&gt;10%) with spittlebug resistance developed</li> <li>At least 5 <i>Brachiaria</i> hybrids that combine resistance to spittlebugs with adaptation to acid soils released for regional testing</li> <li>At least 5 <i>Brachiaria</i> hybrids with combined resistance to spittlebugs and tolerance to waterlogging developed</li> </ul>	<p>NARS researchers, and seed companies</p> <p>NARS researchers, CIAT researchers</p> <p>NARS researchers, CIAT researchers</p>	<p>New cultivars of <i>Brachiaria</i> with potential to increase livestock productivity are released and adopted by farmers in LAC and Asia</p> <p><i>Brachiaria</i> hybrids with superior traits available for multilocal testing in LAC</p> <p><i>Brachiaria</i> hybrids with resistance to spittlebug and adaptation to poorly drained soils evaluated in multilocal trials in LAC</p>	

Targets	Products	Intended User	Outcome	Impact
<b>Outcome 1 Targets 2010</b>	<ul style="list-style-type: none"> <li>Developed a screening method for selecting <i>Brachiaria</i> hybrids for combined adaptation to drought and aluminum toxicity</li> <li>One apomictic hybrid with phenotype similar to cv. Basilisk (stoloniferous, spreading) with good spittlebug resistance in advanced testing for commercial release.</li> </ul>	<p>NARS researchers, CIAT researchers</p> <p>NARS, private seed company</p>	<p>New genotypes incorporated into the <i>Brachiaria</i> breeding program to develop cultivars with combined adaptation to drought and aluminum toxicity</p> <p>One “spittlebug-resistant <i>B. decumbens</i>” to replace cv. Basilisk on large areas subject to spittlebug attack</p>	
<b>OUTCOME 2</b>	Forages as and for high value products developed to capture differentiated markets for smallholders	CIAT and NARS researchers, and seed companies	New stress adapted cultivars of <i>Brachiaria</i> and high quality legumes with resistance to prevalent pests and diseases to capture emerging markets are released by partners and adopted by farmers in LAC and Southeast Asia	Increased efficiency of livestock production and income of smallholder farmers through planting forage grasses and legumes that are adapted to major production constraints and market opportunities
<b>Outcome 2 Targets 2008</b>	<ul style="list-style-type: none"> <li>At least 3 legume varieties with high nutritional quality, capable of improving village pig production by at least 30% in extensive production systems identified</li> </ul>	CIAT and NARS researchers	Small pig producers in extensive production systems in Asia evaluate and adopt forage legumes as supplementary feed	
<b>Outcome 2 Targets 2009</b>	<ul style="list-style-type: none"> <li>Developed a methodology to correlate <i>in vitro</i> and <i>in vivo</i> screening of legumes for monogastric utilization</li> </ul>	NARS and CIAT researchers	Resource efficient screening of high potential forages for monogastric feeding	
<b>Outcome 2 targets 2010</b>	<ul style="list-style-type: none"> <li>At least one forage based feed for monogastric production adopted by smallholders in one country</li> </ul>	CIAT and NARS researchers	Small-scale monogastric producers adopt forage legumes as supplementary	

<b>Targets</b>	<b>Products</b>	<b>Intended User</b>	<b>Outcome</b>	<b>Impact</b>
	in Southeast Asia and one country in Latin America and the Caribbean		feed	
<b>OUTCOME 3</b>	Benefits of multipurpose grasses and legumes realized in crop/ livestock systems through adaptation, innovation and integration	CIAT, ARIs and NARS researchers, and seed companies	New cultivars of <i>Brachiaria</i> and legumes with adaptation to production constraints released by partners and adopted by farmers in LAC, Asia and Africa	Increased profitability and sustainability of livestock/crop production and improved NRM through planting multipurpose forage species adapted to production constraints
<b>Outcome 3 Targets 2008</b>	<ul style="list-style-type: none"> <li>• 3 perennial and annual herbaceous legume accessions that perform well under residual soil moisture and that are suited for hay and silage production identified</li> <li>• Released CaNaSTA for targeting forages (and other crops) to specific environmental and market niches</li> </ul>	<p>NARS researchers and development programs</p> <p>NARS researchers and development programs</p>	<p>Livestock and non-livestock farmers in dry hillsides adopt annual legumes to make high quality hay and silage</p> <p>Researchers and development workers are using CaNaSTA to target forages to specific production and market niches</p>	
<b>Outcome 3 Targets 2009</b>	<ul style="list-style-type: none"> <li>• Released a revised version of SoFT (Selection of Forages for the Tropics) to target forages to different niches</li> </ul>	NARS researchers and development programs	Large number of researchers and development workers use SoFT to identify, access and promote best-bet forage species for different environments and uses	

