Improved Multipurpose Forages for the Developing World

SBA3

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CIAT
Centro Internacional de Agricultura Tropical
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SBA3:

Improved Multipurpose Forages for the Developing World

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Improved Multipurpose Forages for the Developing World
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SBA3: Improved Multipurpose Forages for the Developing World

Project Overview and Rationale

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 in the tropics are located in areas with prolonged dry seasons and with land in different stages of degradation. This leads to an inadequate supply of high quality feed for livestock in particular in the dry season. In addition, in many cases smallholders with livestock and limited land (i.e. in Southeast Asia) do not have easy access to fodder and have to walk long distances to harvest forages. On the other hand, tropical 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 grown not only under favorable conditions but also in marginal environments. Improved tropical 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 crop-livestock interface, can enable smallholders to be more competitive, with positive effects on poverty alleviation; improved food security and related effects on health are additional benefits. At the same time forages can contribute to nutrient cycling via animal manure, resource conservation and reversing land degradation, with further potential for adaptation to climate change through the provision of ecosystem services (e.g. carbon sequestration, inhibition of biological nitrification, improved soil and water quality).

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 Outcome Line entitled Improved Multipurpose Tropical Multipurpose Forages for the Developing World which is housed in the Sharing the Benefits of Agrobiodiversity Research for Development Challenge (RDC). The goal of the work on forages is to conserve and exploit the genetic diversity either the natural variation or through breeding of tropical grasses and legumes to improve the livelihoods of poor rural livestock producers. This is done by integrating improved forages in smallholder systems through linkages to traditional and emerging markets and by contributing 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 the natural resource base and provide environmental services.

To accomplish the objectives of the Tropical Forage Outcome Line, the research is being organized around three major outcomes: 1) Forage germplasm developed through selection and breeding, 2) Forages as high value products developed to capture differentiated markets for smallholders, and 3) Forages integrated into smallholder systems for realizing the benefits of improved grasses and legumes in crop/livestock (including cattle, small ruminants. pigs, and/or poultry) systems through adaptation, innovation and adoption, aiming at higher livelihood security through higher resource use efficiency.

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 and more sustainable crop/livestock and feeding systems using an innovation systems approach.

As an activity across outcomes 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 thesis 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.

Alignment to CGIAR 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 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 production in smallholder systems.

To address the priorities of the CGIAR on livestock, the Tropical Forage Outcome Line of CIAT has the global mandate of developing forage-based technologies for extensive and intensive crop/livestock systems in diverse environments. Selected forages are expected to perform well in low fertility soils and 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 capacity of grasses with deep root systems to improve physical structure of soils and of legumes to improve both soil structure and soil fertility through deep tap root systems and biological N2 fixation. Furthermore, improved forages, mainly legumes, contribute to i) soil improvement through improved soil organic matter quality thereby enhancing soil biological activity and below-ground biodiversity, and ii) 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 RDC dealing with People and Agroecosystems, and with the TSBF (Tropical Soil Biology and Fertility) Institute of CIAT. These 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 Tropical Forage Outcome 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 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 a 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 short and long term training of individuals, group training and knowledge management (SP 5a)

Outcomes Description

Changes from previous MTP Outcomes

To capture emerging market and research opportunities targeted to smallholder farmers, CIAT in 2007 refocused its forage research into the Tropical Forage Outcome Line entitled Improved Tropical Multipurpose Forages for the Developing World. The outcome line concept is now fully implemented. As stated in last years MTP 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 were maintained. However, they were reorganized under the newly defined outcomes, and from 2010 onwards will follow the new outcome line structure. The inclusion of targeting and delivery of research products, as integral parts across the new outcomes, and more concretely addressing emerging market opportunities for forage-based high value and added value products and livestock other than cattle (such as monogastrics), are receiving greater emphasis. 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.

