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Annual Report 1998

Project PE-5 Sustainable Systems for Smallholders: Integrating improved germplasm and resource management for enhanced crop and livestock production

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Annual Report

Project PE-5 Sustainable Systems for Smallholders: Integrating Improved Germplasm and Resources Management for Enhanced Crop and Livestock Production Systems

Project Overview

Objective: To develop more productive and sustainable combinations of crops and livestock technologies to increase family welfare in smallholder systems of the tropics

Outputs: Methodologies for linking resource management with improved germplasm options. Technology components that can be readily integrated to produce productive and sustainable land use systems. Effective partnerships for research and implementation.

Gains: Integration of commodity and natural resource research. New approaches to the development of environmentally sound technologies. Indicators for measuring economic and environmental impact of improved technology at the farm and watershed levels. Methodology to extend results beyond benchmark sites.

Milestones:

1998 Workshop to analyze the effectiveness of FPR in the development of new technology options for smallholder systems.

1999 NARS in Central and South America and Southeast Asia trained in methodology for integrating natural resource and commodity research. Methodology for assessment of socioeconomic and environmental impact at farm level.

2000 New crop and livestock technologies for smallholder systems in Latin America and Southeast Asia, for example, use of legumes for soil improvement in cropping systems, new rice and banana varieties identified for forest margins, forage alternatives for dry season feeding, increased cassava production in mixed cropping systems with demonstrated impact of technologies on increased welfare of poor rural families and sustainable land use.

2001 New crop and livestock technologies for smallholder systems in Latin America, Southeast Asia, for example, increased bean production in low P soils; improved fallow systems for the forest margins, with demonstrated impact of technologies on increased welfare of poor rural families and sustainable land use. An analysis and synthesis of various approaches used for participatory diagnosis of needs and opportunities and in participatory technology development.

Users: The research will benefit low-income farmers in Latin America, Asia, and Africa by increasing available food and cash flow to rural households while providing a basis for more sustainable production systems. Adoption of environmentally sound farming practices will benefit society as a whole.

Collaborators: ICRAF, ILRI, IRRI; linkages with national R&D organizations and specialized research organizations.

CGIAR system linkages: Protecting the Environment (50%); Crop Systems (20%); Livestock Production Systems (15%); Training (10%); Networks (5%).

CIAT project linkages: Conservation of genetic resources; germplasm enhancement in beans, cassava, and tropical forages; natural resource management in areas of land use dynamics, soil processes, and watershed management; strengthening NARS through developing partnerships, participatory research, and impact assessment.

Project Work Breakdown Structure

Sustainable systems for smallholders: integrating improved germplasm and resource management for enhanced crop and livestock production systems

Project Purpose
To develop more productive and sustainable combinations of crops and livestock technologies to increase family welfare in smallholder systems of the tropics

Outputs	**Output 1** **Constraints and opportunities defined in smallholder systems**	**Output 2** **Integrated technology and management options**	**Output 3** **Enhanced capacity to promote adoption of productive and sustainable land use practices**
Activities	1.1 Characterize biophysical and socio-economic resources and resource use systems through PRA, base line characterization, and PD (PE-3, PE-4, BP-1)* 1.2 Ex-ante analysis of new technologies, management and employment options and market opportunities (SN1, BP-1)	2.1 Develop collaborative R&D partnerships through new projects and effective coordination 2.2 Develop new crop and livestock technologies for production systems with farmer participation (IP & PE, SN-1) 2.3 Develop integrated soil, water and management practices with farmer and community participation (PE-2) 2.4 Monitor socio-economic and environmental changes due to new technology and management practices through selection and use of specific indicators (PE-2, PE-4, SN-3, BP-1)	3.1 Investigate methods for increasing adoption of technologies, developed by FPR, that are economic and environmentally sound (SN-1,SN-3) 3.2 Develop integrated resource and GIS models to better target extension of results (PE-2, PE-3) 3.3 Develop training approaches and materials on targeting, development and diffusion of new technologies (SN-1, SN-3) 3.4 Communicate results through networks, workshops and journals

* Indicates collaboration with other CIAT projects

Work Log frame

Narrative Summary	Region	Responsible	Measurable indicators	Means of Verification	Important Assumptions
Purpose: To develop more productive and sustainable combinations of crops and livestock technologies to increase family welfare in smallholder systems of the tropics			- % increase in income of smallholders - Number of new component technologies - Measurable increase in soil fertility and soil water retention and decrease in soil loss	- Adoption and impact evaluation studies	Donor and client support for sustainable production system research
Output 1. **Constraints and opportunities defined in smallholder systems**			01 New approaches for targeting technology development using FPR 00 Reference sites characterized in relation to needs of social groups/ farming systems, baseline data to allow future impact assessment and ex-ante analysis to identify opportunities 99 Summary of diagnostic outcomes and further needs to complete baseline indicators for Pucallpa reference site 99 Summary or diagnostic outcomes and further needs for minimal set of baseline indicators for FSP sites in SE Asia 99 Summary of needs for baseline indicators at Tropileche sites	Review Published articles Summary report, articles Annual report Annual report Annual report	Methodologies can be developed with wide application for different farming systems Resources available Collaboration with ICRAF and CIFOR Input of an economist Input by BP-1
Output 1.1 Biophysical and socio-economic resource use characterized	FM-P FM FM H-Cau Asia	SF SF, RL SF, RL KMS WS	98 Paper on Land Use Strategies in Pucallpa 98 Paper on Comparative Land Use in Pucallpa and Yurimaguas 98 Comparative information on plant communities at forest margin sites under different land use 98 Improved predictability of soil erosion in the Hillsides 99 On-farm FPR evaluation sites in SE Asia characterized for impact assessment 98 PD completed at 18 on-farm sites	Book chapter Draft paper for journal Draft paper for journal Final report Central database established Project report	 RL devotes time to analysis of Yurimaguas data Funds obtained for economist position
Output 1.2 **Ex-ante analysis of the potential of new technologies, management and employment options**	FM-P FM-P FM-P FM,H	DW, FH, RB DW RB FH	99 Ex-ante analysis of the potential of old and new technologies, and management options 99 Enterprise budgets developed for traditional crops (rice, cassava, plantain, livestock) 99 Market opportunities evaluated for traditional crops 98 Ex-ante evaluation of potential for improved feed technologies for dual-purpose cattle	Draft paper for journal Annual report Annual report Paper submitted to Journal	Collaboration with locally based institutions Funds available for study

Narrative Summary	Region	Responsible	Measurable indicators	Means of Verification	Important Assumptions
Output 2 **Integrated technology and management options**		PE-5 team	00 Potential impact of new technology and management options known 98+ Collaborative research partnerships 98+ New technologies available 98+ New integrated technology and management options 98 Improved forage options available in Caqueta	Working documents Annual reports Publications Final report to Nestle	Market opportunities exist for adoption of new options
Output 2.1 Collaborative research and development partnerships					
Output 2.1.1 **Partnerships for participatory technology development**	 Asia Asia LAC FM-P FM-P	 WS,PH RH FH SF SF,PK, JA	Active partnerships 95 Forage research network in SE Asia 95 Cassava research network in Asia 96 Tropileche network in LAC 97 Participatory research group, Pucallpa 98 Adaptive research team Pucallpa	Annual report Newsletter, regional meetings Workshops Newsletter, Internet page Newsletter Report to IDRC,	Continued interest in collaboration by NARS partners
Output 2.1.2 **New projects for adaptive systems research**	Asia Asia	FH, PK WS, PK PK FH PK	99 Funding approved for second phase of Cassava Mgt project in Asia 99 Project approved for continuation of regional forage research in SE Asia 98 PR project for Pucallpa approved 98 New proposals developed for Tropileche in LAC 98 Project submitted for impact assessment in SE Asia	Donor letters, RMWG Annual reports	Approval by RMWG and MT
Output 2.1.3 PE-5 activities coordinated		PK WS FH, CL	98 Expected outputs achieved 98 Regional meeting, Samarinda, Kalimantan 98 Coordination meeting Tropileche	Report to MT	Cooperation within PE-5
Output 2.2 **New crop and livestock technologies for production systems**					
Output 2.2.1 Increased efficiency in utilizing forage resources	FM-P H-CA H-Cq	CL, FH, PJA	00 New combinations of feed resources that will increase milk production by 20% 99 Milk response to new feed resources related to cow's potential for milk production 98 Nutritional management indicators	Journal article Journal article Annual report	Effective collaboration with NARS Have access to cows with varying potential for milk production

Narrative Summary	Region	Responsible	Measurable indicators	Means of Verification	Important Assumptions
Output 2.2 .2 **New legume-based pasture technologies for dual-purpose cattle in tropical Latin America**	FM-P H-CA FM-Cq FM-P	CL, FH, PJA, KR	00 20% increase in milk and beef production with new technologies 97 Field pastures established 98 Consistent increases in milk yield with *Arachis*-based pastures in Caqueta with cows of moderate genetic potential for milk production 98 Milk yield increased with use of stylo by pre-weaned calves	Survey of impact Annual reports of progress in 1998	Effective collaboration with ILRI and NARS
Output 2.2.3 **Forage-based systems for dry season supplementation in tropical Latin America**	H-Cau H-CA	CL, PJA, FH	99 30% response in milk production during the dry season using new technologies 97 Field pastures and shrub legumes established 98 Preliminary results available	Survey of impact Annual report 1997 Technical report of progress in 1998	Government of Colombia project renewed end of 1998
Output 2.2.4 **Forage species evaluated for intensive mixed-systems for beef and milk production in Piedmont, Llanos**	S-Ll	CL, CP	02 New forage technologies adopted by farmers 98 New species established on 4 farms	Impact study Annual report	Gov of Colombia project renewed 1999 Demand for improved forages
Output 2.2.5 **Improved livestock feed supplies for smallholder farmers in South East Asia**	Asia	WS,PH	99 40 farmers at each of 18 sites using improved grass and legumes for livestock feeding in farming systems 98 All on-farm sites established 98 Mid-term project review of progress	Survey of impact Reports to donor, Annual report Report	Effective collaboration maintained with partners - CSIRO Tropical Agriculture and NARS in SE Asia Funds and reviewers available
Output 2.2.6 **Legumes and grasses adopted by farmers for multiple uses**	Asia H-Caq H-CA	WS EB, LHF MP, PJA	01 Increased use of green manures in CA in reference sites 99 Increase in associated crop yields demonstrated in Asia 99 Improved targeting for green manure and legume cover use in CA 98 Legumes established at sites in Asia&CA	Annual report Annual report	Collaboration with NARS in SEA Collaboration with PE-3 Collaboration with PE-2 in Cauca
Output 2.2.7 **New cassava options for Asia**	Asia	RH	98 20% increase in cassava yield with lower unit cost of production using new technologies	Annual Report Proceedings of Regional Workshop	Special project funds continue through 1998
Output 2.3 **Integrated, soil, water and management options**					

Narrative Summary	Region	Responsible	Measurable indicators	Means of Verification	Important Assumptions
Output 2.3.1 **Integrated technologies developed with farmers in Pucallpa**	FM-P	PR Group SF, KR, PK, DW, RL ICRAF NARS	02 40 farmers using new fallow systems 00 100 Farmers in reference area using FPR with 50% increase in income and improved management of soil and vegetation resources 99 Evaluation of new crops targeted by PD 98 FPR experiments with rice, banana, fallow improvement, covers and forages 97 PR Group initiated, PTD commenced in different areas with rice and banana and fallow improvement	Impact study Impact study Annual report Annual Report Annual report	Continued source of funding Local institutions accept FPR Operational funds available
Output 2. 3.2 **Integrated soil conservation strategy for cassava-based systems in Cauca**	H-C	KMS	98 Community demonstrations established	Final Report BMZ Project	Collaboration maintained with NGO's
Output 2.3.3 **Diversified cassava production systems to increase production and reduce soil erosion**	H-Ca	GD	98 Component mixtures evaluated for inter-cropping 98 On-farm validation of inter-cropping	PhD thesis draft	Funds available
Output 2.3.4 **Improved management practices for cassava production in Asia**	Asia	RH	02 40 farmers at 10 sites using improved management practices 98 Increased net benefits to farmers with less erosion at FPR sites	Impact study Annual report Proceedings of regional workshop Project review report	Special Project funding continues
Output 2.3.5 **DSSAT model adapted for smallholder systems and applied in Central America**	H-CA	AG, HB	00 Model adapted for use with maize, beans, GM legumes, coffee, grasses and livestock 99 DSSAT option available from CENICAFE for application in coffee-based smallholder systems 99 DSSAT applied to evaluate different hillside farming systems 98 Century-DSSAT linkage functioning 98 Legume green manure option included 98 Brachiaria option included in DSSAT	Journal article Annual report Annual report Annual report Annual report Annual report	Funding available Collaboration with CENICAFE Collaboration with HB, PE-3 Fortran program operates Can repeat legume growth and development experiment in Honduras Student input is successful Collaboration with HB, PE-3
Output 2.4 **Socio-economic and environmental impact of new technologies**					
Output 2.4.1 **Potential impact of new technologies developed through PR or extended to farmers**	FM-P	DW, SF, RL, AB, MW, PE-2	00 Impact analysis 98 Decision made on indicators and initial baseline sample of farms/farmers in the reference area	Journal article Annual report	Funding remains available for resource economist Economist takes up position in March
Output 2.4.2 **Analysis of trade-off in private vs public benefits with alternative land use systems**	FM-P	DW-CIAT SV-IFPRI	99 Analysis completed 98 Workplan for study	Journal article prepared Annual report	Agreement reached with CIFOR

