Tropical Grasses and Legumes: Optimizing genetic diversity for multipurpose use

Summary
Annual Report 2006

IP-5 PROJECT

CIAT
Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture

SUMMARY
ANNUAL REPORT
2006

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

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1. Project IP5 Logframe (MTP 2006-2008)

	Outputs	Intended User	Outcome	Impact
OUTPUT 1	Grasses and legumes with high forage quality attributes developed	CIAT and NARS researchers, seed companies and farmers	New cultivars of *Brachiaria* and legumes with high quality are released and adopted by farmers in LAC, Asia and Africa	Increased production of livestock fed high quality grasses and legumes
Output Targets 2006	Selected at least 10 *Brachiaria* hybrids with high leaf digestibility (>60%) and protein (>10%) Defined the role of tannins and fiber quality in legumes on methane production	CIAT researchers CIAT, ARIS and NARS researchers	New genotypes incorporated into the Brachiaria breeding program to develop high quality cultivars Development of feeding systems that contribute to less methane emissions by ruminant animals	
Output Targets 2007	Defined effect of environment (soil fertility and rainfall) on quality of 5 selected shrub legumes	CIAT and NARS researchers	Environmental "niches" to grow shrub legumes with tannins in LAC and Africa better defined	
Output Targets 2008	Nutritional synergies of using mixtures of shrub legumes with and without tannins assessed with sheep and milking cows	NARS researcher and farmers	Farmers in LAC, Asia and Africa adopt the use of legume mixtures to maximize efficiency of use of forage- based supplements	
OUTPUT 2	Grasses and legumes with known reaction to pest and diseases and interactions with symbiont organisms developed	CIAT and NARS researchers, seed companies and farmers	New cultivars of *Brachiaria* 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

	Outputs	Intended User	Outcome	Impact
Output Targets 2006	At least 10 *Brachiaria* hybrids with combined resistance to at least 3 species of spittlebug developed Screening method to assess resistance to *Rhizoctonia* foliar blight in *Brachiaria* streamlined in the breeding program	NARS researchers CIAT and NARS researchers	Selected *Brachiaria* hybrid with resistance to spittlebug tested in different regions in LAC Selected *Brachiaria* hybrids resistant to *Rhizoctonia* foliar blight tested in different regions in LAC and Asia	
Output Targets 2007	Alkaloid profile of the endophyte (*Acremonium*)/Brachiaria association elucidated	NARS and ARIS researchers	Defined if alkaloids present in endophyte- Brachiaria association are toxic to sheep	
Output Targets 2008	At least 20 tetraploid *Brachiaria* hybrids identified with *Rhizoctonia* foliar blight resistance as high as that of the commercial *B. decumbens* cv Basilisk	NARS researchers	*Brachiaria* hybrids with resistance to *Rhizoctonia* selected in multilocational trials in LAC and Asia	
OUTPUT 3	Grasses and legumes with adaptation to edaphic and climatic constraints developed	CIAT, ARIS and NARS researchers, seed companies and farmers	New cultivars of *Brachiaria* and legumes with adaptation to low fertility soils, drought and poorly drained soils released 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

	Outputs	Intended User	Outcome	Impact
Output Targets 2006	Selected a genotype of *Brachiaria* that combines resistance to ate least two species of spittlebug with good adaptation to acid –low fertility soils Genetic variability for nitrification inhibition in the collection (40 accessions) of *Brachiaria humidicola* held by CIAT determined	NARS researchers and seed companies CIAT, ARIS and NARS researchers	A new *Brachiaria* hybrid is made available to NARS partners for field testing in LAC, Africa and Asia Selection for nitrification inhibition incorporated in the Brachiaria improvement programs in LAC	
Output Targets 2007	Screening method for selecting *Brachiaria* genotypes adapted to poorly drained soils developed	CIAT and NARS researchers	New genotypes incorporated into the Brachiaria breeding program to develop cultivars with adaptation to poor soil drainage	
Output Targets 2008	Tradeoff of using drought tolerant legumes as cover crops and dry season feed defined	NARS researcher and farmers	Farmers adopt legumes as green manure and as feed resource for the dry season in LAC and Africa	
OUTPUT 4	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