The major change in contrast to the MTP 2008 - 2010 is the revision of outcome 1, to include germplasm selection and breeding to develop superior forage options. While we continue our emphasis on breeding of *Brachiaria* grasses, the revision reflects better CIAT's work on selection of forage legumes and indicates opportunities for the selection and breeding of other forage grasses and legumes. CIAT intends to strengthen its work on forages and the environment. While recognizing that income generation to alleviate poverty remains the key driver in smallholder crop-livestock systems, environmental issues and resilience of systems become increasingly linked to achieve eco-efficient agriculture for sustainable livelihoods. CIAT will capitalize on past and present accomplishments in the areas of abiotic stress physiology, soil-plant-animal relationships, nutrient cycling and biological nitrification inhibition to develop forward looking research for protecting the environment.

These changes are in line with CIAT's recent document on strategic directions with a main focus on eco-efficient agriculture. To achieve the balance between economic, ecological, social and environmental impacts, CIAT forages will further emphasize the application of systems research to climate change. Complementary to developing forages with high tolerance to both drought and waterlogging to *adapt to climate change* (Outcome 1), to increase *income generation* opportunities (Outcome 2) and improve *systems performance* (Outcome 3), we will strengthen our research on integration of forages in crop-livestock systems to protect the environment.

We aim to increase our research efforts on quantifying the benefits of improved forages with deep and abundant root systems in reducing global warming potential through improved carbon sequestration and reduced emissions of methane and nitrous oxide. This research includes the development of forage options that are most suitable for environmental protection. The major challenge for this objective is maximizing agricultural Outcome per unit of input in integrated production systems, including the assessment and quantification of the environmental effects of forage-based livestock production in relation to economic Outcome. The results from this research are anticipated to have a positive impact on *adaptation* to and *mitigation of climate change.*

In 2008 we have consolidated our research for development activities, and our Outcomes are increasingly directed towards an outcome and market driven approach. As part of this effort we are intensifying our research on developing forages for monogastric animals, increasing on-station research and extending the field work from Southeast Asia to Latin America and Sub Saharan Africa. In line with our mandate we are also strengthening the global reach of our work. Responding to the EPMR recommendations in 2007 we have recently employed a Forage Expert for Central America, and a Forage Expert for East Africa is being recruited, to be working with partners in the region by early 2009. We have also secured support in livestock economics for the coming years Budget limitations have required further prioritization of forage research and related consolidation of staff.

However, funding for 2008 has stabilized, but as stated in last years MTP maintenance of core resources at the current level will be essential to deliver the outcomes stated in this document and also to respond to new challenges. Additional resources are sought to implement in consultation with other centers and partners our strategy in Eastern and Southern Africa to strengthen our work on the contribution of forages for more healthy agroecosystems. A key component in this approach is the improved collaboration with CIAT-TSBF, and the People and Agroecosystems

RDC to integrate forages into production systems and to realize their economic and environmental benefits.

Impact Pathways by Outcome

Outcome 1: Forage germplasm developed through selection and breeding.
To contribute to the improvement of livelihoods of poor rural livestock owners through high quality forages (outcomes 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 when 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, resistant to major pests and diseases and adapted to acid, low fertility soils, to poorly drained soils and to drought, are the outcome targets to be used by different partners engaged in research and development activities.

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

Outcome 3: Forages integrated into smallholder systems for realizing the benefits of improved grasses and legumes in crop/livestock (including cattle, small ruminants. pigs, and/or poultry) systems through adaptation, innovation and adoption, aiming at higher livelihood security through higher resource use efficiency. For its work in Sub-Saharan Africa, Southeast Asia and Latin America and the Caribbean, CIAT Tropical Forages Outcome Line is collaborating with ILRI and CIAT-TSBF, with complementary research priorities and expertise to integrate 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 outcomes. Information sharing through knowledge tools such as SoFT (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 a number of strong organizations in developed countries (e.g., Australia, USA) were involved in development of forages for sub-tropical and tropical environments. Currently the only suppliers of improved forages with an international mandate are CIAT, ILRI and ICARDA. The forage work carried out by these CGIAR Centers is complementary. For example, forages developed at ICARDA are mostly for the arid and semi-arid regions. ILRI is concentrating its work on maintaining and characterizing forage diversity, with forages integrated in systems through partners (including CIAT) along other feed components in Sub-Saharan Africa and Asia. Forages developed by CIAT are targeted for tropical lowlands and mid-altitude hillsides. EMBRAPA in Brazil is an additional important participant in tropical forage R&D, but with a national mandate.