Narrative Summary	Region	Responsible	Measurable indicators	Means of Verification	Important Assumptions
Output 2.4.3 **Potential economic and environmental impact of new forage technologies in LAC assessed**	FM-Cq H-CA	FH, PK KR, DW Univ CR PE-2	00 Impact of new forage technologies developed through Tropileche 99 Selection of indicators in CR 98 Data collection in Pucallpa 98 Data collection in CR 98 Persons trained in data collection	Journal article Annual report	Assistance obtained through PhD student Collaboration with UCR
Output 2.4.4 **Potential impact of new forages in SE Asia assessed**	Asia	WS, PH, SF	00 Impact analysis 99 Data collected at selected sites 99 Persons trained in collection of data for impact analysis 98 Pilot collection of basic data for future monitoring and impact analysis at one site 98 External review of FSP project	Annual report Annual report Trip report/paper Report	Resources for impact analysis
Output 3 **Enhanced capacity to promote adoption of productive and sustainable land use practices**		PE-5 team	01 Approaches developed in PE-5 being used by others	Survey of secondary information and literature	Collaboration and input from other CIAT projects and Communication unit
Output 3.1 **Synthesis of FPR approach for production systems research**					
Output 3.1.1 **Synthesis of participatory and systems research in CIAT**		SF	01 Review of approaches using FPR methodology for sustainable technology development 97 Workshop on systems research held at CIAT 98 Publication of workshop including an appraisal of FPR approaches to technology development	Publication Proceedings of CIAT workshop	Success of PTD in different regions Collaboration with SN-3 Communication Unit has resources to undertake publication
Output 3.2 **Integrated resource and GIS models to better target extension of results**					
Output 3.2.1 **Integrated resource model for targeting research and dissemination**	H	AG	00 DSSAT model used to define applicability of new technologies in mixed-farming systems 98 Data available for application of DSSAT in Honduras hillside farming systems	Working document	Resources remain available for modeling activities
Output 3.2.2 **Cornell rumen model adapted for tropical feeds**		FH	00 Modified Cornell ruminant model for tropical conditions 98 Plan developed with Cornell for modification of model		Funding obtained for PhD or Master's student
Output 3.2.3 **Adaptation of forages integrated with GIS database**	H	MP, GH, LHF	99 – Model for integrating forage adaptation with GIS data bases	Annual report	Funding available

Narrative Summary	Region	Responsible	Measurable indicators	Means of Verification	Important Assumptions
Output 3.2.4 **Farm level options for resource use integrated with options at landscape and regional levels**		PK, RK, GH	00 Methodology for integration of farm level options at landscape level 98 Strategy defined for achieving this output	Annual report	Collaboration with PE-3 and PE-4
Output 3.3 **Increased institutional capacity for participatory technology development and dissemination**					
Output 3.3.1 **Manuals developed on participatory research and persons trained**	Asia	WS, PH	98 Manual produced on forage seed production 98 4 in-country courses conducted on PTD with forages 98 On-site training provided for 2 forage scientists	Manual available Persons trained Proceedings Persons trained	Continued collaboration with partners
Output 3.3.2 **Increased capacity for using FPR methodology**	Asia Asia FM-P	RH, SF WS SF, AB	1998 In-country courses held in Indonesia and China and 30 persons trained 1998 In –country courses held in forage development using FPR methodology 1998 20 persons trained in FPR methodology in Pucallpa	Persons trained Annual report	Collaboration with training Demand for FPR training
Output 3.4 **Communication of results**					
Output 3.4.1 **Regular newsletters distributed**		SF, AB, KR FH WS, PH	98 Regular newsletter of PR activities in Pucallpa 98 Tropileche newsletters 98 Maintenance of Tropileche database on Internet 98 SEAFRAD newsletters	Newsletters available Newsletters available Website Newsletters available	Time allocation
Output 3.4.1 **Research publications**		SF WS FH CEL PK AG	Research papers 1.1 (4) Journal article (1), Conference articles (3), Proceedings published (3) Research paper (1), Conference (1) Research paper (1), Conference (2) Research paper (1), Proceedings (1) Research paper (1)	Annual Report	Time allocation

Project strategy

CIAT 's mission is:

To contribute to the alleviation of hunger and poverty in tropical developing countries by applying science to the generation of technology, leading to lasting increases in agricultural output while preserving the natural resource base

CIAT's strategy to achieve this is through *Doing Research Together*, i.e. collaborating with a range of partners, to integrate germplasm improvement with natural resource management.

Project PE-5, Sustainable Systems for Smallholders, follows this strategy of integrating improved germplasm and resource management practices in smallholder farming systems. It operates at two levels:

i. Taking improved germplasm, primarily from CIAT germplasm improvement projects, and developing technology components with farmers and

ii. Facilitating solutions at the landscape or watershed level, through evaluation of various options for increasing productivity while improving resource management, and synthesis of the results so that they can be presented as policy options to decision makers.

At both levels, research is conducted in a systems context.

For component technology development, this involves diagnosis and evaluation of opportunities for a new technology within the overall farm system, participatory development of the technology with farmers and local partners (essentially adaptation of potentially useful technologies developed through applied research), monitoring and impact assessment, feedback to applied researchers, and dissemination of the results.

For landscape or watershed level research, it involves facilitating the formation and operation of multi-disciplinary research teams comprised of all organizations working in the area, characterization of the area, diagnosis of problems, evaluation of options, facilitating adaptive research to work on priority issues, monitoring and impact assessment and synthesis of results for presentation to policy makers.

The strategic outputs from this research will be:

i. Appropriate component technologies in areas where CIAT has a comparative advantage such as in beans, cassava, forages, rice, soils through participatory approaches.

ii. Models of multi-institutional collaboration and participation.

iii. Increased capacity of national institutions to conduct component and systems research using a participatory approach.

iv. Policy options for decision makers on alternative options for sustainable management of resources

The research is dependent on effective partnerships within CIAT and with national and international organizations.

At present PE-5 is involved in development of component technologies for cassava, forages and rice and in landscape systems research in the forest margins, Pucallpa, Peru. We are also partners in systems team led by the University of Hue in Vietnam.

Highlights and Progress towards achieving objectives

PE-5 undertakes research on component technology development on forages and cassava in Southeast Asia and on forages in dual-purpose farms in Latin America, and on systems research at the landscape level in the forest margins, Peru. Work on modeling and economic analysis aims to integrate outputs from this and other projects at the agroecosystem or regional level. This is an overview of *highlights* from the year's research, the progress made and the contribution to the intermediate outputs of the project.

Output 1. Constraints and opportunities defined in smallholder systems

Output 1.1 Biophysical and socio-economic resource use characterized

a) Characterization of the reference site for the forest margins agro-ecosystem, Pucallpa. Peru (p22)

The initial characterization carried out in collaboration with PE-4 has been completed and was reported previously. This year we report on biodiversity changes under different land uses.

- *Although continuing to have high plant species counts, non-forest land uses in Pucallpa have greater densities of weeds and a decline in counts of farmer-named useful species than forest.*

This completes the initial characterization of the site. Additional characterization will be related to the need to monitor changes as new issues that are addressed, e.g. development of agro-industry.

b) Improved predictability of soil erosion in the Hillsides (p24)

This is the output of a Special Project on reducing soil erosion in cassava-based systems that has terminated. The final year was devoted to collecting additional data on rainfall events, integrating project databases with the CIAT GIS database, and evaluating indicators for predicting erosion.

- *Recording and analysis of the kinetic energy of more than 140 rainfall events will allow a more reliable assessment of the rainfall erosivity factor for predicting soil loss risk in the Andean zone.*
- *Data from > 10 years of rainfall events and soil erosion have been integrated with the CIAT GIS database for the Hillsides.*
- *Turbidimetry measurement of soil dispersed from aggregates has potential for being used as an indicator of soil health in relation to the resistance of soil erosion to erosion.*

Selected sites from this project are now being managed by PE-2.

c) Characterization of on-farm sites for forage evaluation in Southeast Asia characterized (p29)

The Forage for Smallholders Project works at 18 sites in Indonesia, Lao PDR, Philippines and Thailand. Sites have been characterized so that the impact of new forage technology can be monitored.

- *Collected and summarized environmental and farming system site characterization information for 18 on-farm sites of the Forages for Smallholders Project*
- *Participatory diagnosis conducted at 18 sites*

This characterization provides basic data for an impact assessment study that is planned next year (see 2.4.4)

Output 1.2 Ex-ante analysis of new technologies, management and employment options

a) Potential of new technologies and management options in the forest margins, Pucallpa (p34)

An economic optimization and feasibility analysis of smallholder farming systems is being carried out at the Pucallpa in association with the participatory technology development project, DEPAM

- *Existing economic data available in Pucallpa has been summarized and development of farm budgets for different commodities commenced*

The initial ex-ante evaluations of alternative technologies will be completed next year. It is planned to develop a generalized model that can be used for evaluating technology alternatives in the future.

b) Ex-ante evaluation of potential for improved feed technologies for dual-purpose cattle farms (p36)

- *New forage alternatives of Cratylia+sugarcane for dry season supplementation and Brachiaria-Arachis pastures to replace existing pastures allow purchased supplementation to be reduced or eliminated, and steep land reallocated for reforestation in Costa Rica*
- *New forage alternatives offer a large increase in productivity and decrease in cost of production of milk if used in conjunction with the credit scheme that is being offered to small farmers in Nicaragua*
- *In contrast, in Pucallpa, Peru, new forage alternatives do not offer a viable option to farmers in a situation where there is abundant existing pasture and a low market potential*

An outcome of this analysis is a decision to move some Tropileche activities to a forest margin site at Moyobamba, also in Peru, where there is greater need and opportunity for improved forage technologies.

Another outcome has been training CORPOICA staff in the use model for ex-ante evaluation of forage technologies in different regions in Colombia.

Output 2. Integrated technology and management options for production systems

Output 2.1 Collaborative research and development partnerships

2.1.1 Collaborative partnerships

a) DEPAM Consortium, Aguaytia watershed, Pucallpa, Peru (p.47)

CIAT with IDRC and CODESU is facilitating the development of a multi-institutional and participatory approach to technology development in the forest margins reference site, Pucallpa.

- *Program coordinator and agro-industry and market specialist appointed*
- *Multi-institutional teams have commenced farmer participatory research on specific problems identified by the farming community.*

This is an on-going process in developing a model for applied and adaptive research led by local partners.

b) TROPILECHE Consortium, Latin America and the Caribbean (LAC) (p.48)

This has a focus on intensifying livestock production through improved forage technologies.

- *Publication of a book on methodologies for on-farm research*
- *New partnerships with organizations in Nicaragua and Honduras*
- *Research programs in Peru and Costa Rica now well established*

Tropileche was initially an acronym coined for a project submitted to the SLP. It has become a platform for moving new germplasm and forage technologies and communication between researchers working on dual-purpose cattle systems in Latin America.

c) Forages for Smallholders Project (FSP) and SEAFRAD network, Southeast Asia (p.49)

This project is using a farmer participatory approach to introduce germplasm and develop forage technologies through national organizations in Indonesia, Lao PRD, Philippines and Vietnam, and which also networks with China, Malaysia and Thailand.