	Outputs	Intended User	Outcome	Impact
Output Targets 2006	Two forage seed delivery systems developed to pilot stage to test linking small seed producers to large company/export market opportunities A superior *Brachiaria* hybrid combining drought tolerance, resistance to spittlebug and adaptation to acid infertile soils released by a commercial seed company in LAC countries	Forage seed companies, development programs and farmers Forage Seed companies, development programs and farmers	Alliance with large seed companies reduces risk and increases income of small farmers engaged in seed multiplication Seed of a superior grass genotype available to small and large farmers in LAC, Asia and Africa	
Output Targets 2007	Elite accessions (5- 10) of shrub legumes (*Flemingia macrophylla* and *Desmodium velutinum*) and short term herbaceous (*Vigna unguiculata, Canavalia brasilensis, Lablab purpureus*) deployed in NARS forage evaluation programs	NARS researchers and development programs	Researchers in LAC, Asia and Africa incorporate into their forage evaluation programs new shrub legume alternatives	
Output Targets 2008	A superior *Brachiaria* hybrid with resistance to spittlebug and adaptation to acid soils and drought planted in over 50,000 ha	Small and large farmers	Farmers in LAC, Africa and Asia who adopt new pasture species increase milk and beef production	

2. Output Targets 2006

Project	Outputs	Output Targets 2006	Category of Output Target	Achieved?
IP- 5	**Output 1** Grass and legume genotypes with high forage quality attributes are developed	Selected at least 10 *Brachiaria* hybrids with high leaf digestibility (>60%) and protein (>10%)	Materials	**Achieved** Ten hybrids with IVDMD > or = to 59% and CP > 14% identified. Need to refine logistic to streamline in the breeding program. Annual Reports 2004, 2005 and 2006
		Defined the role of tannins and fiber quality in legumes on methane production	Other kind of knowledge	**Achieved** 1. Annual Report 2006 2. One. Journal article (Animal and Feed Science and Technology. 13 (Suppl): 95-98) 3. Proceeding of Workshop (Publication CIAT 2006 No 352. 52p)
IP- 5	**Output 2** Grass and legume genotypes with known reaction to pests and diseases and interaction with symbiont organisms are developed	At least 10 *Brachiaria* hybrids with combined resistance to at least 3 species of spittlebug developed	Materials	**Exceeded** Annual Report 2006
		Screening method to assess resistance to *Rhizoctonia* foliar blight in *Brachiaria* streamlined in the breeding program	Practices	**Achieved** Annual Reports 2005 and 2006. Need to refine logistics to streamline in the breeding program.
IP- 5	**Output 3** Grass and legume genotypes with superior adaptation to edaphic and climatic constraints are developed	Selected a genotype of *Brachiaria* that combines resistance to at least two species of spittlebug with good adaptation to acid-low fertility soils	Materials	**Exceeded** 1. Annual Report 2005 and 2006 2. One Journal article (Crop Science. 46: 968-973, 2006)
		Genetic variability for nitrification inhibition in the collection (40 accessions) of *Brachiaria humidicola* held by CIAT determined	Other kind of knowledge	**Achieved** 1. Annual report 2004 and 2006 2. One Journal article (Plant and Soil, 2007 in press)

IP- 5	**Output 4** Superior and diverse grasses and legumes evaluated in different production systems are disseminated	Two forage seed delivery systems developed to pilot stage to test linking small seed producers to large company/export market opportunities	Capacity	**Achieved** A pilot smallholder forage seed enterprise is in place in Honduras. Small farmers in Nicaragua are multiplying seed from legumes. 1. Annual Report 2005, 2006 2. Legal constitution of the enterprise
		A superior *Brachiaria* hybrid combining drought tolerance, resistance to spittlebug and adaptation to acid infertile soils released by a commercial seed company in LAC countries	Materials	**Achieved** 1. Annual Reports 2005 and 2006 2. Technical Bulletin (Spanish, English and Portuguese) of cultivar released 3. Certification by Papalotla of seed produced and sold in different countries in 2005/2006

3. Research Highlights 2006

- **Legumes mixtures with and without tannins when fed to cows as supplements result in increased milk production**
  Previous studies had shown that supplementation with hay of *Calliandra calothyrsus* (Calliandra) did not increase milk production of dual purpose cows grazing low quality pastures during the dry season. This lack of response to supplementation with Calliandra has been associated to its high level of tannins, which results in low levels of ammonia production in the rumen and as a result bacterial protein synthesis is reduced. It has been hypothesized that mixing legumes with and without tannins could contribute to improve the effects of supplementation of legumes with tannins on milk production due to increased production of rumen ammonia and flow of total nitrogen to the lower digestive tract. To test this hypothesis, four supplements consisting either of the tanniniferous Calliandra or the tannin free high quality *Vigna unguiculata* (Cowpea) alone or in mixtures were offered to grazing cows. Replacing in the supplement 1/3 of Calliandra with cowpea resulted in a 22% increase in daily milk yield relative to the Calliandra alone supplement. Thus it can be concluded that legume based supplements based on high yielding shrub legumes with tannins can be significantly improved by mixing them with small proportions of a high quality legume without tannins.