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

1. 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 aluminum and low levels of phosphorus
- Understanding how forages adapt to drought and waterlogging
- Understanding how grasses inhibit biological nitrification in soil
- Understanding how and to what extent leguminous forages fix nitrogen and contribute to soil fertility and/or animal production

2. 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 forages 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

3. Developing superior grass and legume genotypes and cultivars (for increasing livestock productivity and protecting the environment)
   - Grasses and legumes selected from germplasm collections that have broad adaptation to environmental factors prevailing in target areas and with multiple functions in crop/livestock production systems
   - Grasses and legumes 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 forages for soil enhancement or as animal feed.

4. 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
   - Protocols for indexing diseases of quarantine importance that limit the flows of germplasm between LAC, Africa and Southeast Asia
   - Decision Support Tools with information on adaptation, uses and management of different forage species.

Elaboration of Partners Roles

Through partnerships with different organizations from developed and developing countries, the Tropical Forage Outcome 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 three outcomes of the Tropical Forage Outcome Line shown in parenthesis.

1. 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.

2. Cambodia DAHP, DA Kampong Cham and RUA: (Outcome 3) Improved feeding systems for more efficient beef cattle production in Cambodia. Funds from ACIAR via UNE.

3. Colombia FONTAGRO, Nicaragua INTA; Colombia CORPOICA; (Outcome 1) Desarrollo de Genotipos de *Brachiaria* spp. Adaptados a Suelos con Drenaje Deficiente para Aumentar Producción Bovina y Adaptar Sistemas de Pastoreo al Cambio Climático en América Latina. Funds from FONTAGRO.

4. Colombia MADR IICA FEDEGAN: (Outcome 3) Development and use of forage resources for improving competitiveness and productivity in sustainable livestock production systems for the Cauca department in Colombia. Funds from MADR.

5. Colombia MADR: (Outcome 3) Implementation and transfer of technologies for restoration of degraded pastures for beef production systems in the departments of Córdoba, Sucre and Atlántico. Funds from MADR.

6. Colombia Universidad de Cauca, Fondo Ganadero del Cauca: (Outcome 3) Increase of productivity, competitiveness and sustainability of small and medium livestock producers in the watersheds of Patía and plateau of Popayán. Funds from MADR.

7. Colombia CORPOICA-CVS-CARSUCRE-GANACOR-FEGASUCRE: (Outcome 3). Recuperation of degraded pastures. Funds from MADR.

8. Costa Rica SIDE; Guatemala ICTA and MAGA; Honduras DICTA; Nicaragua IDR; IICA and ILRI: (Outcome 2). Analysis of the beef chain in Central America. Funds from CFC.

9. France ANR: (Outcome 3) Biodiversity and environmental services at landscape level in the Amazon. Funds from ANR.

10. Germany CIM: (Outcomes 1 to 3) Forage Conservation and Feed Systems for Monogastrics; Forage experts for Central America and Eastern Africa. Funds from BMZ and CIM.

11. Germany U of Hohenheim; Colombia CORPOICA and U del Cauca, (Outcomes 2 and 3) Development of multipurpose forage legumes for smallholder crop/livestock systems in the hillsides of Latin America. Funds from Volkswagen Foundation.

12. Germany U of Hohenheim; Nicaragua INTA; Honduras DICTA: (Outcomes 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.