- *A project review in 1998 showed a high rate of adoption of new forage materials by farmers*
- *This was attributed to a well executed program of technical input and training which had produced enthusiastic national teams at the FSP pilot sites*

The outputs of the 5-year project will be presented at an international conference to be held in Cagayan de Oro, Mindano, Philippines, in October 1999.

d) Asian Cassava Research and Development Network (p.50)

This is a network of researchers involved in improvement and management of cassava in Asia.

- *Proceedings of the 5th Regional Workshop, held in Danzhou, Hainan, China, Nov 3-8, 1996, were published in April 1998.*

A Regional Stakeholders Consultation Meeting to define a new cassava strategy and to set priorities for future research in Asia, has been organized for November 1998.

2.1.2 New projects for adaptive systems research

New funding was obtained for the DEPAM project in Pucallpa, Peru, and for the Tropileche project from BID and the Systemwide Livestock Program.

New projects have been submitted for component technology development of forages and cassava in Southeast Asia, for impact assessment in Asia and for funding from the Systemwide Alternatives to Slash and Burn Program.

2.1.3 Coordination

a) Forest margins site – Pucallpa. Peru (p.53)

Research within CIAT and with other organizations has been consolidated through development of:

- *A common vision for IARC research*
- *A consolidated work plan for research in the reference site*

CIAT, CIFOR and ICRAF will hold a planing workshop in May 1999.

b) PE-5 – Sustainable Systems for Smallholders project (p.54)

The main focus has been on developing a research program at the landscape level at the forest margins site in Pucallpa, Peru. This included a consultation with stakeholders, project development (DEPAM) and recruitment of scientists in resource economics and participatory research. Visits were made to Asia and with input into reviews for the forage and cassava related projects.

- *Systems research consolidated in forest margins site, Pucallpa*

It is suggested that future coordination efforts need to be concentrated on consolidating agroecosystem and regional teams rather than to coordination of project activities *per se*.

c) Tropileche (p.54)

The main coordination activities were:

- *A participatory workshop was held in Costa Rica during February of 1998 with all partners to review current research and planning of new activities*
- *Research programs in Peru and Costa Rica are now well established and being developed in Nicaragua and Honduras*
- *Discussions were held with Venezuela to become active partners in Tropileche*
- *Database on livestock research results in LAC expanded and made available on the internet*

There are plans to hold a meeting with national partners in 1999 to review the areas in which Tropileche can best interact with national partners and to plan future projects and activities.

d) Forages for Smallholders Project (p.55)

Coordination is achieved through the annual meeting and regular site visits.

- *Third Annual Regional Meeting of the Forages for Smallholders Project in Samarinda, Indonesia from 22-27 March 1998*
- *Mid-term external review of the Forages for Smallholders Project from 19 March to 8 April 1998*
- *Feature article in December 1998 issue of In Focus, in-house magazine of AusAID.*

The next annual planning meeting will be held in Vietnam in January1999.

e) Integrated Cassava-based Cropping Systems in Asia (p.57)

Coordination was maintained through regular visits to collaborators in the different countries.

- *End-of-Project review which stated that the project had met its objectives and that the outcomes formed a sound basis for a new project.*

The review included a strong recommendation from partners that funds be sought to continue the coordination of cassava research activities and the network by CIAT staff.

Output 2.2 New crop and livestock technologies for production systems

2.2.1 Increased efficiency in utilizing forage resources

This output aims to increase the efficiency of utilization of forages and feeds for milk production from dual-purpose cattle. The following are highlights of individual experiments conducted during the year.

a) Supplementation with *Cratylia argentea* and sugarcane (p.56)

- *Response in milk yield to legume supplementation of sugarcane and a basal grass diet was greater in the dry than wet season*

b) Supplementation with Cratylia argentea and sugarcane during the wet season (p.59)

- Cratylia argentea *increased milk production in cows with a high potential for milk production when fed as 100% of the supplement*

c) Use of *Cratylia argentea* for dry season supplementation of sugarcane supplementation (p.60)

- *It was shown that* Cratylia argentea *can be used to replace purchased protein supplements for cows of medium-high potential for milk production.*

d) Use of *Stylosanthes guianensis* hay as a supplement for increasing milk yield (p.61)

- *Low quality legumes cannot make a contribution to increasing milk yield.*

e) Legumes as protein sources for supplementing sugarcane in feed rations for milking cows (p.62)

- *Legumes with crude protein composition of <12% are not an appropriate substitution for chicken manure for milking cows*

f) Milk urea nitrogen as an indicator for devising feeding strategies for milk production (p.64)

- *Milk urea nitrogen (MUN) concentration is a good indicator of the protein to energy ratio in the diet, responses to protein supplementation being expected below <10 mg/dl MUN.*
- *MUN concentration could be a useful indicator in increasing the efficiency of use of on-farm feed resources*

This research has highlighted the important role that a relatively new shrub legume, *Cratlylia argentea*, might play in providing a protein supplement for milk production during the dry season. It also demonstrates that tropical legumes *per se* are not a useful feed source when mature and low in protein. There is need for more emphasis on managing legumes (and processing in the case of hay) to ensure that a high quality product is obtained.

The use of MUN as an indicator of protein to energy status will be evaluated under on-farm conditions. This could improve the precision of on-farm research for milk production.

We plan to continue this research on optimizing efficiency of utilization of forages and feeding stuffs as it provides a sound basis for devising potential feed technologies that can be further developed on farm.

2.2.2 Legume-based pasture technologies for dual-purpose cattle production in Latin America

These are initial results from the on-farm trials conducted under Tropileche

a) Use of an *Arachis pintoi-Brachiaria decumbens* association for milk production, Atenas, Costa Rica (p.66)

- Arachis pintoi *associated with* Brachiaria decumbens *increased milk production from 9.7 to 10.7 l/d even when concentrates were being fed.*

b) Use of grass legume mixtures to increase milk production in the forest margins of Peru (p.67)

- *Initial results of the role of legumes in increasing milk production are inconclusive*

c) *Stylosanthes guianensis* for strategic supplementation of pre-weaned calves (p.68)

- *Use of a legume to feed pre-weaned calves increased the collection of milk from dual-purpose calves with the potential to increase farmer cash income*

These results demonstrate a potential for legumes where there is a high level of farm management. These on-farm trials will be continued for another two years in order to measure associated effects on soil fertility as well as on milk production.

2.2.3 Forage-based systems for dry season supplementation in tropical Latin America

This research aims to overcome feed limitations during the 6 months dry season in Central America.

a) Evaluation of *Cratylia argentea* as a new legume-based forage alternative (p.70)

- *Forage systems for strategic supplementation during the dry season reduce the need to buy concentrate feeds and increases income in dual purpose farms*
- *The use of legume fodder with an energy source during the dry season maintains milk yield*

b) Use of legumes for supplementing calves during the dry season (p.71)

- L. leucocephala *is an alternative option for supplementing pre-weaned calves on higher fertility soils during the dry season.*

The on-farm trials will be conducted for another two years to allow time for the technologies to be adapted by farmers to their particular needs.

2.2.4 Forage species evaluated for intensive mixed-systems in the Piedmont, Llanos

Renovation of degraded pastures using *Arachis pintoi (p.72)*

- *Four new accessions of* Arachis pintoi *are being evaluated under grazing on four farms*

The on-farm trials were only planted in August 1998 and will be continued for another 3 years.

2.2.5 Improved feed supplies for smallholder farmers in Southeast Asia

- *Established 18 on-farm sites in Indonesia, Laos, Philippines, Thailand and Vietnam, where the Forages of Smallholders Project is developing forage technologies with farmers are beginning to utilize significant areas of forage*

At sites that have been established 3 years, there is considerable spontaneous adoption occurring. This special project will terminate in December 1999. It is expected that outputs (at least 40 farmers using improved forages at each site) will be met. We are seeking funds to continue this research beyond 2000, so that participatory adaptation of forages can be facilitated beyond the initial adoption stage.

2.2.6 Legumes and grasses adopted by farmers for multiple uses

Forages are promoted as contributing to improved resource management as well as feeding livestock. This output aims to better assess this multiple use in different agroecosystems.

a) Participatory evaluation and strategic targeting multipurpose germplasm in the hillsides of Central America (p.77)

- *In 1998, sites were selected and forage germplasm nurseries established at four sites in Honduras where legumes will be evaluated with farmers for multiple uses.*

b) Legumes as green manures in cassava-based systems in Asia (p.78)

- *Short-term use of green manure (2-4 mths) increased cassava yields but not as high as the yield obtained with high rates of fertilizer*
- *Long-term green manuring (18 mths) resulted in very high yields of cassava. Green manures have a role where there is no shortage of land and/or labour.*

c) Grasses for use as contour barriers to control erosion in cassava-based systems (p.81)

- Paspalum atratum *was the most promising hedgerow species, as it is less competitive than other grasses and is highly drought tolerant.*

d) Multiple use of forage legumes and grasses in smallholder systems in Asia (FSP project) (p.82)

- *In on-farm sites in Southeast Asia where farmers are selecting forages for feed improvement, they also select them for resource management such as erosion control and soil improvement.*

These results illustrate the wider impact of grasses and legumes than for livestock feed. This work will be continued in various cross-project activities and in special projects.

2.2.7. New technology options for cassava in Asia

a) New varieties of cassava (p.84)
- *Improved varieties serve as an entrance point for NRM research*

b) The nutrient requirements of cassava (p.84)

- *High yields of 20-30 t/ha can be maintained during continuous cropping for 6-10 years with annual applications of 80-100 kg/ha N, 17-20 kg/ha P and 60-80 kg/ha K.*

c) The effect of planting date on cassava production and on erosion (p.88)

- *Under the soil and climatic conditions of Rayong Research Center in Thailand the best time for planting cassava is in December; this resulted in the highest root and starch yield, as well as the lowest level of erosion.*

This output provides inputs for the FPR research (2.3.4).

Output 2.3 Integrated soil, water and management practices

2.3.1 Integrated technologies developed with farmers in Pucallpa (DEPAM)

a) Farmer participatory testing of new rice varieties (p.92)

- *Farmers tested new rice varieties. Yields of two introduced varieties were equal or slightly superior to farmers' varieties; and yields of three introduced varieties matched or were slightly lower than the lowest yielding farmer variety. The growing season was subject to severe drought stress. Farmers are enthusiastic to continue testing.*
- *Participatory research methods involve farmers in a new relationship with researchers in the technology development process.*
- *Local institutions are testing new methods to work with farmers.*

b) Inputs into the design of inter-institutional farmer participatory research projects (p.93)

- *CIAT is providing inputs into multi-institutional projects proposed for DEPAM funding. Inputs contribute to the nature of research (as opposed to extension), farmer participation, and inter-institutional collaboration.*

It is expected that there will be a need to continue this activity for at least 5 years as part of the process of developing a multi-institutional and participatory model for developing new technologies.

2.3.2 Integrated soil conservation strategy for cassava-based systems in Cauca

Case studies of evaluation of technologies for soil conservation (p.96)

- *Adoption of soil conservation technology sharply increased when short-term value could be added to the conservation components*
- *Partiña grass, a local source of raw material for brooms fabrication and blackberry-grass strips, a technology based on market opportunities, were evaluated and identified as new technology options for soil conservation in Cauca, Colombia.*
- *An interdisciplinary project on the introduction of blackberry – a market opportunity selected for better soil conservation was set up in CIAT's pilot watershed in southern Colombia.*

This project has terminated and results are being promulgated widely.

2.3.3 Diversified cassava production systems to increase production and reduce soil erosion in Cauca, Colombia

- *Cassava yields are heavily affected by undersowing and intercropping.*
- *Additional soil cover and biomass production by the intercrops are not sufficient to compensate for the loss in total cassava biomass, either biologically or economically.*
- *Farmer's reactions to on-farm trials indicate that short-term economic benefits are of higher priority than long term sustainability considerations.*

These outputs are from research for a PhD thesis which will be completed this year.

2.3.4 Improved management practices for cassava-based systems in Asia

Demonstrations on farmers fields and FPR trials (p.106)

- *During 1997/98 105 farmers conducted FPR trials on erosion control, varieties, fertilization and intercropping practice at nine pilot sites in four countries.*
- *Many farmers at the FPR pilot sites have adopted new cassava varieties, better fertilization practices (i.e. higher levels of N and K and lower levels of P, in combination with farmyard manure), intercropping with peanut or maize, and contour ridges hedgerows of sugarcane, vetiver,* Tephrosia candida *or* Gliricidia sepium.