- **Demonstrated possibility to overcome negative attributes of *Brachiaria humidicola* through breeding**
  The grass specie *Brachiaria humidicola* has a number of highly desirable attributes, notably its strongly stoloniferous growth, good resilience under grazing mismanagement, and tolerance to poorly drained soil conditions. However, available cultivars of the species have a number of defects such as poor nutritional quality, susceptibility to spittlebug, poor seed yield, and strong physiological seed dormancy. Two tetraploid accessions of *B. humidicola* with different reproductive modes (CIAT 26146, sexual; CIAT 26149, apomictic) were selected for carrying out experimental crosses. A number of microsatellite markers were assessed on the two parental genotypes. Informative markers – those present in the male (apomictic) parent and absent in the female (sexual) parent – were identified. Fourteen putative hybrid seedlings were obtained. Detection of the band present in the male parent and absent in the female in all 14 putative hybrids, confirmed that all hybrids were true hybrids. These results open the possibility of genetic improvement in *B. humidicola*, particularly if inheritance of reproductive mode (sexuality vs. apomixis) is found to be simply inherited.

- **Improved forages adopted by smallholders in SE Asia increased income and returns to labor and opened opportunities to link to markets**
  CIAT commenced forage research in Southeast Asia in 1992 with the introduction of a large range of forge accessions. In 2005, two major CIAT forage projects – the regional Livelihood and Livestock Systems Project and the bi-lateral Forages and Livestock Systems Project in Laos were completed. By this time, the long-term commitment of CIAT and its partners had led to significant livelihood benefits and adoption of planted forages by a large number of smallholder households in the region. These were documented in a survey and impact studies carried out in 2005. Planted forages significantly improved household income and, most importantly, the returns to labor from livestock production. The initial benefit from planted forages was in labor savings from easy access to feed. Subsequently, improved growth of animals receiving planted forages emerged and farmers looked for ways of maximizing the opportunities provided by the new feed resources. Participatory approaches to technology development were an essential component of success. The key role of planted forages in enabling smallholder farmers to intensify their extensive livestock production system and become more market-oriented has been accepted by development agencies. Similarly, the participatory approaches developed for forage technology development and scaling out have attracted interest from development practitioners.

4. PROJECT OUTCOME: A superior *Brachiaria* hybrid combining drought tolerance, resistance to spittlebug and adaptation to acid infertile soils released by a commercial seed company in LAC countries

The output was identified in the MTP 2005-2007. This outcome contributes to improved rural livelihoods through increased efficiency of livestock production and through sale of seed, vegetative planting material and fodder.

Brachiaria hybrid cultivar 'Mulato II' (CIAT 36087) is an apomictic selection from a hybrid population generated in 1995. It produces high yields of high quality forage. It has antibiotic resistance to a range of Colombian and Brazilian spittlebug species. It has good drought

tolerance and better acid soil adaptation than the common spittlebug resistant cultivar. Seed yields is at least double than that of cv. Mulato, first hybrid produced by CIAT and released commercially.

The cv. Mulato II was released by the Papalotla Seed Company in 2005. Seed sales in 2005-2006 totaled over 63.5 tons, which is sufficient to sow 13,000 ha (assuming a sowing rate of 5 kg/ha), generating over one million dollars in revenues. Seed sales projected for 2007 total over 400 tons, which will generate an estimated US$4.5 million in revenues and sow an additional 80,000 ha.

Livestock producers who benefit from cv. Mulato II range from large livestock producers in LAC to smallholders in Asia who grow Mulato II to produce high quality forage to feed livestock. Additional economic benefits to smallholders are derived from artisanal seed production of cv. Mulato II as shown in Bolivia and Thailand.

The information on seed distribution in this document is based on seed sales data, experimental results on animal performance (CIAT Forages Project Annual Reports 2004, 2005, 2006), and economic analysis of crop production in Thailand (M.D. Hare: In Proceedings Forage Symposium: Forages- a pathway to prosperity for smallholder farmers, March 5-7, 2007. Faculty of Agriculture, Ubon Ratchathani University, Thailand. P. 35-60).