Targets	Products	Intended User	Outcome	Impact
<p><b>Outcome 3 Targets 2010</b></p>	<ul style="list-style-type: none"> <li>• Production vs environmental trade-offs determined between use of 2 cover legumes as feed supplement and for soil fertility improvement in maize-based systems in one hillside region</li> <li>• Production and soil quality improvement benefits from introducing 2 multipurpose forage grass and legume options to restore degraded pastures quantified in one savanna region</li> </ul>	<p>CIAT and NARS researchers</p> <p>NARS researchers and development programs</p>	<p>Livestock and non-livestock farmers in dry hillsides adopt at least one cover legume in their production systems</p> <p>Livestock farmers in savannas realize the benefits of the multipurpose forages</p>	



### 3. Research Highlights (2007)

#### Outcome 1: Improved *Brachiaria* grasses

- **Developed a screening method for evaluating *Brachiaria* hybrids for adaptation to poorly drained soils conducted initial screenings**

In the Tropics, pastures often confront waterlogging conditions. We developed a screening method to evaluate waterlogging tolerance in *Brachiaria* hybrids. Using the screening method, we showed that waterlogging for 21 days resulted in senescence and death of a great proportion of shoot biomass of the majority of hybrids and also affected the development of adventitious roots in some hybrids. We identified three sexual hybrids (SX05/1918, SX05/2043, SX05/2411) that were superior in their tolerance to waterlogging from a group of 37 preselected hybrids. The superiority of these hybrids was due to their greater ability to produce green leaf biomass and green leaf area together with higher proportion of green leaf biomass to total shoot biomass under waterlogging stress. These three attributes could serve as criteria for selection for waterlogging tolerance in *Brachiaria*. The finding of differences in tolerance to waterlogging among sexual clones is a very important result: genetic improvement of waterlogging tolerance in *Brachiaria* hybrids through selection in the sexual breeding population will be possible.

#### Outcome 2: Forages as and for high value products developed to capture differentiated markets for smallholders

- **Impact of the adoption of improved grasses in Central America**

During 2003 to 2007, CIAT monitored 56 smallholder dual purpose farms in Central America. These producers adopted 6 and 3 species of improved grasses and legumes, respectively. The adoption of new forages increased stocking rate by 15% in Honduras, 21% in Nicaragua, and 38% in Costa Rica, resulting in an increase in the number of milking cows by 24% in Honduras, 41% in Nicaragua, and 36% in Costa Rica.; milk production increased by 47% in Honduras and Nicaragua, and 53% in Costa Rica while beef production increased by 15% in Nicaragua, 46% in Honduras, and 74% in Costa Rica, respectively.

At the same time, milk price increased from 7% in Nicaragua up to 36% in Costa Rica, while beef prices increased between 4% and 11%. The increase in herd size and milk and beef production, coupled with higher product prices allowed family income to drastically increase by 288% in Honduras, 177% in Nicaragua, and 238% in Costa Rica. Seed sales of improved forages has increased significantly throughout Central America and, as a result, (degraded) pastures are currently being renovated. Current national policies to liberalize grass seed imports have favored the dissemination of CIAT's forage products in the region.

### **Outcome 3: Benefits of multipurpose grasses and legumes realized in crop/livestock systems through adaptation, innovation and adoption**

- **Realizing the benefits of *Canavalia brasiliensis* in smallholder crop-livestock systems in the hillsides of Central America**

Livestock trials were established on three smallholder farms in the watershed of Rio Pire (Condega, Estelí, Nicaragua) to test whether the introduction of the drought tolerant cover legume *Canavalia brasiliensis* (Canavalia) into the traditional maize-bean-livestock system can produce more dry season feed of better quality and can overcome soil fertility decline.

At each farmer two plots of 0.35 ha were planted with maize during the first rainy season and either beans or Canavalia during the second rainy season. After the maize harvest, three groups of 3-5 lactating cows entered the maize fields and grazed first the plots with the maize stover (and weeds/legumes) followed by the maize plots with Canavalia. Each treatment had a duration of eight days, of which four days of adaptation and four days of data collection.

Planting of *C. brasiliensis* increased average biomass availability by almost a tonne per hectare and resulted in a significantly higher milk production of 0.5 kg/animal/day ( $p < 0.05$ ). No effect was found on milk quality. The positive effect on milk production is recognized by the farmers and they show a clear interest in continuing with this technology to increase milk production during the dry season and recuperate degraded soils.