13. Germany U of Hannover; Nicaragua INTA: (Outcome 1) Developing Brachiaria hybrids with combined resistance to drought and aluminum toxicity. Funds from BMZ.

14. Germany – U of Hohenheim; U Rostock ; Colombia U del Cauca; U Nacional de Colombia; Nicaragua INTA; Rwanda ISAR; (Outcome 2). More chicken and pork in the pot, and money in pocket: Improving forages for monogastric animals with low-income farmers. Funds from BMZ.

15. Honduras and Nicaragua MIS Consortium: (Outcome 3) Quesungual Slash and Mulch Agroforestry System (QSMAS): Improving Crop Water Productivity, Food Security and Resource Quality in the Sub-Humid Tropics. Funds from IWMI.

16. Lao PDR National Agriculture and Forestry Research Institute; Australia Queensland Department of Primary Industries and Fisheries; Canada Nutrition Prairie Swine Centre, Saskatoon: (Outcome 2) Forage legumes for supplementing village pigs in Lao PDR. Funded by ACIAR.

17. Mexico PAPALOTLA Seed company and national partners: (Outcome 1) Breeding and evaluation of Brachiaria hybrids. Funds from PAPALOTLA.

18. Switzerland ETHZ; Nicaragua INTA: (Outcome 3). Improved feeding systems for dairy cattle in tropical smallholder farms. Funds from ZIL-SDC.

19. Switzerland ETHZ; Nicaragua INTA: (Outcome 3). Realizing the benefits of cover crop legumes in smallholder crop/livestock systems. Funds from ZIL-SDC.

20. Switzerland ETHZ; Nicaragua INTA; ILRI-Colombia: (Outcome 3). Trade-off analysis of using legumes for soil enhancing or as animal feed resource. Funds from Systemwide Livestock Program (SLP).

21. Thailand World Vision Khon Kaen University: (Outcome 3) Improving the reliability of rain-fed, rice/livestock-based farming systems in North East Thailand. Funds from ACIAR via WorldVision.

22. Viet Nam ILRI, National Institute of Animal Husbandry and Tay Nguyen University: (Outcome 2) Enhancing livelihoods of poor livestock keepers through increasing use of fodder. Fund from IFAD via SLP.

1. Logframe (2008). Improved Multipurpose Forages for the Developing World: Product Linea SBA3

Targets	Products	Intended User	Outcome	Impact
PRODUCT 1	Long term production and environmental benefits of multipurpose grasses and legumes secured through conservation, documentation and distribution, of forage germplasm	CIAT, CG centers, NARS, forage networks and development projects in LAC, Sub-Saharan Africa and Southeast Asia, and other users anywhere in the world interested in clean and documented forage genetic resources.	Conservation, multiplication, documentation and worldwide availability of tropical forage germplasm under mandate of CIAT	Short and long term availability of forage germplasm to ensure sustainable agriculture based production of smallholders in the tropics
PRODUCT 1 Targets 2008 **(recurrent activities)**	Tropical forage collection of 23,140 materials is maintained fully viable, clean, and documented, and available at any time for distribution to any bona fide user, according to procedures set in the MTA/ SMTA of the Treaty. 1,400 accessions/ year conserved in long-term conservation (-20C) at CIAT and safely duplicated at CIMMYT as security back-up. Identified, clean and documented germplasm of forages (anticipated at 600 samples/ year) is distributed to users in accordance with international standards (plant quarantine, IP norms as applicable) Forage legume germplasm taxonomy better understood	CIAT forage projects in LAC, Sub-Saharan Africa and Southeast Asia, forage networks, development projects, NARS, CG centers, others users anywhere in the world interested in clean and documented for forage genetic resources. Forage scientists, breeders, agrostologists, forage networks and consortia from both public and private sectors Taxonomists, Forage scientists and breedeers	On demand availability of forage germplasm to users throughout the world Forage genetic resources adapted to specific agronomic and market conditions are better known and used troughout the entire forage/animal production chain Improved description of forage legume genera andspecies	