This project terminates this year. New funding is being sought to further develop improved NRM practices with farmers and to develop methodology for dissemination of the results.

2.3.5 DSSAT model adapted for smallholder systems

- ***Brachiaria decumbens** option added to DSSAT*
- *DSSAT linked to the soil-organic-matter and crop-residue module of CENTURY.*

These are initial activities in adapting the DSSAT or other process model for simulating mixed crop and livestock production on small farms.

Output 2.4 Socio-economic and environmental impact of new technologies

Output 2.4.1 Potential impact of new technologies developed through PR

An indicator framework for impact analysis in the Forest Margins, Pucallpa, Perú (p.118)

- *Set in place a plan to develop indicators for different research issues that are being undertaken by the Ecoregional Center for the forest margins, Pucallpa*

This research has a much wider perspective than the issue of FPR. We will work with all scientists in Pucallpa to develop indicators for different issues under a common framework. This is an iterative process it is expected to have a initial framework for major issues being researched by 1999.

2.4.2 Analysis of trade-off in private vs public benefits with alternative land use systems

No activity in 1998. More focus will be devoted to this area as initial studies at the farm level are expanded to the landscape and agroecosystem levels and additional funding is obtained.

2.4.3 Potential and environmental impact of new forage technologies assessed

Early adoption of Arachis pintoi in the humid tropics, Caqueta, Colombia (p.121)

- *85% of the 68 producers using Arachis pintoi from the 229 interviewed expression satisfaction of growing the legume in association with a grass. Advantages were given as stocking rate, milk yield, and/or increased weight gain.*
- *Concurrent economic analysis during the process of adoption or adaptation of a new technology is useful to identify constraints that might be addressed.*
- *Adoption will be enhanced by a reduction in the cost of seed or planting material, management practices that increase the rate of establishment and providing more information to farmers.*

This analysis was made towards the final stages of a project funded by Nestle. It will serve as input for future projects in the area or as a model that might be followed for other projects.

2.4.4 Potential impact of new technologies in forages in Southeast Asia assessed

Developing a framework for on-going impact analysis of forages-FPR in Asia (p.126)

- *A initial study has provided guidelines for developing tools for participating NARS researchers and farmers to monitor and analyze impacts of FPR in systems in which forages play important roles*

This work will be intensified in 1999 through collaborative research with the University of Queensland funded through an ACIAR project. An intermediate output is expected in 1999 with final output in 2000.

Output 3 Enhanced capacity to promote adoption of productive and sustainable land use practices

Output 3.1. Methods for increasing adoption of technologies developed by FPR

3.1.1 Synthesis of participatory and systems research in CIAT

Results of the workshop at CIAT on participatory and systems research (p.128)

- *CIAT researchers have contributed to participatory and systems research in Latin America, Asia, and Africa and to the development and evolution of such approaches from on-site characterization through development of ways to facilitate new inter-institutional and cross-stakeholder relationships*

The proceedings from this workshop "Systems and Farmer Participatory Research: Developments in Natural Resource Management " are with the CIAT Communication Section and will be available at the end of 1998 or early 1999. This output is being addressed together with Project SN-3. It is planned to produce a further review of experiences with FPR and Systems research in 2000.

Output 3.2 Integrated resource and GIS models to better target extension of results

3.2.1 Integrated resource model for targeting research

This has been summarized in 2.3.5

3.2.2 Cornell Rumen Model adapted for tropical feeds

Adapting a decision tool to overcome nutrition management constraints on dual-purpose cattle production (p.130)

- *An evaluation of the Cornell Net Carbohydrate and Protein System model suggests that it will be a useful tool for use in optimizing tropical feeds*

Further progress in this area is dependent on obtaining special funds to undertake feeding trials and chemical analyses and for a student to work on the model. A proposal is being submitted to the SLP.

3.2.3 Adaptation of forages integrated with GIS

a) Targeting of forage germplasm through a Geographical Information Systems (p.135)

- *Established an interdisciplinary working group to develop an integrated database of forage adaptation linked to the CIAT GIS database*

b) A GIS database of livestock in Latin America (p.136)

- *Linkage of livestock inventory data from LAC to the CIAT GIS database*

This is an inter-project activity that is expected to produce intermediate outputs in 1999.

Output 3.3 Persons trained and materials developed on participatory technology development and diffusion

3.3.1 Manuals on participatory research

- *a training manual for in-country courses on "Developing forage technologies with smallholder farmers" was produced in English, Indonesian, Lao and Vietnamese*

3.32 Increased capacity in FPR

Development and conduct of courses on farmer participatory research in Southeast Asia (p.138)

- *Courses on farmer participatory research have been adapted for researchers working in Asia on forage and cassava systems and natural resource management systems.*
- *Five in-country training courses on "Developing forage technologies with farmers" were held in Vietnam, Laos, and Indonesia (two courses); a further two courses are planned for the Philippines before the end of 1998*

- *Provided practical training for three development workers from the Philippines, Laos and Indonesia at FSP sites in Indonesia*
- *31 and 27 researchers and extension staff associated with cassava R & D were trained in FPR methodologies in Indonesia and China, respectively.*

This is an on-going activity where there are FPR projects.

Output 3.4 Results communicated

3.4.1 Network newsletters and databases

a) Tropileche (p.141)

- *A readily accessible database on research on dual-purpose cattle systems is available through the internet in addition to publishing two newsletters*

b) Forages for Smallholders Project (p.142)

- *published two issues of the SEAFRAD newsletter*

Summary of main achievements in 1998

Component technology development

(a) Forages for tropical dual-purpose systems in LAC (Tropileche)
Constraints and opportunities:

- *Ex-ante analysis has confirmed potential for new technologies in Costa Rica and Nicaragua but with limited potential in Pucallpa, Peru (p.36)*

Technology development:

- Cratylia argentea *was shown to have potential as a high protein supplement for the dry season feeding of dual-purpose cattle in the CA Hillsides (p.58-60)*
- *Eighty-five percent of farmers in Caqueta expressed satisfaction with using* Arachis pintoi-Brachiaria *associations* (p.121)

Enhanced capacity:

- *Training provided in ex-ante analysis*
-
- *Nicaragua and Honduras have joined the Tropileche consortium (p.48)*

(b) Forages in upland farming systems in Asia
Constraints and opportunities:

- *Characterized environment and farming system at 18 on-farm pilot sites and concluded participatory diagnoses (p.29)*

Technology development:

- *Forage technologies being developed at the 18 on-farm sites through FPR with spontaneous adoption occurring after 3 years (p.73)*
- *Legume covers increased yields of cassava and maize (p.78)*
- Paspalum atratum *identified as an alternative for use in erosion barriers (p.81)*

Enhanced capacity:

- *Seven in-country courses held on "Developing Forage Technologies with farmers" (p.138)*

(c) Cassava management in Hillsides, LAC
Constraints and opportunities:

- *Data sets on rainfall and erosion linked to GIS database (p.24)*

Technology development:

- *Adding short-term cash value, such as broom straw and blackberry strips, to conservation strategies increased adoption rates (p.96)*

Enhanced capacity:

- *Local NGO's involved in development of conservation strategies*

(d) Cassava management in Asia

Constraints and Opportunities:

- *identified previously as varieties, limiting soil nutrients, soil erosion*

Technology Development:

- *Use of an FPR approach has led to adoption of improved management practices in fertilization, use of intercropping and contour hedge rows (p.106)*

Enhanced Capacity:

- *Research and extension staff in Indonesia and China received training in FPR (p.138)*

Landscape/watershed level research

(a) Slash-and-burn systems in the Forest Margins, Peru

Constraints and Opportunities:

- *The major opportunity is to develop land use systems that do not involve annual burning of primary and secondary forest*
- *Colonist farmers identified constraints in their slash-and-burn system as diseases in rice and banana, and fallow management*
- *Non-forest land uses increase presence of weeds and decreases the number of farmer-named useful species (P.22)*

Technology Development:

- *Facilitated an inter-institutional team among national and international organizations to conduct adaptive research using participatory approaches (Depam) (P.47)*
- *FPR commenced in evaluation of rice and banana accessions and fallow improvement (P.92)*
- *Research has commenced on providing an economic package to evaluate potential technologies and alternative land use systems and on developing indicators for assessing impact (P.34,118)*

Enhanced Capacity:

- *Course provided to Depam team members in farmer participatory research*

(b) Community-based natural resource management, Hue,Vietnam

Constraints and Opportunities:

- *In a watershed in the A'Luoui district, populated by ethnic tribes, major constraints are poverty, food shortage, and degradation of vegetation, soil and water resources*
- *CIAT was given an opportunity to provide technical support to a local research team addressing the above constraints*

Technology Development:

- *Assisted in development of an IDRC funded project*

Enhanced Capacity:

- *CIAT has trained project officers in evaluation and adaptation of new technologies using FPR*

Output 1. Constraints and opportunities defined in smallholder systems

Output 1.1 Biophysical and socio-economic resource use characterized

1.1.1. Comparative land use in Pucallpa and Yurimaguas

There has not been any activity in 1998. Data has been collected but still needs to be summarized and written up.

1.1.2 Comparative information on plant communities at forest margin sites under different land uses

Weedy forests and fields: Interaction between colonists' land use and plant community and diversity in the Peruvian Amazon

Highlights

- Although continuing to have high plant species counts, non-forest land uses in Pucallpa have greater densities of weeds and a decline in counts of farmer-named useful species than forest.

Purpose: To determine patterns of plant community and species numbers changes accompanying changes in land use from forest to cropping, fallow, re-cropping, and conversion to pasture.

Rationale: There is a need to quantify and analyze changes in forest biodiversity, losses of plants useful to local settlers, increases in weeds and weediness, and the implications of such changes for land use in slash-and-burn systems.

Methods: We sampled vegetation in fields at the following stages: forest; first year of cropping after forest clearing; second year of cropping; fallows of 1 to 2 years; fallows of 3 to 5 years; fallows of more than 5 years; first year of cropping after fallow; and second year of cropping after fallow. We sampled six transects per land use. In each transect we sampled ten 4 m^2 plots with a 5 m distance between each, and identified species and recorded number of individuals per species. Each land use, as a result, provided a total of 240 m^2 of sample area.

In order to understand the plant community changes, we used published sources to evaluate forest species not continuing in other uses and each of the most frequently appearing species per land use in terms of habitat and seed size, production, and means of dispersion.

We interviewed a sample of 71 farmers--including 19 practicing slash-and-burn agriculture in the *selva alta* (higher forested area) away from the river, 19 slash-and-burn farmers who had also planted oil palm, 18 settlers along the Rio Aguaytia (where lands are seasonally flooded and soils are lighter and richer), and 15 colonists with small cattle ranches along the Lima-Pucallpa highway. Respondents were asked about desirable forest plant species not slashed and allowed to grow in their crop fields, worst crop weeds, and desirable and undesirable species in fallows.

Outputs: Slash-and-burn agriculture represents a sequence of interactions between colonist farmers and the forest ecosystem. Plant species and frequencies were determined for land uses which spanned forest, cropping, fallows, and cropping after fallows. Two hundred and thirty-five species were encountered in the forest, of which 143 were not found in any successive land use. Plants not found in the forest, however, colonized fields and fallows such that a total of 580 species were identified across treatments (Table 1). Plant species changes generally reflected replacement of shade-adapted plants with seed dispersed by bats, other mammals, ants, and larger birds by pioneer plants adapted to open, drier, sunny conditions and producing larger numbers of small seed dispersed by smaller birds and the wind. Each non-forest land use was hospitable to from 7% to 25% of the forest species and to 13 to 66 plant species exclusive to that land use. As field conditions changed over time, different sets of more competitive weeds in higher numbers emerged. In response, farmers changed crops, fallow fields, and cleared more forest. Farmers were most worried about *Rottboellia cochinchinensis* which appeared in fields opened from fallows and *Imperata brasiliensis*, an indicator of land degradation. Older fallow fields were similar to forest in many respects, although species composition differed. Counts of farmer-named useful species across treatments were very low, indicating high human intervention in the forest and heavy pressure on such species in all land uses.

Impact: Policy dealing with land use in the Amazon has been and needs to be concerned with plant biodiversity losses. Losses cannot be considered in terms of species numbers only, but also in terms of types of species lost and types of pioneer and weed species replacing forest species. Human land use directly tends to "mine" desirable species and more indirectly, tends to create environments favorable to weedy invaders and less favorable to forest-adapted species.