#### **4. PROJECT OUTCOME: Adoption of forages in Southeast Asia (MTP 2005 to 2007)**

Since the mid-1990s, CIAT and partners have worked together with smallholder farmers to develop forage technologies in Southeast Asia. By the end of 2005, more than 10,000 smallholder farmers had adopted intensively managed forage plots for improved livestock production. This outcome relates to Output 4 of the 2005-2007 MTP, stating 'A forage production systems established with >5000 farmers in 4 countries of SE Asia by 2006'.

A survey of the adoption of planted forages by smallholders at project sites of the 'Livelihood and Livestock Systems Project (ADB funded, 2003-2005), was conducted in 2005. More than 500 households were interviewed. In addition, several case studies documented the impact of adoption of forages in defined livestock production systems; cattle fattening, cow-calf production and herbivorous fish production. Adoption of forages was 172 households (hh) in Cambodia, 157 hh in PR China, 2632 hh in Indonesia, 32 hh in Laos, 491 hh in the Philippines, and 4091 in Vietnam. Additional forage adoption was recorded in non-project sites; mainly Laos, adding another 2700 hh.

Planting forages on their own land was the key factor that enabled smallholders to improve livestock production. The initial benefit from planted forages was, almost invariably, labor savings from easy access to feed. Subsequently, improved growth of animals receiving planted forages emerged and farmers started to intensify livestock production based on the additional new feed resource. This led to improved feeding and management systems, and a shift from extensive to more market-oriented livestock production. Relative small areas of

forages (500 – 2000 m<sup>2</sup>) were needed to achieve these benefits. Participatory approaches to working with farmers were an essential component of success. Partnerships varied and changed from more research-oriented partners to development-oriented partners as the project moved from developing forage technologies to scaling out, by end of 2006 reaching >5000 additional adopters

## 5. List of Publications (2007)

### *Articles in Refereed Journal*

- Abello, J. F.; Kelemu, S.; Garcia, C. 2007. *Agrobacterium*-mediated transformation of the endophytic fungus *Acremonium implicatum* associated with *Brachiaria* grasses. Mycological Research (in press)
- Abello, J. F.; and Kelemu, S. 2006. Hongos endofitos: Ventajas adaptativas que habitan al interior de las plantas. Revista Corpoica Ciencia y Tecnología Agropecuaria 7(2):55-57.
- Amézquita, E.; Rao, I. M.; Barrios, E.; Rondón, M.; Ayarza, M. A.; Hoyos, P.; Molina, D.; Corrales, I. I. 2007. Advances in developing screening methods and improving aluminum resistance in common bean and *Brachiaria*. Braz. J. Agric. Res. (in review).
- Andersson, M.S.; Jarvis, A.; Schultze-Kraft, R.; Peters, M. Is climate at collection site useful for the rapid assessment of diversity in wild-species germplasm collections? Comparative analysis of different approaches for germplasm characterization. Plant Genetic Resources: Characterization and Utilization (in review).
- Andersson, M.S.; Schultze-Kraft, R.; Peters, M.; Duque, M.C.; Gallego, G. (2007) Extent and structure of genetic diversity in a collection of the tropical multipurpose shrub legume *Cratylia argentea* (Desv.) O. Kuntze as revealed by RAPD markers. Electronic Journal of Biotechnology 10(3): 386–399. Available at: <http://www.ejbiotechnology.cl/content/vol10/issue3/full/2/>.
- Basamba, T. A.; Barrios, E.; Singh, B. R.; Rao, I. M. 2007. Impact of planted fallows and a crop rotation on nitrogen mineralization and phosphorus and organic matter fractions on a Colombian volcanic-ash soil. Nutrient Cycling in Agroecosystems 77: 127-141.
- Basamba, T. A.; Barrios, E.; Singh, B. R.; Rao, I. M. 2007. Nitrogen and phosphorus availability, organic matter fractions and maize yield under fallows and manure management on a Colombian volcanic-ash soil. Journal of Sustainable Agriculture (in press).
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- Gómez-Carabalí, A.; Rao, I. M.; Beck, R. F.; Ortiz, M. 2007. Rooting ability and nutrient uptake by tropical forage species that are adapted to degraded andisols of hillsides agroecosystem. Acta Facultatis Ecologie Vol. 12 (in press).