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6. List of proposals funded (2006)

- Implementación y difusión de Tecnologías para rehabilitación de praderas degradadas en el Sistema de Producción de Carne en los departamentos de Córdoba, Sucre y Atlántico. Collaborative work with CORPOICA. Proposal submitted by CORPOICA to MADR, Colombia for $ US 0.63 million. **Funds for CIAT: US $70,000 over 3 years**

- Trade-off analysis of using legumes for soil enhancing or as animal feed resource. Collaborative work with ILRI and INTA-Nicaragua. Proposal approved by ILRI led SLP **Funds for CIAT: US$ 195,300 over 2 years**

- Realizing the benefits of cover crop legumes in smallholder crop-livestock systems of the hillsides of Central America. Collaborative work with ETH and INTA-Nicaragua. Proposal approved by ZIL- SDC for US $ 425,000 over 3 years. **Funds for CIAT: US 100,000 over 3 years**

- Enhancing livelihoods of poor livestock keepers through increasing use of fodder. Proposal submitted to IFAD by the SLP led by ILRI. Funds for CIAT to operate in Vietnam. **Funds for CIAT: $ US 414,000 over 4 years**

- Forage legumes for supplementing village pigs in Lao PDR. ACIAR Project No.: LPS/2004/046. Jan 2006 - Dec 2008. **Funds for CIAT: US$300,000 over 3 years**

7. Problems encountered and their solution

Problems: In 2006/2007 the annual core budget of the Forage Project was cut by more than 50% and as a result there was a reduction in IRS and NRS in 2006 and again in early 2007. Starting in mid 2007 the Forage Project will have new leadership and will have to revise its strategy and research outputs to be in line with human and financial resources available and the product concept.

Less funding for forage work at HQ will result in the following research activities being affected:

a. Livestock economics studies and impact of forage technologies will not be continued

b. Pathology. Work will focus in host-plant resistance in *Brachiaria* to Rhizoctonia foliar blight. Work on fungal endophytes and nitrogen-fixing endophytic bacteria will either be stopped or moved to IPM related research in the Peoples and Agroecosystems RDC

c. Entomology. In the absence of Senior Entomologist, will focus on routine screening of *Brachiaria* hybrids for spittlebug resistance. Research on host-plant resistance in *Brachiaria* for adult spittlebug damage will be stopped.

d. Biological Nitrification Inhibition (BNI) work in *B. humidicola* will be stopped. The research priorities on BNI in *B. humidicola* will be in defining the tradeoffs between BNI and yield/quality, which will be key for defining breeding objectives.

e. Forage Quality/Utilization. Work on anti-nutritional factors in grasses and legumes and on forage utilization to define improved feeding systems for ruminants will be reduced significantly. With the appointment of a Post Doc in Animal Nutrition it is envisioned that work on forage quality and forages for monogastrics could continued, particularly if special project funding is identified.

Solutions: The future of Forage R&D at CIAT is conditioned to:

a. Successful fund raising strategy that involves traditional and new donors (i.e. Gates Foundation) in Asia and Africa and Public-Private Alliances in LAC. These Public-Private Alliances should not follow a single model but rather have two directions: Forage Improvement with the Seed Sector (i.e. Papalotla) and Forage Utilization/Management with NARS and Livestock Associations, following the CLAYUCA model.

b. Strong research group at HQ responsible for the development of improved forages with high quality and adaptation to major biotic and abiotic constraints in demand by producers.

c. Appointment of “Forage Champions” in the target regions working in close collaboration with staff at HQ and with different farmer groups and partners from the public and private sector.

d. Strong partnerships with ARIs to undertake joint strategic research and with NARS and Development Organizations interested in adapting and promoting forage/livestock technologies.

8. Staff List (IRS)

Principal Staff
Lascano Carlos E, Project Leader and Animal Nutritionist (100%)
Argel Pedro, Forage Agronomist, Costa Rica (until December 2006) (60%)
Cardona Cesar, Entomologist (until May 2006) (50%)
Holmann Federico, Animal Production Systems/Economics (until December 2006) (50%)
Kelemu Segenet, Plant Pathologist (50%)
Miles John, Plant Breeder (100%)
Peters Michael, Forage Biologist (100%)
Rao Idupulapati, Plant Nutritionist/Physiologist (30%)
Stur Werner, Forage and Livestock Systems, Southeast, Asia (100%)

Consultants
Cardona Cesar, (August 2006-August 2007)

PostDoc
Lentes, Peter, Socio-Economics and GIS, Honduras (100%)
van der Hoek, Rein, CIM Forage Expert, Nicaragua (100%)

9. Summary of Budget

A) HQ

ACTUAL EXPENDITURES 2006

PROJECT IP5: Tropical Grasses and Legumes - Headquarters

SOURCE	AMOUNT US$	PROPORTION (%)
Unrestricted Core	823,775	52%
Restricted Core		0%
		0%
Sub-total	**823,775**	**52%**
Special Projects	748,427	48%
Total Project	**1,572,202**	**100%**

B) Asia

ACTUAL EXPENDITURES 2006

PROJECT IP5: Tropical Grasses and Legumes - Asia

SOURCE	AMOUNT US$	PROPORTION (%)
Unrestricted Core	120,908	33%
Restricted Core	0	0%
	0	0%
Sub-total	**120,908**	**33%**
Special Projects	243,100	67%
Total Project	**364,008**	**100%**