Contributors: Sam Fujisaka, German Escobar, Erik Veneklaas, and CIAT, COLOMBIA

Table 1. Totals of plants species and individuals by land use, Pucallpa, Peru, 1997

Category	Forest	Cropped after forest		Fallows (years)			Cropped after fallow	
		yr 1	yr 2	1-2	3-4	>5	yr 1	yr 2
Total species	235	89	133	125	135	183	104	103
Total individuals	1298	3152	3539	2485	2253	1814	3857	4225
Number of tree/palm species	128	27	38	35	53	59	16	21
% species trees/palms	54	30	29	28	39	32	15	20
% individuals trees/palms	38	10	7	6	13	16	3	3
Number of weed species	13	58	81	80	72	112	79	75
% species weeds	6	65	61	64	53	61	76	73
% individuals weeds	42	42	75	65	45	80	89	86
Number of forest species	235	20	27	40	46	58	16	19
Number exclusive to land use	143	18	29	20	36	66	14	13

1.1.3. Improved predictability of soil erosion in the hillsides

Comprehensive databases for model calibration and evaluation of indicators of soil health

Highlights

- Turbidimetry (the photometric quantification of soil dispersed from aggregates in a defined water volume) has a high potential for being used as an indicator of soil health in relation to its resistance to soil erosion.
- Continued use of legume components in rotations led to higher presence of mycorrhiza in these soils.
- Recording and analysis of the kinetic energy of more than 140 rainfall events will allow a more reliable assessment of the rainfall erosivity factor for predicting soil loss risk in the Andean zone.

Purpose: i) To continue research towards calibration of the Universal Soil Loss Equation model for tropical conditions, and ii) to evaluate physical and biological parameters as indicators of soil health.

Rationale: Predicting levels and quantities of soil erosion or soil loss per unit of land under a given scenario of climate and land use, is a difficult task. This is especially true for the Andean hillsides in southern Colombia where soil spatial variability is very high. Long term evaluations in CIAT's soil conservation project over the last years have shown, that the Universal Soil Loss Equation model (USLE) overestimates soil losses on Andean Inceptisols and fails to detect major short term changes in the soil's susceptibility to erosion due to effects of management. It was considered that further progress in model development would be facilitated by obtaining more information on rainfall events and linking this information with other data on soil erosion to the GIS databases in CIAT.

Complementary to the development and testing of mathematical models for prediction of soil erosion, simpler tools, e.g. aggregate stability, can be developed to relate the risk of erosion to specific management practices. Therefore research was also carried to evaluate predictive tools that can be used by farmers and technicians as indicators of soil health.

Output:

Development of databases

Records of over ten years of soil loss from more than 40 plots under different management were collected and compiled in a central database in collaboration with the CIAT's GIS unit. The database can be used in an interactive GIS decision support system. Some intermediate products already have been developed (see below). Though the existing soil loss models are still not predicting soil loss with a high degree of accuracy, it can be assumed, that with more data available, models can be modified to better predict the magnitude of risk of soil loss under different management scenarios. They then can be used to inform farmers and planners of the constraints and opportunities that can be expected under different management systems to improve resource use in the highly populated mountain areas of tropical South America.

Rainfall characteristics and soil water dynamics

Soil erosion can be related to high intensity rainfall, in addition to inherent soil properties and land use. The energy of raindrops on an open soil surface, e.g. at planting, breaks the soil aggregates at the surface into smaller particles. These particles close the soil pores impeding water infiltration, leading to excessive water runoff and topsoil erosion.

In order to revise the equations that exist for the relationship between rainfall intensity and kinetic energy for the tropical Andean zone, more than 140 rainfall events were recorded over the last 18 months. We used a Distromet Disdrometer which characterizes rainfall by counting the raindrops that fall on a $50cm^2$ Styrofoam cone and dividing them by size into 20 different channels, thus providing information about kinetic energy, rainfall intensity and other parameters (Figure 1).

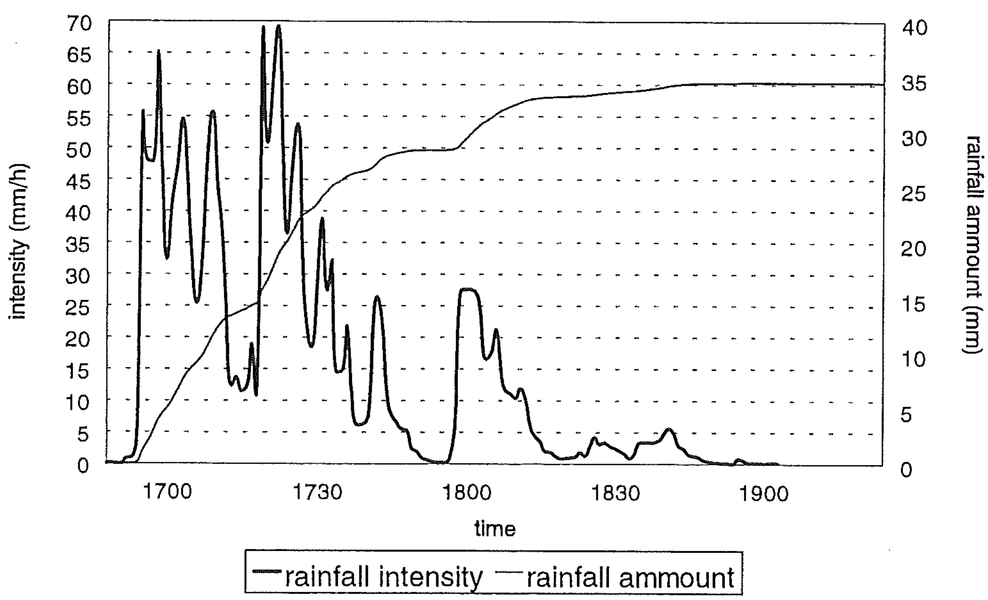

Figure 1. Rainfall intensity during a thunderstorm (total rainfall was 34.5mm)

Several rainstorms with intensities higher than 70mm per hour were registered, even though rainfall in 1997/98 was affected by "el Niño" and below the long-term average precipitation. Combined with the rainfall intensity data collected over 10 years on two trial sites in the Cauca department and additional data obtained from the Colombian coffee federation, we now have the most complete database on rainfall characteristics in the Andean zone.

Whereas soil erosion has long term effects on soil productivity, soil water dynamics have a more immediate effect on crop yields. The available water retained in the soil profile after rainfall is an important factor influencing crop yields. Soil texture is the most important determinant of available water but management practices that affect soil physical properties and, most important in hillsides, infiltration and runoff, can also be important in water retention. Time domain reflectometry (TDR) measurements were collected for four management practices over a period of 14 months at five depths up to 1,2 m. Compared to neutron probes, TDR devices are save to handle and allow a permanent monitoring of soil moisture in different layers of the soil profile. By June 1998 more than 26 000 records, have been obtained. Data will be analyzed and evaluated in 1998/99 for differences in soil water dynamics.

Indicators of sustainability

Research has been undertaken to identify parameters of soil quality that are correlated with a soil's susceptibility to erosion and measured soil losses in the field under different soil-crop management practices. Parameters with such characteristics can be applied immediately as *indicators for the sustainability* of land use. More specifically they can assist farmers and extension agents to monitor and predict if a certain practice is leading to more or less soil erosion. When they are developed in conjunction with the users they provide immediate feedback on management strategies and existing opportunities to restore favorable soil conditions. The simpler and cheaper the procedure, the easier it is to apply the indicators in the field. More sophisticated indicators are limited in their applicability, but can be used by scientists to better characterize and understand the influence of cultural practices on soil properties and for deriving technical recommendations.

In 1997, we reported that proportions of certain soil aggregate classes (following wet sieving) and aggregate size distribution patterns were highly correlated with a soil's resistance to erosion and also reported on the use of "hot water extractable carbohydrates" as an indicator. This year we have focussed on the use of "turbidimetry" and some biological parameters.

Turbidimetry is a simple method, where a sample of soil aggregates is added to a tube of water and shaken for a defined time period to partially disperse the soil aggregates. The level of dispersion or turbidity is determined by measuring the degree of light extinction. Experiments were conducted with soil samples from runoff plots under different soil/crop management practices. Dispersion of soil aggregates of sizes 1-2 mm and 2-4 mm (Table 2) reflected changes

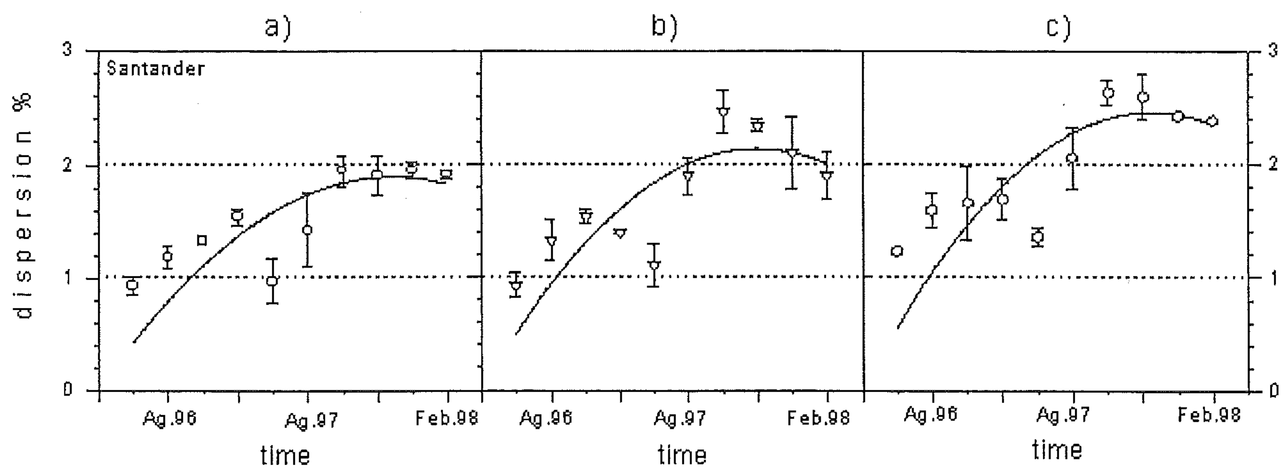

Figure 2. Percentage dispersion of soil aggregates from surface soil collected from the long-term erosion plots at Santander de Quilicaho site: a) "virgin" soil after more than 10 years of improved pastures, b) crop rotation plus fertilizer plus minimum tillage, and c) crop rotation plus chicken manure plus tillage.

in soil structural stability due to organic amendments and different rotation patterns. Small aggregates led to more particles in suspension than the larger soil aggregates. Readings taken after two minutes and after two hours gave consistent results. The results suggest that secondary products of manure break down to enhance soil dispersion. Similar results with higher dispersion values were observed in samples from the Mondomo soil erosion trial site.

Biological parameters were evaluated in relation to response to soil-crop management practices and tests. The study was also designed to learn about the importance of soil organisms; how they improve soil physical properties and how they respond to soil-crop management practices to assess whether they can be used as indicators of soil health.

Preliminary results show that abundance of soil fungi (determined after adding a soil suspension to petri dishes) was highest after grassland and lowest after cassava mono-cropping (Figure 3). Highest abundance of mycorrhiza spores was found where legumes were undersown or intercropped with cassava. Mites were most abundant among the mesofauna of the soils but there was no clear interaction with the treatments and structural soil properties.