- Holmann, F.; Rivas, L.; Pérez, E.; Castro, C.; Schuetz, P.; Rodriguez, J. The beef chain in Costa Rica: Identifying critical issues for promoting its modernization, efficiency, and competitiveness. *Journal of Livestock Research for Rural Development* (in press).
- Holmann, F. and Tiemann, T. Costs and benefits of supplementing milking cows with legumes during the dry season in the hillsides of Nicaragua. *Journal of Livestock Research for Rural Development* (submitted).
- Kelemu, S.; Fory, P. 2007. *Brachiaria* plant growth enhanced by endophytic bacteria containing *nifH* gene sequences. *Phytopathology* 97: S55.
- Kelemu, S.; Fory, P.; Zuleta, C.; Ricaurte, J.; Rao, I.; Lascano, C. 2007. Bacterial endophytes in tropical grasses of the genus *Brachiaria* and their role in plant growth. *Environmental and Experimental Botany* (in review).
- Mejía Kerguelen, S.; Rao, I.; Louw-Gaume, A.; Gaume, A.; Frossard, E.. 2007. Evaluación de genotipos de *Brachiaria* contrastantes por su adaptación a suelo con bajo fósforo disponible y alta saturación de aluminio. *Acta Agronómica* (in review).
- Nakamane, G.; Srisomporn, W.; Phengsavanh, P.; Samson, J.; Stur, W. (2008). Sale of fresh forage - a new cash crop for smallholder farmers in Yasothon, Thailand. *Tropical Grasslands* (accepted for publication).
- O'Brien, R.; Cook, S.; Corner, R.; Peters, M. (2007) Spatial decision support using uncertain and sparse data *International Journal of Geographical Information Science*, submitted.
- Pabón, A.; Cardona, C.; Miles, J. W.; Sotelo, G. 2007. Response of resistant and susceptible *Brachiaria* genotypes to simultaneous infestation with multiple species of spittlebugs (Hemiptera: Cercopidae). *J. Econ. Entomol.* 100(6): 1896-1903.
- Rao, I.; Wenzl, P.; Arango, A.; Miles, J.; Watanabe, T.; Shinano, T.; Osaki, M.; Wagatsuma, T.; Manrique, G.; Beebe, S.; Tohme, J.; Ishitani, M.; Rangel, A.; Horst, W. 2007. Advances in developing screening methods and improving aluminum resistance in common bean and *Brachiaria*. *Braz. J. Agric. Res.* (in review).
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- Subbarao, G. V.; Rondon, M.; Ito, O.; Ishikawa, T.; Rao, I. M.; Nakahara, K.; Lascano, C.; Berry, W.L. 2007. Biological nitrification inhibition (BNI) – Is it a widespread phenomenon? *Plant and Soil* 294: 5-18.

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Amezquita, E.; Rao, I. M.; Hoyos, P.; Molina, D.; Chavez, L. F.; Bernal, J. H. 2007. Development of an arable layer: A key concept for better management of infertile tropical savanna soils. In: A. Bationo, B. Waswa, J. Kihara and J. Kimetu (Eds). *Advances in integrated soil fertility research in sub Saharan Africa: challenges and opportunities*. Springer, the Netherlands (in press).

Nandwa, S. M.; Bationo, A.; Obanyi, S. N.; Rao, I. M.; Sanginga, N.; Vanlauwe, B. 2007. Inter and intra-specific variation of legumes and mechanisms to access and adapt to less available soil phosphorus and rock phosphate. In: A. Bationo (Ed) *Fighting Poverty in Sub-Saharan Africa: The Multiple Roles of Legumes in Integrated Soil Fertility Management*, Springer-Verlag, New York (in press).

### ***Book Chapters***

Ayarza, M.; Barrios, E.; Rao, I.; Amézquita, E.; Rondon, M. 2007. Advances in improving agricultural profitability and overcoming land degradation in savanna and hillside agroecosystems of tropical America. In: A. Bationo, B. Waswa, J. Kihara and J. Kimetu (Eds). *Advances in integrated soil fertility research in sub Saharan Africa: challenges and opportunities*. Springer, the Netherlands , p.209-229

### ***Articles and Abstracts in Proceedings***

Gabunada, F.G. Jr.; Stür, W.W.; Asis, P.T.; Saguinhon, J.; Velasco, C.; Moneva, L.A.; Magboo, E.C. (2007). Adoption and use of forages in the uplands of the Visayas and Mindanao, Philippines. In: Hare, M.D. and Wongpichet, K. (eds). *Forages – A Pathway to Prosperity for Smallholder Farmers*. Proceedings of a Forage Symposium, Ubon Ratchathani University, Thailand, 5-7 March 2007, 111-126.