1. Logframe (2008). Improved Multipurpose Forages for the Developing World: Product Linea SBA3

Targets	Products	Intended User	Outcome	Impact
PRODUCT 2	Improved Brachiaria grasses	CIAT and NARS researchers and seed companies	New cultivars of *Brachiaria* 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
Product 2 Targets 2008	A reliable, high throughput screening methodology, based on artificial inoculation, for assessing Rhizoctonia foliar blight resistance is developed A screening method to assess waterlogging tolerance in *Brachiaria* hybrids streamlined in the breeding program	NARS researchers, CIAT researchers NARS researchers, CIAT researchers	Sexual tetraploid *Brachiaria* hybrids with high resistance to *Rhizoctonia* foliar blight identified and introgression of resistance into the tetraploid sexual breeding population initiated Selected *Brachiaria* hybrids tolerant to waterlogging tested in different regions in LAC and Asia	
PRODUCT 3	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 *Brachiaria* 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
Product 3 Targets 2008	At least 3 legume varieties with high nutritional quality, capable of improving village pig production by at least 30% in extensive production systems identified	CIAT and NARS researchers	Small pig producers in extensive production systems in Asia evaluate and adopt forage legumes as supplementary feed	

1. Logframe (2008). Improved Multipurpose Forages for the Developing World: Product Linea SBA3

Targets	Products	Intended User	Outcome	Impact
PRODUCT 4	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 *Brachiaria* 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
Product 4 Targets 2008	3 perennial and annual herbaceous legume accessions that perform well under residual soil moisture and that are suited for hay and silage production identified Released CaNaSTA for targeting forages (and other crops) to specific environmental and market niches	NARS researchers and development programs NARS researchers and development programs	Livestock and non-livestock farmers in dry hillsides adopt annual legumes to make high quality hay and silage Researchers and development workers are using CaNaSTA to target forages to specific production and market niches	

2. Outcome targets 2008. Improved Multipurpose Forages for the Developing World: Product Linea SBA3

TARGETS 2008	Fully Achieved	75% Achieved	>50% Achieved	<50% Achieved	Cancelled	Deferred	EXPLANATION
OUTCOME 1 Tropical forage collection of 23,140 materials is maintained fully viable, clean, and documented, and available at any time for distribution to any bona fide user, according to procedures set in the MTA/ SMTA of the Treaty. 1,400 accessions/ year conserved in long-term conservation (-20C) at CIAT and safely duplicated at CIMMYT as security back-up.	X (1,480; also 1,086 to Svalbard in 2008)						GRU Annual Report 2008, also GPG2 Annual Report for 2008.
Identified, clean and documented germplasm of forages (anticipated at 600 samples/ year) is distributed to users in accordance with international standards (plant quarantine, IP norms as applicable)			X				(332 samples distributed in 2008; GRU responds to requests, and is not responsible for less requests than anticipated) GRU Annual Report 2008, also GPG2 Annual Report for 2008.
Forage legume germplasm taxonomy better understood	X						(245 Desmodium accessions were identified by Harvard specialist) GRU Annual Report 2008.

x

2. Outcome targets 2008. Improved Multipurpose Forages for the Developing World: Product Linea SBA3

TARGETS 2008	Fully Achieved	75% Achieved	>50% Achieved	<50% Achieved	Cancelled	Deferred	EXPLANATION
OUTCOME 2 A reliable, high throughput screening methodology, based on artificial inoculation, for assessing Rhizoctonia foliar blight resistance is developed	X						CIAT SBA3 Annual Report 2008, forthcoming http://www.ciat.cgiar.org/forrajes/index.htm
A screening method to assess waterlogging tolerance in *Brachiaria* hybrids streamlined in the breeding program	X						Rao, I. M., J. Rincon, R. Garcia, J. Ricaurte and J. Miles. 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. CIAT SBA3 Annual Report 2008, forthcoming http://www.ciat.cgiar.org/forrajes/index.htm