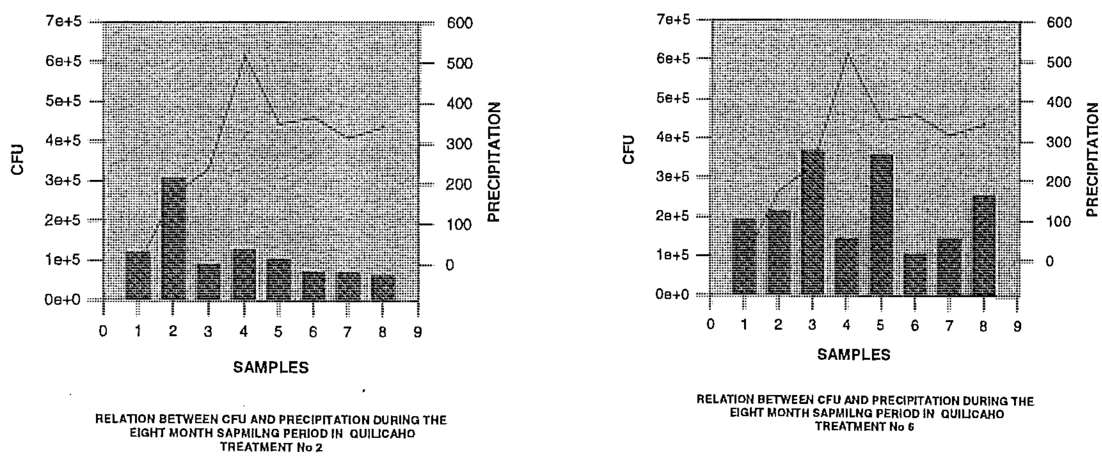

Figure 3. The relation between CFU (Colony forming units) and rainfall in the continuos cassava treatment (left) and the cassava rotation with a pasture component (*Brachiaria decumbens* and *Centrosema macrocarpum).*

Impact: Research on basic processes that effect erosion such as rainfall intensity form a basis for improving models that can be used for decision support in applied research and in implementing polices that may affect soil conservation. The availability of data from more than 150 rainfall events will make it possible to validate relationships between rainfall and energy for the Andean zone. Combined with the database on rainfall intensities for Colombia, there is a basis to develop more precise maps of erosion hazard in the Andes. The larger database of results on soil loss and crop yield under different management practices coupled to the GIS databases in CIAT, will enable better predictions to be made of which agricultural systems lead to sustainable land use in the long term.

The "turbidimetric" method of diagnosing a soils resistance to erosion by comparing dispersion of granules in a test soil relative to values in undegraded adjacent grassland can be used to express soil health with respect to its susceptibility to erosion. The method is simple and cheap enough to be used by most laboratories. It is thus a tool that can contribute to orienting farmers to manage their soils in a more sustainable manner.

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References:

Amezquita, E. y Escobar, C.J. 1996. Degradación de Tierras en Regiones Húmedas. Congreso latinoamericano de la Ciencia del Suelo. Sao Paulo, Brasil, Solo Suelo. 24p

Bryan, R.B. 1968. The development, use and efficiency of indices of soil erodibility. Geoderma. 2, 5-26

Castillo, J.A.; A. González M. and K.M. Müller-Sämann. 1995. Determinación del indice de erodabilidad (K) en dos suelos del Departamento del Cauca, Colombia. Suelos Ecuatoriales. Vol. 25: 81-85.

Pieri, C.; et. al. 1995. Land Quality Indicators, World Bank Discussion Paper, No. 315, (Ed.) World Bank, Washington D.C.

Pajasok, T and Kay, B.D. 1990. Assessment of a combination of wet sieving and turbimetry to characterize the structural stability of moist aggregates. Canadian J. of Soil Science, 70: 33-42

Ribeiro et al. 1996. Fluctuacao populacional da Mesofauna Edáfica em Sistema de Plantio Directo, Escarificacao, Gradagem e un Ecosistema Natural em dourados. MS. Congreso Brasileiro Plantio Directo para una Agricultura Sustentavel. Ponta Grossa. P.R. Brasil.

Topp,G.C., S.J. Zegelin and I. White 1994. Monitoring Soil Water Content using TDR: an Overview of Progress. In Proceedings of the Symposium and Workshop on Time Domain Reflectometry in Environmental, Infrastructure, and Mining Applications, Northwestern University, Evanston, Illinois, September 7-9, 1994

William et al. 1996 Techniques for the determination of the stability of soil aggregates. Soils Science. 101:157-163.

1.1.4 On-farm FPR evaluation sites in Southeast Asia characterized

Highlights

- Collected and summarized environmental and farming system site characterization information for 18 on-farm sites of the Forages for Smallholders Project (FSP)
- Participatory diagnosis conducted at 18 sites

Purpose: To provide a basis for assessing the extent and impact of adoption and adaptation of forage technologies at Forages for Smallholders Project sites in Southeast Asia.

Rationale: The FSP selected 18 on-farm sites for participatory development of forage technologies covering the range of environmental and farming systems commonly encountered in the region. Characterization of the environmental conditions at sites is needed for GxE analysis of forage species performance. Characterization of the farming systems and their constraints is needed for a better understanding of adoption and adaptation of forage technologies by farmers, and the identification of indicators for monitoring progress towards impact. It is hoped that this analysis will facilitate extrapolation of site-specific results.

Methods: Information sources for site characterization included data and maps from government offices, key information from discussions with government officers, village heads and key farmers, personal observations, and participatory diagnosis with farmer groups. Direct measurements include soil analyses and climatic data at project sites. Methods for site characterization were described in detail in the 1997 Annual Report.

Outputs: Site characterizations have been summarized and were presented by national partners at the Third Regional Meeting of the FSP in Samarinda, Indonesia from 22-27 March 1998. The papers containing the site characterization will be included in the proceedings of the meeting which will be published as a Technical Report of the FSP. Missing information on site characterization has been identified from these papers and will be collected. A brief summary is presented in Table 1.

Participatory diagnosis (PD) has been conducted in >18 sites, resulting in the selection of 18 on-farm sites where the FSP reached an agreement with farmers to work together to develop forage technologies. PD is only a first step to initiate the process of participatory technology development. Problems identified by farmers during participatory diagnosis at the different sites showed that several of these problems were common to many sites, despite contrasting farming systems (Table 2). Feed shortages, either general or specific to certain parts of the year, ranked high on the list at most sites. Weed invasion, often *Imperata cylindrica* or *Cromolaena odorata*, was also recognized by farmers as a major problem. While labour shortage was only mentioned as a problem at two sites at the time of the PD, farmers at many sites are now expressing that labour-saving is one of the most important benefits of planting forages.

Impact: The site characterisations are providing the baseline information for impact assessments to be conducted in 1999, partly in collaboration with a project sponsored by ACIAR.

Missing information has been identified and will be collected and summarized for presentation at the next Regional Meeting of the FSP in January 1999.

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Table 1. Descriptions of on-farm sites of the Forages for Smallholders Project in Southeast Asia.

Site	Location			Long-term rainfall		Soils		Dominant farming and livestock system
	Latitude	Altitude m	Market access[1]	Annual rainfall mm	No. of dry months <50mm	Soil fertility [2]	Soil pH (% Al. sat.)	
Indonesia								
Sepaku II, East Kalimantan	1°S	<100	D-M	2,600	<3	L	4.8 (64%)[3]	Extensive upland; cattle grazing *Imperata* grasslands
Makroman, East Kalimantan	1°S	<100	M	2,200	<3	M	4.6 (65%)	Moderately extensive upland and rainfed lowland; cattle and goats tethered or stall-fed
Gorontalo, North Sulawesi	0°N	20	M	1,290	4-6	M	6.8	Moderately intensive upland under coconuts; cattle herded or tethered grazing
Marenu, South Tapanuli	1°N	300	D	2,500	1-3	L	4.7 (82%)	Sheep production emphasis, herded and stall-fed; extensive upland agriculture
Pulau Gambar, North Sumatra	4°N	<100	E	2,000	0	M	6-7	Intensive rainfed and irrigated lowland; sheep production, herded and stall-fed
Saree, Aceh	5°N	700	M	1,600	2-4	L	5.6	Natural grassland; cattle grazing managed communal land in mountainous upland..
Vietnam								
Xuan Loc	16°N	100	M	3,200	2-4	L-M	5-6	Moderately intensive upland with cattle grazed in forests during the day and penned at night
M'Drak, Daklak	12 °N	500	M	1400	4	M	4.5-5.5	Extensive grassland with cattle herded during the day and penned at night
Vietnam-Swedish Project (northern provinces)	21 °N	300	E	1700	5	M	5-6	Intensive upland with cut forage for mixed livestock production, especially pigs, fish and buffalo

Site	Location			Long-term rainfall		Soils		Dominant farming and livestock system
	Latitude	Altitude m	Market access[1]	Annual rainfall mm	No. of dry months <50mm	Soil fertility [2]	Soil pH (% Al. sat.)	
Laos								
Luang Phabang	20 °N	300-1000	D	1400	5	L-H	5-7	Short rotation slash & burn systems, with cattle grazed either in the forest or on fallow fields
Xieng Khouang	19 °N	1,300	D	1400	5	L-H	4.5-6.5	Short rotation slash & burn systems, with cattle grazed either in the forest or on fallow fields
Philippines								
Cagayan de Oro, Mindanao	8°N	185	D-M	1,500	2	M	5.8	Moderately extensive upland; cattle tethered grazing
Cotabato, Mindanao	7°N	<300	D	1,590	0	F	6.5	Moderately intensive rainfed lowland; cattle and goats grazing
Davao, Mindanao	7°N	125	E	2,210	0	F	5.5	Moderately intensive upland under coconuts; dairy cattle
Guba, Cebu	10°N	550	E	1,680	0	F	4.9 (31%)	Intensive upland; cut & carry feeding of cattle
Malitbog, Bukidnon	8°N	700	D	1,830	0	L-M	5.6	Moderately extensive upland; cattle and buffalo tethered grazing
Matalom, Leyte	10°N	30	M	1,970	0	M	4.9 (13%)	Moderately intensive upland cropping; cattle, buffalo and goats tethered grazing
Thailand								
Sung Nuen	14 °N	120m	E	805	N/A	M	5.5-6.5	Intensive smallholder dairy farming based on cut & carry planted forages, concentrate and crop residues.

1 Market access: E = easy (close to markets), M = medium, D = difficult (very remote)
2 Soil fertility: L = low (infertile), M = moderate fertility, H = high fertility
3 Aluminum saturation (%)

Table 2. Major problems identified by farmers in participatory diagnoses

SITES	General feed shortage (quantity and quality)	Dry season feed shortage (mainly quality)	Declining soil fertility	Weed invasion (e.g. *Imperata, Cromolaena*)	Labour shortage (overall or seasonal)	Lack of control of livestock (e.g. crop damage)	Soil erosion
Indonesia							
Sepaku II, East Kalimantan		✔		✔	✔		
Makroman, East Kalimantan			✔	✔	✔		
Gorontalo, North Sulawesi		✔					
Marenu, South Tapanuli	✔	✔					
Pulau Gambar, North Sumatra	✔						
Saree, Aceh		✔					
Laos							
Luang Phabang	✔	✔	✔	✔		✔	✔
Xieng Khouang		✔	✔	✔			
Philippines							
Cagayan de Oro, Mindanao		✔		✔			
Cotabato, Mindanao	✔	✔				✔	
Davao, Mindanao	✔						
Guba, Cebu	✔						✔
Malitbog, Bukidnon		✔		✔			
Matalom, Leyte	✔	✔				✔	
Vietnam							
Xuan Loc	✔						
M'Drak, Daklak		✔		✔			
Vietnam-Swedish Project		✔					✔
Thailand							
Sung Nuen		✔					

Output 1.2 Ex-ante analysis of new technologies, management and employment options

1.2.1 Potential of new technologies and management options in Pucallpa

Economic optimization and feasibility analysis of smallholder farming systems

Highlights

- Existing economic data available in Pucallpa summarized and development of farm budgets for different commodities commenced

Purpose: To provide a comprehensive agro-economic decision support system (DSS) to farmers, researchers and policymakers working in the Pucallpa region.

Rationale: The adoption of land use alternatives developed by national and international institutions in the Peruvian Amazon has been modest at best. The PE-5 program recognized this shortcoming and has taken action to develop a multi-disciplinary team of scientists in the Forest Margin Eco-Regional Benchmark site. One member of the CIAT team is a natural resource economist who duties include investigation of agro-economic and environmental issues.

Since farmers base their land use decisions upon a variety of agricultural, environmental and economic factors, land use alternatives need to take into account these multiple criteria in order to improve adoption rates and in turn improve impact. The agro-economic analysis incorporates earlier agronomic research results within a larger framework of economic opportunities and limitations facing smallholder farmers.

Relevant agro-economic information remains dispersed amongst the various institutions of Pucallpa (DRAU, INEI, INIA, IIAP, CODESU, CIAT, ICRAF, CIFOR). By compiling the data and providing a comprehensive DSS, the relative merits of improved land use systems can be ascertained. The required inputs of land use alternatives such as land quality, labor, and capital inputs can then be easily related to farmer constraints. By using participatory approaches researchers and policymakers can work along with farmers to identify both opportunities and restricting factors. With the insights gleaned from the DSS, technologies can be developed and refined in an ex-ante manner, thus improving the probability of adoption of alternative land use systems.