Holmann, F.; Bartl, K.; Muñoz, El.; Gomez, C.; Dieter Hess, H.; Kreuzer, M. Costs and benefits of traditional and improved feeding systems for dairy cattle in two communities in the central highlands of Peru. Poster presented at the Tropentag 07 in Berlin, Germany. [www.tropentag.de](http://www.tropentag.de)

Lascano, C.E.; and Peters, M. (2007) Developing and targeting multipurpose legumes: Exploiting diversity to benefit farmers. Invited paper. Proceedings of an International Forage Symposium 'Forages – a pathway to prosperity for smallholder farmers', March 5-7, 2007, Faculty of Agriculture, Ubon Ratchathani University, Ubon Ratchathani, Thailand (Eds.: Hare, M.D. and Wongpichet, K.), p 15-34.

Lentes, P.; Holmann, F.; Peters, M.; White, D.; Cruz, H. (2007) Dry Season Resource Use Efficiency of Cattle Farms in Olancho, Honduras and Implications for Forage Technology Adoption. Poster presented at the Tropentag, Utilisation of diversity in land use systems: Sustainable and organic approaches to meet human needs, October 9 - 11, 2007, Witzenhausen, Germany. [www.tropentag.de](http://www.tropentag.de)

Louw-Gaume, A.; Gaume, A.; Rao, I.M. ; Frossard, E. 2007. Morphological and physiological markers for enhanced phosphorus (P) acquisition in *Brachiaria* species provide mechanistic insights into P uptake and P use in these tropical grasses. Poster paper presented at the annual conference on Tropical and Subtropical Agricultural and Natural Resource Management (TROPENTAG), October 9-11, 2007. Witzenhausen, Germany. [www.tropentag.de](http://www.tropentag.de)

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- Rao, I.M.; Rincon, J.; Garcia, R.; Ricaurte, J.; Miles, J. 2007. Screening for tolerance to waterlogging in *Brachiaria* hybrids. Poster paper presented at ASA-CSSA-SSSA International Annual Meeting, New Orleans, LA, USA. 4-8 November, 2007.
- Reiber, C.; Schultze-Kraft, R.; Peters, M.; Lascano, C.; Hoffmann, V. (2007) Smallholder-forage conservation in Central America – A participatory research project in Honduras. Invited paper Proceedings of an International Forage Symposium 'Forages – a pathway to prosperity for smallholder farmers', March 5-7, 2007, Faculty of Agriculture, Ubon Ratchathani University, Ubon Ratchathani, Thailand (Eds.: Hare, M.D. and Wongpichet, K.), p 127-164.
- Spain, J.; Amezcuita, E.; Rao, I.M.; Ayarza, M.; Barrios, E.; Rondon, M. 2007. Improving productivity and sustainability of crop-livestock systems in tropical savannas of South America. Poster paper presented at ASA-CSSA-SSSA International Annual Meeting, New Orleans, LA, USA. 4-8 November, 2007.
- Stür, W.W.; Horne, P. M.; Phengsavanh, P.; Gabunada, F.; Khanh, T.T.; Connell, J. (2007). Planted forages – the key for making money from smallholder livestock production: Experiences from CIAT's forage R&D in Southeast Asia. In: Hare, M.D. and Wongpichet, K. (eds). Forages – A Pathway to Prosperity for Smallholder Farmers. Proceedings of a Forage Symposium, Ubon Ratchathani University, Thailand, 5-7 March 2007, 313-331.
- Tuhulele, M.; Taufiq, Hariadi A.; Hasim, S.; Fathoni, Aldrin M.; Stür, W.W. (2007). Adoption of *Brachiaria humidicola* by smallholder farmers in Central Kalimantan, Indonesia. In: Hare, M.D. and Wongpichet, K. (eds). Forages – A Pathway to Prosperity for Smallholder Farmers. Proceedings of a Forage Symposium, Ubon Ratchathani University, Thailand, 5-7 March 2007, 297-312.

### ***Conferences and workshops***

- Douxchamps, S.; Frossard, E.; Rao, I. M.; Schmidt, A.; Van der Hoek, R.; Mena, M.; Oberson, A. 2007. Effects of *Canavalia brasiliensis* on nitrogen dynamics in crop-livestock systems of the Nicaraguan hillsides. Paper presented at NITROGEN 2007 International Conference, Lancaster, UK. 27-31 July 2007.
- Hanson, J.; Lima, C.; Peters, M.; Debouck, D. (2007) A key resource for the improvement of animal productions worldwide: forty thousand options from the in-trust forage collections of CIAT and ILRI. Poster presented at the eleventh Regular Session of the CGRFA "Plant genetic resources of grassland, Side Event held on 14 June on "Biodiversity and productivity in Grassland", FAO, Rome."
- Kelemu, S.; Fory, P.; Bonilla, X.; Rao, I.; Lascano, C. 2007. Efecto de inoculación de bacterias endofitas asociadas a *brachiaria* en plantas del híbrido CIAT 36061 (cv. mulato) y *Brachiaria*

*brizantha* CIAT 6294 (cv. marandú): XXVII Congreso Asociación Colombiana de Fitopatología y Ciencias Afines (ASCOLFI), 3- 5 de Octubre del 2007, Palmira, Colombia.