2. Outcome targets 2008. Improved Multipurpose Forages for the Developing World: Product Linea SBA3

TARGETS 2008	Fully Achieved	75% Achieved	>50% Achieved	<50% Achieved	Cancelled	Deferred	EXPLANATION
OUTCOME 3 At least 3 legume varieties with high nutritional quality, capable of improving village pig production by at least 30% in extensive production systems identified	X						Phengsavanh, P.; Stür, W. (2008). Farmer-led research in village pig production in Lao PDR. In: Thorpe W and Tesfaye Jemaneh. (eds). 2008. Pig systems in Asia and the Pacific: How can research and development enhance benefits to the poor? Proceedings of a regional workshop held in Bangkok, Thailand, 23–24 November 2006, co-organized by APHCA, FAO-RAP and ILRI. ILRI (International Livestock Research Institute), Nairobi, Kenya, p. 57-63. http://www.ilri.org/Infoserv/webpub/fulldocs/Pig%20Systems_proceeding/PigSystems_Asia_Pacific.pdf Phengsavanh, P.; Stür, W.; Keonouchanh, S. (2008). Adoption of the forage legume 'Stylo 184' (*Stylosanthes guianensis* CIAT 184) in smallholder pig systems in Lao PDR. Proceeding of the 13th AAAP congress: Animal Agriculture and the role of small holder farmers in a global economy, held in Hanoi, Vietnam 22-27 Sept 2008. CIAT SBA3 Annual Report 2008, forthcoming http://www.ciat.cgiar.org/forrajes/index.htm Martens, S.; Avila, P.; Franco, L.H.; Peters, M. (2008): Canavalia Brasiliensis and Vigna unguiculata at Different Growth Stages. In: Tielkes E. (Ed.) Competition for Resources in a Changing World: New Drive for Rural Development: International research on food security, natural resource management and rural development; book of abstracts / Tropentag 2008 Stuttgart-Hohenheim. Göttingen, 209.

2. Outcome targets 2008. Improved Multipurpose Forages for the Developing World: Product Linea SBA3

TARGETS 2008	Fully Achieved	75% Achieved	>50% Achieved	<50% Achieved	Cancelled	Deferred	EXPLANATION
							Martens S., Avila P., Franco L.H., Peters M. (2008): Rapid Assessment of Ensilability of Vigna Unguiculata and Canavalia Brasiliensis as an Option for Alternative Pig Feeding. In: Tielkes E. (Ed.) Competition for Resources in a Changing World: New Drive for Rural Development: International research on food security, natural resource management and rural development; book of abstracts / Tropentag 2008 Stuttgart-Hohenheim. Göttingen, 448. Martens, S.; Avila, P.; Gil, J.L.; Franco, L.H.; Peters, M. (2008): Silage Quality of the Legumes Vigna unguiculata and Canavalia brasiliensis Solely and with Sweet Potato Roots as an Alternative Pig Feeding. In: Tielkes E. (Ed.) Competition for Resources in a Changing World: New Drive for Rural Development: International research on food security, natural resource management and rural development; book of abstracts / Tropentag 2008 Stuttgart-Hohenheim. Göttingen, 447. L.S.Muñoz, P. Sarria, S. Martens, M. Peters, P.A. Aguirre and C.A. Montoya. Nutritional characterization of Vigna unguiculata as alternative protein source for monogastric animals. In: Organizing Committee of IGC/IRC Congress (ed.) Multifunctional Grasslands in a Changing World. Proceedings of the International Grassland Congress and the International Rangeland Congress, 29 June-5 July 2008, Hohot, China, 728.