Methods: The first steps required to elaborate the agro-economic DSS are an extensive literature review of the Pucallpa region and a compilation of existing information from associated Pucallpa institutions. Land use activities included in the DSS will range from traditional agricultural crops to perennials and exotic species (Table 1).

Table 1. Land use activities

Traditional Annual Crops	*Traditional Perennial Crops*	*Exotic Species* [c]
Rice	Cacao	Camu-camu
Maize	Citrus	Palmito
Cassava	Improved fallows [b]	Uña de Gato
Beans	Multi-strata agroforestry [b]	Cocona
Plantains	Improved germplasm forests [b]	Castaña
Pineapple		Aguaje
Dual-purpose cattle [a]		Barbasco
Improved pastures [a]		Copoazú

Activity coordinated with [a] Federico Holmann; [b] with ICRAF; Carlos Ostertag

Outputs: (expected)

1998-1999 Article contributions to Farmer Participatory Research newsletter of Pucallpa

1999 Booklet of enterprise budgets and labor calendars
User-friendly computer program for decision support (Microsoft Excel)
Training course for optimization and feasibility analysis (activity coordinated and financially supported by DEPAM)

Impact: With the realization that multiple farm-level surveys have been and continue to be conducted (CIAT-1996, CIFOR-1997, ICRAF -1998) the initial plans to conduct an extensive survey were altered. Rather a synthesis of existing information was deemed a more efficient data gathering method. Additional information can be acquired with specific topic inquiries. Future surveys are planned to provide both time-series and cross-sectional information.

With the development of the agro-economic DSS, communication has increased amongst the researchers, both national and international. This trend will also include other stakeholders (farmers, policymakers) to gather more insights regarding the feasibility of alternative land use systems.

Contributors: CIAT - Douglas White, Ricardo Labarta, Sam Fujisaka, Federico Holmann (PE-5) Carlos Ostertag (SN-1)

Collaborators: Keneth Reategui (DEPAM), David Yanggen (ICRAF), Héctor Campos (INIA), Javier Soto (DRAU), Alfredo Riesco (CODESU).

1.2.2 Ex-ante evaluation of potential for improved feed technologies for dual-purpose cattle

Economic evaluation of new forage alternatives for farms with dual-purpose cattle in Peru, Costa Rica, and Nicaragua

Highlights

- New forage alternatives of *Cratylia*+sugarcane for dry season supplementation and Brachiaria-Arachis pastures to replace existing pastures allow purchased supplementation to be reduced or eliminated, and steep land reallocated for reforestation in Costa Rica
- New forage alternatives offer a large increase in productivity and decrease in cost of production of milk, in particular, if used in conjunction with the credit scheme that is being offered to small farmers in Nicaragua
- In contrast, in Pucallpa, Peru, new forage alternatives do not offer a viable option to farmers in a situation where there is abundant existing pasture and a low market potential

Purpose: To carry out an ex-ante economic evaluation of new forage alternatives for dual-purpose cattle producers in the lowland tropics of Latin America using, as case studies, collaborating producers of the Tropileche Consortia in the humid forest margins, Pucallpa, Peru, and in the subhumid hillside areas of Esparza, Costa Rica, and Esquipulas, Nicaragua.

Rationale: One of the objectives of Tropileche is the development of new feeding alternatives based on improved grasses and legumes. New germplasm selected by CIAT researchers is evaluated with producers at different agroecosystem sites to assess whether it overcomes some seasonal or other feed limitation. Ex-ante economic analysis are performed to estimate the potential impact of these new technologies and the possible constraints to adoption.

Methods: Data for this study was obtained through interviews with each collaborating producer. Information was collected on the type of production systems, resource use, inputs, outputs, product prices, and technologies utilized. Secondary information was collected about the watersheds where farms were located. The analysis was carried out using a farm linear programming farm model that had been developed at CIAT.

Outputs: Table 1 shows mean data for livestock inventory, milk production, land use, and labor productivity in dual purpose farms in Peru, Costa Rica, and Nicaragua. As observed, larger herds are found in Costa Rica (47 cows and 72 AU) followed by Peru (31 cows and 50 AU) and Nicaragua (29 cows and 48 AU). The average milk production was greater in Costa Rica (5.0 kg/cow/d) than Nicaragua (3.7 kg/cow/d) and Peru (3.0 kg/cow/d). The lower milk production in Peru appears to be due to (a) market milk restrictions (which will be discussed in detail later) and (b) the low percentage of cows in milk, 42% in Peru compared with 60% in Costa Rica and 58% in Nicaragua, rather than differences in animal genotype *per se*.

Table 1. Averages of livestock inventory, production of milk, and use of the land in farms with of double-purpose cattle in Peru, Costa Rica, and Nicaragua.

Variable	Peru (n=9)	Costa Rica (n=7)	Nicaragua (n=4)
Livestock Inventory (#)			
Cows in milk	10.6	28.0	16.9
Dry cows	20.1	19.3	12.0
Heifers	21.9	16.1	14.5
Calves	15.7	35.1	15.3
Bulls	1.3	2.0	1.3
Total Animal Units (AU)[1]	49.8	71.7	45.3
Daily production of Milk (kg)			
Total	32.1	139.9	62.5
Per cow	3.0	5.0	3.7
Cows in milk (%)	41.5	60.1	58.5
Land use (ha)			
Native pasture	48.3	69.1	37.5
Improved pasture	8.4	8.7	12.2
Agriculture	1.5	4.6	0.7
Forest/fallow	17.7	9.1	2.3
Total	75.9	91.6	52.7
Area under improved pastures (%)	14.8	11.2	24.5
Stocking rate (AU/ha)	0.88	0.92	0.91

[1] Cows = 1.0, heifers = 0.7, female calves = 0.3, and bulls = 1.3

The majority of farm area is pasture, ranging from 75% for Peru up to 95% for Nicaragua. The greater proportion of forest area/farm is in Peru (23%) while in Nicaragua this area is very low (4%). The agricultural area in Peru and Nicaragua is small (0.7 to 1.5 ha/farm) and limited to subsistence crops such as rice, beans and corn while in Costa Rica the crop area is larger, 4.6 ha, and more diversified with crops such as rice, corn, beans, sugarcane, mango, cashew, and melon.

Most of the pasture area is covered with native or with naturalized species (e.g. *Hyparrhenia rufa* in Costa Rica and Nicaragua) with a small proportion of improved pastures (11% in Costa Rica, 15% in Peru, and 24% in Nicaragua). Pasture land is in different states of degradation, no nitrogen fertilizer is used, and this results in a low, and similar, stocking rate (0.9 AU/ha for all countries).

Resource prices and capital investment

Table 2 shows resource prices and capital invested in dual-purpose farms in each country. The price of milk to the producer is very different in each country, US$0.22/kg in Esquipulas, Nicaragua, US$0.28/kg in Costa Rica and US$0.32/kg in Pucallpa, Perú. The price is for raw milk in Peru and Nicaragua while it is for milk cooled to 5^{0}C in the farm in Costa Rica, the later being a much better quality product.

Table 2. Resource prices and capital invested in dual-purpose farms in Peru, Costa Rica, and Nicaragua.

Variable	Peru (n=9)	Costa Rica (n=7)	Nicaragua (n=4)
Prices			
Milk ($/kg)	0.32	0.28	0.22
Beef ($/kg cull cows)	0.60	0.60	0.50
Labor ($/day)[1]	4.40	8.80	1.75
Land ($/ha)	200	2,364	347
Pasture rental ($/cow/month)	3.00	4.30	3.00
Cow ($/ea)	500	550	350
Heifer ($/ea)	450	500	250
Weaned calf ($/ea)	150	170	100
Bull ($/ea)	700	700	600
Establishment of improved grass ($/ha)	250	270	225
Establishment of Arachis with grass ($/ha)	340	370	310
Establishment of Stylosanthes ($/ha)	150	165	150
Establishment of Cratylia ($/ha)	400	420	390
Establishment of sugarcane ($/ha)	NA	550	500
Invested capital ($/farm)			
Land	15,244	216,522	18,287
Livestock	29,561	42,260	18,538
Shed, corral & equipment	2,000	12,896	2,125
Improved pastures[2]	1,050	1,175	1,372
Fences[3]	4,752	6,822	4,597
Total	53,147	279,675	44,919

The price of beef, as culled cows, is similar in Peru and Costa Rica at $0.60/kg live weight but lower in Nicaragua at $0.50/kg. The price of animals is greater in Costa Rica while Nicaragua has the lowest prices for beef and live animals for all categories. The labor cost is quite different between countries, ranging from $1.75/day in Nicaragua up to $8.80/day in Costa Rica, including social benefits. These differences in labor cost have a great influence on the establishment cost of forage alternatives. Similarly, the commercial value of land varies widely, ranging from $200/ha in Pucallpa, Peru, up to $2,364/ha in Esparza, Costa Rica. The main reason for this contrast lies in the high level of public infrastructure and proximity to markets in Costa Rica, as well as its long social and economic stability compared to Pucallpa, Peru, or Esquipulas, Nicaragua.

These factors contribute to a higher capital investment in the farms of Costa Rica, with a commercial value of $280,000/farm, contrasting with an average value of $53,000/farm for Peru and $45,000/farm for Nicaragua. Land and livestock are the most costly components of investment in all countries; the value of land representing 77%, 44% and 28% and livestock 15%, 41% and 56%, of total investment in Costa Rica, Nicaragua and Peru, respectively.

Costs of Production and Income

Table 3 contains an estimate of direct costs (variable + cash costs) of production, gross income, net cash flow, and current profitability on invested capital during 1997. Labor contributes most to the cost of production in Peru (43%) and Costa Rica (63%), and is second most important in Nicaragua (32%). This assumes that family labor is valued at the minimum wage. The second highest cost is for supplementation, i.e. for concentrates, mineral salts, etc., except in Nicaragua, where it was the highest cost.

Table 3. Direct costs of production, gross Income, net cash flow, and family labor retribution in dual purpose farms in Peru, Costa Rica, and Nicaragua.

Variable	Peru (n=9)	Costa Rica (n=7)	Nicaragua (n=4)
Direct cost of production ($/farm/year)			
Hired labor	257	5,586	1,155
Family labor	1,606	3,212	630
Total permanent labor (#/farm)	1.16	2.74	2.83
Supplementation	683	2,848	2,205
Animal Health	784	224	390
Maintenance infrastructure & equipment	727	1,617	817
Others	318	549	427
Total	4,375	14,036	5,624
Cost/kg of milk	0.29	0.23	0.20
Cost of labor as % of the total	43	63	32
Gross Income ($/farm/year)	6,018	17,856	6,759
Milk	3,643	13,572	5,019
Sale of culled cows	970	1,490	760
Sale of calves	1,405	2,794	980
Net Cash Flow			
$/farm/year	1,643	3,820	1,135
$/ha pasture/year	29	49	23
$/cow/year	54	81	39
Return to family labor			
$/day	8.90	19.27	4.83
Number of times the minimum wage	2.02	2.19	2.76
Annual profitability on the invested capital (%)	2.87	1.37	2.53

The total cost of production of milk is significantly different in the three countries, ranging from $0.20/kg in Esquipulas, Nicaragua, $0.23/kg in Esparza, Costa Rica, and reaching $0.29/kg in Pucallpa, Peru. The principal reason for the low cost of production in Nicaragua is due to the labor cost being 5 times lower than in Costa Rica and 2.5 times lower in Peru.

The cost of production in Pucallpa, Peru, is high and above the international price of milk (US$2,000/tm or $0.26/kg fluid milk, assuming 130 gr of powdered milk/liter of fluid milk,), due to the low yield of milk/cow (3.0 l/cow/day) and the small proportion of cows in milk, 45%. The value of gross sales is mostly from milk (60% in Peru, 76% in Costa Rica, and 74% in Nicaragua). The rest of the income comes from the sale of weaned calves and culled cows.

Estimated family income was $270/month for Pucallpa, Peru, $586/month for Esparza, Costa Rica, and $147/month for Nicaragua. This income is approximately double the minimum wage in Peru and Costa Rica and almost 3 times greater in Nicaragua.

The profitability on invested capital during 1997 was very low in Costa Rica (1,37%), followed by Nicaragua (2,53%), and greater in Peru (2,87%). The reason for low profitability in Costa Rica was, that despite having the greatest family income and return for labor retribution, the high commercial value ($280,000/farm).