- Khan, M.S.H.; Wagatsuma, T.; Tawaraya, K.; Kambayashi, M.; Chuba, M.; Ishikawa, S.; Akhter, A.; Wenzl, P.; Rao, I. M. 2007. Aluminum tolerance is not always the primary strategy for better growth of rice in long-term under low ionic strength conditions. Paper presented at RHIZOSPHERE 2 International Conference, Montpellier, France. 26-31 August 2007.
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- Louw-Gaume, A.; Gaume, A.; Frossard, E.; Kerguelén, S.M.; Rao, I. 2007. Adaptación de especies de *Brachiaria* a suelos bajos en disponibilidad de fosforo. Paper presented at the LIII Reunión Anual de PCCMCA (Program Cooperativo Centroamericano para el Mejoramiento de Cultivos y Animales), Antigua Guatemala, Guatemala. 23-27 April, 2007.
- Miles, J.W. 2007. Apomixis for cultivar development in tropical forage grasses. *Crop Sci.* 47:S-238-S-249. [Paper presented at the second International Plant Breeding Symposium, held 20-25 August 2006, in Mexico City.]
- Miles, J.W.; and Hare, M.D. 2007. Plant breeding and seed production of apomictic tropical forage grasses. p. 74-81. In: Aamlid, T.S., L.T. Havstad, and B. Boelt (eds.) Seed production in the northern light: Proceedings of the Sixth International Herbage Seed Conference, Gjøennestad, Norway. 18-20 June 2007. (Bioforsk: Ås, Norway).
- Montoya, C.A.; Torres, J.; Franco, L.H; Lascano, C.E.; Muñoz, L.E.; Peters, M. (2007) Tropical grain legumes as alternatives to soybean meal for small producers of monogastric animals in the tropics. Poster presented at the 6<sup>th</sup> European Conference on grain legumes, Lisbon 12 to 16 November 2007.
- Moreta-Mejía, D.; Hurtado, P.; Salcedo, A. F.; Chávez, L.; Rondón, M.; Ishitani, M.; Duque, M.; Miles, J.; Lascano, C.; Rao, I.; Subbarao, G. V.; Ito, I. 2007. Chemical, biochemical, and molecular studies for the biological nitrification inhibition (BNI) in crops. An integrated approach to study BNI phenomenon. Oral paper presented at the VI The Latin America and the Caribbean Meetings on Agricultural Biotechnology (REDBIO), Viña del mar -Valparaiso, Chile, October 22- 26, 2007.
- Moreta-Mejía, D.; Hurtado, P.; Salcedo, A.F.; Chávez, L.; Rondón, M.; Duque, M.; Subbarao, G. V.; Ito, I.; Miles, J.; Lascano, C.; Rao, I.; Ishitani, M. 2007. Biological Nitrification Inhibition (BNI) -A novel phenomenon. Poster paper presented at the VI The Latin America and the Caribbean Meetings on Agricultural Biotechnology (REDBIO), Viña del mar -Valparaiso, Chile, October 22- 26, 2007.
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- Muñoz, L.E.; Sarria, P.I.; Martens, S.; Peters, M.; Aguirre, P. A.; Montoya, C.A. (2007). Nutritional characterization of *Vigna unguiculata* as alternative protein source for monogastric animal. Accepted for presentation at the XXI. International Grassland Congress/VIII. International Rangeland Congress, 29<sup>th</sup> June – 5<sup>th</sup> July, 2008, Hohhot, China.
- Peters, M.; Schultze-Kraft, R.; Vivas, N.; Hernandez, L.A.; Tabares, M.C.; Zöfel, K.; Franco, L.H. (2008) Integration of on-station and farmer participatory evaluation of multipurpose legumes - a case from Cauca, Colombia. Accepted for presentation at the XXI. International Grassland Congress/VIII. International Rangeland Congress, 29<sup>th</sup> June – 5<sup>th</sup> July, 2008, Hohhot, China.