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OUTCOME 4 3 perennial and annual herbaceous legume accessions that perform well under residual soil moisture and that are suited for hay and silage production identified	X						Reiber, C.; Schultze-Kraft, R.; Peters, M.; Cruz, H. (2008) Smallholder innovation of hay and silage technologies in Central America as an alternative to improve adoption of forage conservation. Proceedings of thr XXI. International Grassland Congress/VIII. International Rangeland Congress, 29th June – 5th July, 2008, Hohhot, China, 1113 CIAT SB 3 Annual Report 2007, Pages 121-142, 148-149 http://www.ciat.cgiar.org/forrajes/index.htm
Released CaNaSTA for targeting forages (and other crops) to specific environmental and market niches		X					O'Brien, R. (2008) Visualising Uncertainty in Spatial Decision Support. Proceedings of the 8th International Symposium on Spatial Accuracy Assessment in Natural Resources and Environmental Sciences, *Shanghai, P. R. China, June 25-27, 2008, pp. 335-340* *CaNaSTA, Crop Niche Selection in Tropical Agriculture: a Spatial Decision Support Tool* ***http://csusap.csu.edu.au/~robrien/canasta/index.htm*** While CaNaSTA is used internally in CIAT, user-friendliness needs to be improved and documentation developed before eventual release

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3. Research Highlights 2008

- **A quick screening technique for resistance to adult spittlebug damage was developed and tested**

  The Forage Program has made significant progress in the characterization and development of antibiosis resistance to nymphs in *Brachiaria* grasses. In previous years, no major attention had been given to the screening of germplasm for resistance to adults. In 2007 we developed a method to screen for adult damage and to study categories of resistance to adult feeding damage. We used twenty-day old plants infested with four neonate adults per plant until all adults died, usually 8-10 days after infestation. Results of those studies suggested a need to incorporate routine screening for tolerance to adult feeding damage as an additional selection criterion in the breeding scheme. To facilitate the process and assist the *Brachiaria* breeding program, in 2008 we developed a simpler, fast technique that can be used to screen hundreds of genotypes in a very short period of time. We used leaf cages to house isolated adults feeding for 7 days on a leaf of a fully grown *Brachiaria* plant. After screening more than nine hundred genotypes, we concluded that the leaf cage technique can be used to massively discard obviously susceptible genotypes.

- **Response of *Brachiaria* grasses to combined stress factors of drought and aluminum toxicity**

  A greenhouse study was conducted to determine differences in regulation of water use, water use efficiency (WUE) and shoot growth of six *Brachiaria* genotypes (and *Brachiaria* hybrid cv. Mulato 2 (CIAT 36087)) that were subjected to a combined stress of drought and Al toxicity in soil. *B. decumbens* CIAT 606 and *B. brizantha* CIAT 26110 cv. Toledo were found to be superior in their ability to tolerate the combined stress conditions of terminal drought and Al toxicity. The superior performance of these two genotypes was attributed to a delay in stomatal closure combined with efficient use of the moisture stored in the soil for plant growth during the dehydration process. Two genotypes, *B. ruziziensis* 44-02 and *B. brizantha* CIAT 6294 cv. Marandu were found to be sensitive to the combined stress conditions due to early stomatal closure that impacted their ability to use water to produce the shoot biomass. Two *Brachiaria* hybrids, cv. Mulato (CIAT 36061) and cv. Mulato 2 (CIAT 36087) showed greater demand for water with their higher growth rate and an intermediate type of response with moderate ability to adjust shoot growth to the decreasing soil moisture.

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

  Canavalia brasiliensis (Canavalia) shows potential to fix a significant amount of N. When completely removed for utilization as forage, it bears the risk of soil N depletion unless N would be recycled to the plot by animal manure. Integration of Canavalia increased average dry matter biomass availability with three tonnes per hectare and resulted in a significantly higher milk production of almost one kg/animal/day ($p<0.01$) with no negative effect on milk quality. The farmers recognize the positive effect of Canavalia both on soil fertility and on milk production. They showed significant interest in integrating Canavalia in their cropping system as a partial substitution to chemical fertilizers, to benefit from increased milk production during the dry season and to recuperate degraded soils.