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- Rao, I.M. 2007. PCCMCA conference to make two oral presentations. Guatemala. 22- 27 April. 2007
- Rao, I.M. 2007. Progress Forum of ZIL-Planning workshop of ZIL-SLP funded projects. ETH-Zurich, Switzerland. 24-30 June 2007.
- Rao, I.M. 2007. Kick-off workshop of the GCP-BMGF funded project on Tropical Legumes; Review of progress of BMZ-GTZ funded project on drought and aluminum toxicity. South Africa; Rwanda. 15 – 29 September.
- Rao, I.M. 2007. Present 1 oral and 2 poster papers at the Centennial meeting of the American Society of Agronomy. New Orleans, USA. 4-9 November.
- Rao, I. M.; Polania, J.; García, R.; Beebe, S. 2007. Desarrollo de un método en invernadero usando tubos con suelo para cuantificar diferencias fenotípicas en desarrollo y distribución de raíces en líneas avanzadas de frijol común bajo condiciones de estrés por sequía. Paper presented at the LIII Reunión Anual de PCCMCA (Program Cooperativo Centroamericano para el Mejoramiento de Cultivos y Animales), Antigua Guatemala, Guatemala. 23-27 April, 2007.
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- Rincón, J.; Polania, J.A.; Rao, I.M.; Miles, J.; García, R. 2007. Variación genotípica por tolerancia a sequía en *Brachiaria* bajo condiciones de invernadero usando un sistema de cilindros plásticos transparentes. Paper presented at the XXXVII Congreso Anual de COMALFI (Sociedad Colombiana de Control de Malezas y Fisiología Vegetal), Santa Marta, Colombia. 2-4 May, 2007.
- Schmidt, A.; Heider, B.; Peters, M. (2007) Wild legumes and marginal production systems – synergy or trade-off? Invited paper presented at the Symposium 'Tropical pastures and global change - Contribution of tropical pastures to future food security and environmental health, Friday, 16th of February 2007, University of Hohenheim (Stuttgart, Germany).
- Schultze-Kraft, R.; Peters, M.; Franco, L.H.; Hincapie, B. (2008) *Dendrolobium* spp. – a source of tropical multipurpose legumes. Accepted for presentation at the XXI. International Grassland Congress/VIII. International Rangeland Congress, 29<sup>th</sup> June – 5<sup>th</sup> July, 2008, Hohhot, China.
- Subbarao, G.V.; Ito, O.; Watanabe, T.; Nakahara, K.; Pearse, S.; Zakir Hussain, A.K.M.; Gopalakrishnan, S.; Rondon, M.; Rao, I.M.; Lascano, C.; Miles, J.; Ishitani, M.; Hurtado, M.P.; Kishii, M.; Ban, T.; Hash, T.; Sahrawat, K.L.; Upadhyaya, H.D. 2007. Seeking a genetic strategy to control nitrification and N<sub>2</sub>O emissions from agricultural systems – Biological nitrification inhibition (BNI). Paper presented at NITROGEN 2007 International Conference, Lancaster, UK. 27-31 July 2007.
- Subbarao, G.V.; Ito, O.; Watanabe, T.; Rondon, M.; Rao, I.M.; Pearse, S.; Hussain, Z.; Gopalakrishnan, S.; Nakahara, K. 2007. Natural nitrification inhibition by plants – A novel genetic strategy to combat nitrification and N<sub>2</sub>O emissions from agricultural systems. Paper presented at RHIZOSPHERE 2 International Conference, Montpellier, France. 26-31 August 2007.
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#### **Working Documents and Leaflets:**

- Franco, L. H.; Calero, D.; Ávila, P. (2007). Alternativas para la conservación de Forrajes. Proyecto: Evaluación de tecnologías por métodos participativos para la implementación de sistemas ganaderos sostenibles en el norte del departamento del Valle del Cauca. CIAT, Universidad Nacional de Colombia- Gobernación del Valle del Cauca – Secretaría de Agricultura y Pesca.

- Franco, L. H.; Calero, D. (2007). Producción Artesanal de Semillas de plantas forrajeras Multipropósito. Proyecto: Evaluación de tecnologías por métodos participativos para la implementación de sistemas ganaderos sostenibles en el norte del departamento del Valle del Cauca. Leaflet, CIAT, Universidad Nacional de Colombia- Gobernación del Valle del Cauca – Secretaría de Agricultura y Pesca.
- Franco, L.H.; and Peters, M. (2007) *Canavalia brasiliensis*. Una leguminosa multipropósito. Leaflet, CIAT.
- Franco, L.H.; Peters, M.; Schultze-Kraft, R. (2007) *Lablab purpureus*. Una leguminosa multipropósito. Leaflet, CIAT.
- Holmann, F.; Rivas, L.; Pérez, E.; Castro, C.; Schuetz, P.; Rodriguez, J. (2007) La Cadena de la Carne Bovina en Costa Rica. Identificación de puntos críticos para impulsar su modernización, eficiencia y competitividad. Documento de trabajo # 206. CIAT (Centro Internacional de Agricultura Tropical). Cali, Colombia.
- Reiber, C.; Cruz, H.; Peters, M.; Franco, L.H.; Lascano, C.; Avila, P.; Schmidt, A.; Schultze-Kraft, R.; Burgos, C.; Mena, M.; Lentés, P. (2007) Heno – forraje conservado para la época crítica. Leaflet, CIAT.
- Reiber, C.; Cruz, H.; Peters, M.; Franco, L.H.; Lascano, C.; Avila, P.; Schmidt, A.; Schultze-Kraft, R.; Burgos, C.; Mena, M.; Lentés, P. (2007) El ensilaje – alternativa para conservar forrajes. Leaflet, CIAT.

## 6. List of proposal funded (2007)

- Aumento de la productividad, competitividad y sostenibilidad de sistemas de pequeños y medianos productores de carne en la cuenca del Patía y meseta de Popayán. MADR. 2008-2010
- Biodiversity and environmental services at landscape level in the Amazon. ANR-France grant for Euros 843,180 for 3 years.
- Desarrollo y uso de recursos forrajeros para mejorar la competitividad y productividad en sistemas sostenibles de producción bovina para el departamento del Cauca. MADR – IICA-FEDEGAN. \$1.394.726.000 pesos colombianos. 4 años.
- Forage conservation and Feed Systems for Monogastrics. CIM – Germany. For 2 years.
- Implementation and transfer of technologies for restoration of degraded pastures for beef production systems Córdoba, Sucre and Atlantic departments” MADR-Colombia grant for Colombian Pesos 850,000,000 for 3 years.
- Realizing the benefits of cover crop legumes in smallholder crop-livestock systems in the hillsides of Central America – funded by ZIL-SDC for a total budget of 340,000 Swiss Francs over 3 years.

## 7. Staff List (IRS)

### Principal Staff

Peters Michael, Forage Germplasm Specialist and Outcome Line Leader 100%

Elizabeth Alvarez, Plant Pathologist (MIP) 30%

Holmann Federico, Animal Production Systems/Economics (joint position with ILRI) 100%

Kelemu Segenet, Plant Pathologist (until August 2007)

Lascano Carlos, Animal Nutritionist and Forage Project Leader (until March 2007)

Miles John, Plant Breeder 100%

Rao Idupulapati, Plant Nutritionist/Physiologist 50%

Rein van der Hoek, Forage Expert, Nicaragua (Associate Researcher, CIM)100%

Stur Werner, Forage and Livestock Systems, Southeast Asia 100%

### Consultants/Advisors

Cardona Cesar, (August 2007-August 2008)

Schultze-Kraft Rainer, Specialist Germoplasm

Wenzl Peter, CAMBIA, Canberra, Australia

### PostDoc

Lentes Peter, Socio-Economics and GIS, Honduras (until November 2007)

Martens Siriwan, Animal Nutritionist (Associate Researcher, CIM) (since March 2007)

## 8. Summary of Budget

### ACTUAL EXPENDITURES 2007

#### Outcome Line SBA-3: Forages

SOURCE	Forages Program			Total US\$	(%)
	HQ + LAC	Asia	URG + Biotech		
Unrestricted Core	127,045	104,533	423,161	654,738	20%
Restricted Core, CE + Japan	688,856			688,856	21%
<b>Sub-total Core</b>	<b>815,901</b>	<b>104,533</b>	<b>423,161</b>	<b>1,343,595</b>	<b>40%</b>
<b>Restricted</b>					
Special Projects	796,019	457,538	68,827	1,322,384	40%
Water and Food Challenge Program	208,756			208,756	
<b>Sub Total Restricted</b>	<b>1,004,775</b>	<b>457,538</b>	<b>68,827</b>	<b>1,531,141</b>	<b>46%</b>
<b>Direct Expenditures</b>	<b>1,820,676</b>	<b>562,071</b>	<b>491,988</b>	<b>2,874,735</b>	<b>86%</b>
Non Research Cost	287,617	88,792	77,721	454,129	14%
<b>Total Expenditures</b>	<b>2,108,292</b>	<b>650,863</b>	<b>569,709</b>	<b>3,328,864</b>	<b>100%</b>

<sup>(1)</sup> Excluding Non Operational expenses: Phase-out and Fixed Assets adjustment.