4. PROJECT OUTCOME: Impact from adopting improved grasses for fish farming in Vietnam

(Outcome of 10 year collaboration in Viet Nam, indicated in MTP for that time period)

Authors: W. Stur (CIAT), T.T. Khanh (Tay Nguyen University), V.H. Yen (NAFRI), L.H. Binh (NIAH), P. Phengsavanh (NAFRI), P. Horne (ACIAR), F. Holmann (CIAT)

While fishing must surely be one of the oldest recorded sources of livelihood, it is only comparatively recently that fish have become important components of the diets of the majority of the world's people, especially those living in developing countries. Consumption of fish and seafood products reached 14 kg per capita in developing countries in 2001, nearly twice the level recorded in the early 1970s, while population in those countries doubled over the same period. Most of the net growth in fish production over the past 20 years has come from the development of fish farming, especially in the developing countries of Asia. The majority of the growth in fish production has come from aquaculture, which ranges from simple ponds utilizing naturally occurring food sources to highly intensive systems with water control, aeration, and supplemental feeding. With global fish supply struggling to keep pace with projected demand over the next 20 years, technology will play a crucial role. Production growth in aquaculture will come from (a) expansion of area; (b) from increased intensity of input use, especially feed; and (c) from technological improvements in both inputs and organisms (*Delgado et al*., 2003)[1].

In Vietnam, NARS's partners, together with the International Center for Tropical Agriculture (CIAT), begun testing improved grasses to increase fish production in 1997 in the province of Tuyen Quang. In 2005, CIAT and partners were working with about 1700 farmers and 500 of them were using improved grasses to feed herbivorous fish, replacing or complementing the traditional feed sources of specific native vegetation, cassava, rice bran, and banana stem. The main grasses adopted for herbivorous fish production were the grasses Panicum maximum ("Simuang"), Paspalum atratum ("Terenos"), and to a small extent Pennisetum purpureum (Napier). Herbivorous fish production in Tuyen Quang was practiced exclusively by smallholders, with a mean fish pond size of 1540 m2 and a mean forage plot size of 697 m2.

Farmers who adopted improved grasses were able to harvest 63% more fish by weight as well as to obtain 10.7% higher price per kilo of fish harvested because farmers received a "premium" due to the sale of heavier, larger fish (US$0.93/kg vs. $0.84/kg). Thus, forage adopters produced 2.3 times more income per pond than farmers who produced fish in the traditional way (ie. US$299 vs $90). The benefit : cost ratio of fish production was 72% higher for forage adopters than for non-adopters (2.56 vs. 1.49). Using planted forages for herbivorous fish production also reduced the amount of time needed to collect feed for fish ponds. The combination of higher fish production and reduced labour requirements resulted in higher economic returns to labour, which was was 5 times higher for forage adopters than for non-adopters (i.e., US$1.35/hr vs. $0.26/hr).

All forage adopters mentioned they invested the extra income from fish in the education of their children and in the acquisition of household needs. About half of them invested in the improvement of their overall standard of living. Twenty-seven percent in expanding cattle production and 17% increased fishpond area.

Adoption of planted grasses for herbivorous fish production has spread to neighboring provinces in northern Vietnam and other provinces where CIAT and NARS partners had introduced forages for smallholder livestock production. A recent survey of forage adopters in Ea Kar district, Daklak province in the central highlands of Vietnam showed that the grass Panicum maximum "Simuang" had been adopted for fish feeding by 1306 of a total of 3082 housholds with fish ponds; this equates an adoption rate of 42%.

The 10-year collaboration between CIAT and NARS in Vietnam in evaluating and validating improved forages has now translated into more market-oriented, profitable fish production for smallholder farmers in Vietnam.

[1] Delgado, Christopher L.; Wada, Nikolas; Rosegrant, Mark W.; Meijer, Siet; Ahmed, Mahfuzuddin (2003). Outlook for fish to 2020. Meeting Global Demand. Ifpri International Food. Policy Research Institute