Ex-ante analysis for Costa Rica

Figure 1 shows the cost of production per kilogram of milk for the different forage options. The cost of production on the naturalized pasture found in Esparza (i.e. Hyparrhemia rufa) makes it necessary for producers to supplement their milking herd during the 5-month dry season. With an average lactation of 1,350 kg/l, the cost of production of milk is $0.31/kg while the milk price received is $0.28/kg. That is, with the sale of weaned calves farmers break even if it is assumed they receive a salary similar to the minimum wage.

The cost of production is reduced as the productivity per cow increases. At 1,350 kg/lactation (5 kg/cow/day) it is $0.31/kg. at 1,500 kg/lactation (5.55 kg/day) it is $0.29/kg and at 2,000 kg/lactation it is only $0.23/kg for cows grazing on *H. rufa* and supplemented throughout the year with sufficient chicken manure and molasses to overcome the nutritional limitations of *H. rufa*.

Using a combination of *Cratylia* with sugarcane, it is possible to eliminate the need for purchasing concentrated food, molasses, or chicken manure during the dry period. This forage option is capable of maintaining production during the dry period even with cows producing 2,000 kg/lactation (7.4 kg/day). The cost of production/kg of milk would be reduced by 13% at 2000 kg/lactation and 9% at 1,500 kg/lactation compared to feeding with *H. rufa* and supplements. The investment required to implement this option in a farm with a herd of 47 cows in Esparza is $6,000 (for planting 8.9 ha of *Cratylia*, 1.8 ha of sugarcane and purchasing a cane-chopper).

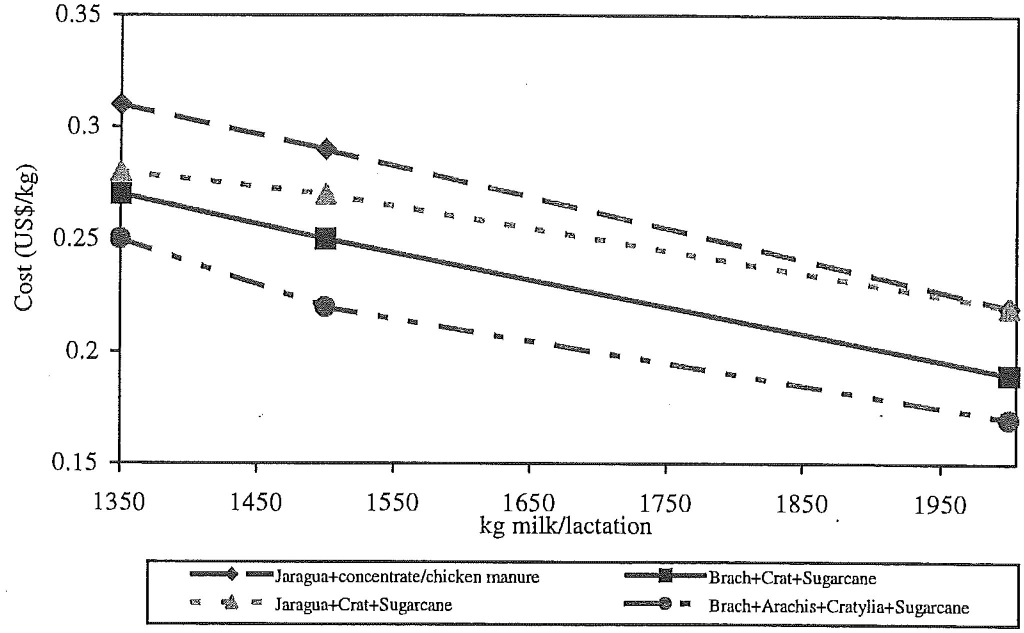

Figure 1. Cost of producing milk in Costa Rica with different forage alternatives and same herd size

Figure 2 shows that at real interest rates, it would only be possible to pay for this investment assuming a production of 2000 kg/lactation and if the producer allocates 50% of the marginal income to pay back the loan. The real interest rate in Costa Rica is currently set at 13% (24% nominal interest--11% inflation rate) and the available credit is for a 5-year term with a one year grace period. With a productivity of 1,500 kg/lactation it would only be possible if the real interest rates were lower (between 5-10%) or with longer payback period.

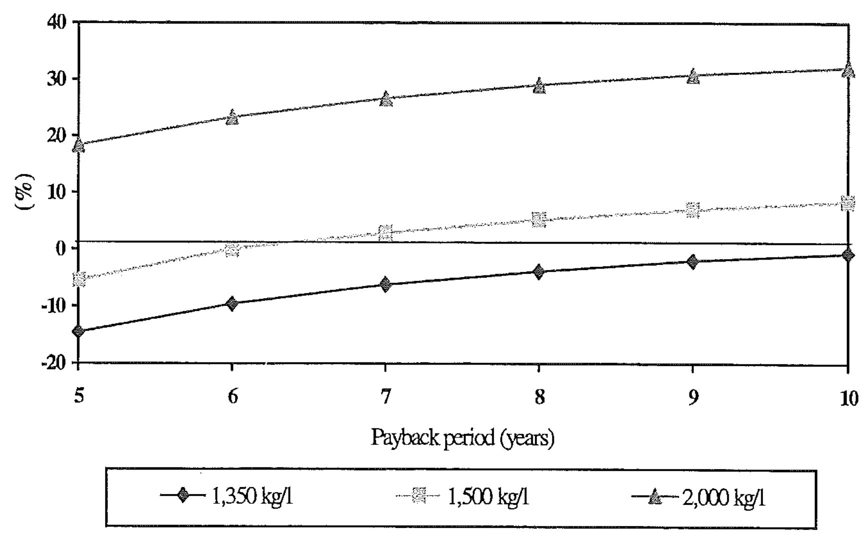

Figure 2. Real interest rate which could be possible to pay by adopting Cratylia and sugarcane based on alternative milk yields in Costa Rica.

It is worth commenting on this situation with respect to livestock policy and competition. In a scenario of open market economies operating without subsidies, producers should have the option to obtain credits with real interest rates that reflect the opportunity cost of money at the international level, which is currently at 5-7% in real terms and with 15 years to pay back the loan.

Other forage alternatives analyzed, e.g. establishing *Brachiaria brizantha* with or without *Arachis pintoi*, provided similar results. Moreover, the establishment of these options release fragile lands which could be put to other alternative uses, such as reforestation. Figure 3 shows the percentage of livestock area which could be released to other uses in Costa Rica with various forage options.

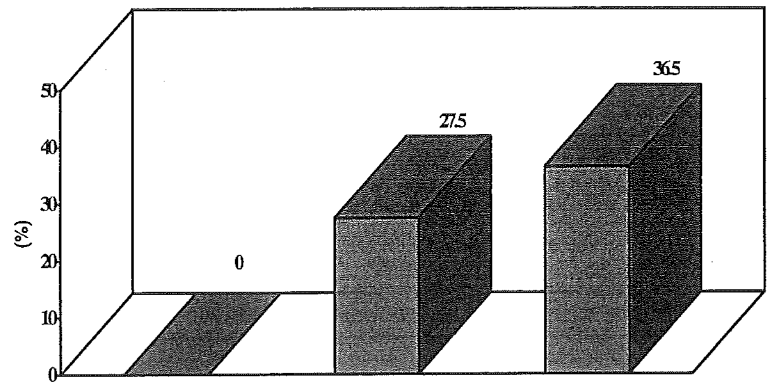

Figure 3. Percentage of pasture area which could be allocated to alternative uses due to adoption of improved forage alternatives with same herd size in Costa Rica

Ex-ante Analysis for Nicaragua

The situation in Esquipulas, Nicaragua is similar to that in Costa Rica in the sense that the forage alternatives evaluated in this study reduce significantly the costs of production. Figure 4 shows the cost of producing milk with different forage options according to the productivity of the cow. Under the current scenario, the cost of production of milk is $0.26/kg while the price received is $0.22/kg. That is, with the income obtained from the sale of weaned male calves, the producers obtain a total income similar to that of the minimum wage.

However, profitability would increase if the productivity of cows were greater. Feed of the quality of *H. rufa* is capable of maintaining cows producing up to 1,500 kg/lactation without additional supplementation during the rainy season and of 2,000 kg/lactation, with supplementation of energy and protein throughout the year. It is also possible with *H. rufa* pasture to reduce the cost of producing milk $0.20/kg with improved grazing management through control of weeds, rotation, provision of shade, increasing water available for grazing animals.

Using the forage option of *Cratylia* with sugarcane it is possible to eliminate completely the need for supplementation during the dry season, as is the case in Costa Rica. The cost of production can be reduced by 31% (from $0.26/kg to $0.18/kg) with a productivity of 1000 kg/lactation, to $0.14/kg with a productivity of 1,500 kg/lactation, and to $0.12/kg with a cow productivity 2,000 kg/lactation. The investment required to establish this forage option for an average farm of 29 cows is approximately

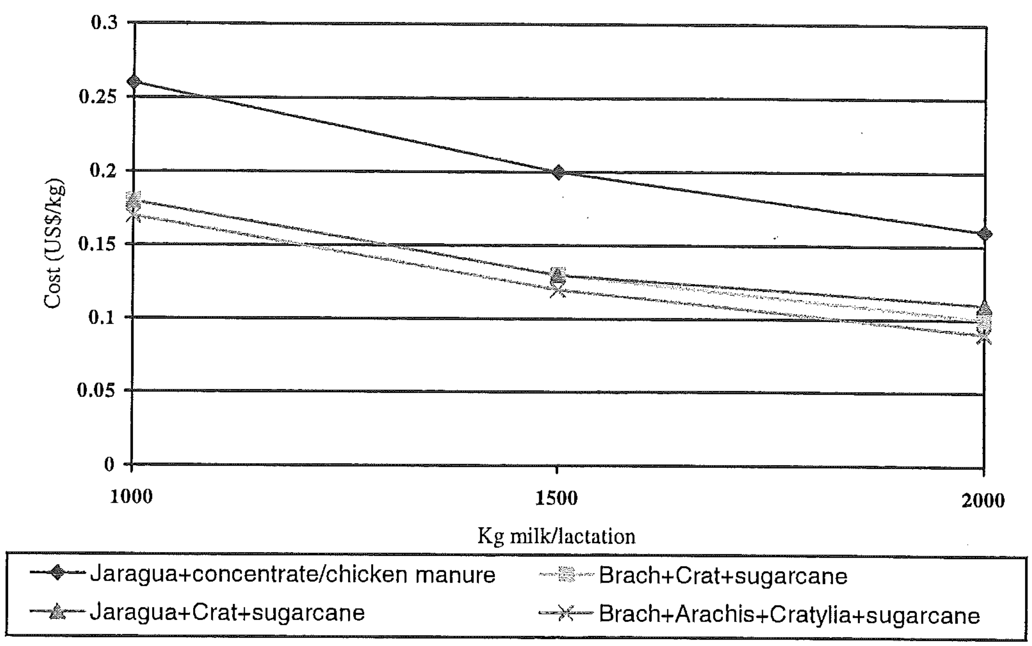

Figure 4. Cost of producing milk with different forage feeding alternatives assuming the same herd size in Nicaragua.

$4,600. This investment consists of establishing 5 ha of *Cratylia argentea*, 2.4 ha of sugarcane, and purchasing a cane chopper and engine since there is no rural electrification as in Costa Rica.

Figure 5 shows the real interest rates under which it would be possible to pay for this investment dependent on the productivity of the cow and assuming that the producer allocates 50% of the marginal income to pay back a loan with respect to the base scenario (*H. rufa* + feed concentrates). At present, the Nicaraguan financial system offers a real interest rate of 18% for agricultural and livestock credits with a 5-yr payback period. Under this situation and with the current milk productivity it would not be possible to adopt this forage alternative since it is not viable financially. However, with a productivity 1,500 kg/lactation it is a viable since it is possible to pay a real interest rate of up to 22% with a payback period of 5 years. With levels of production of 2,000 kg/lactation, the situation is even more viable.

The MAG-WFP dairy development project in Nicaragua offers credits to small milk producers at a real interest rate of 10% with a 5-yr payback period up to a maximum loan of $3,000/farm. This provides an excellent opportunity for small producers to adopt these new forage options since it improves their competitiveness and income through a reduction in the costs of production.

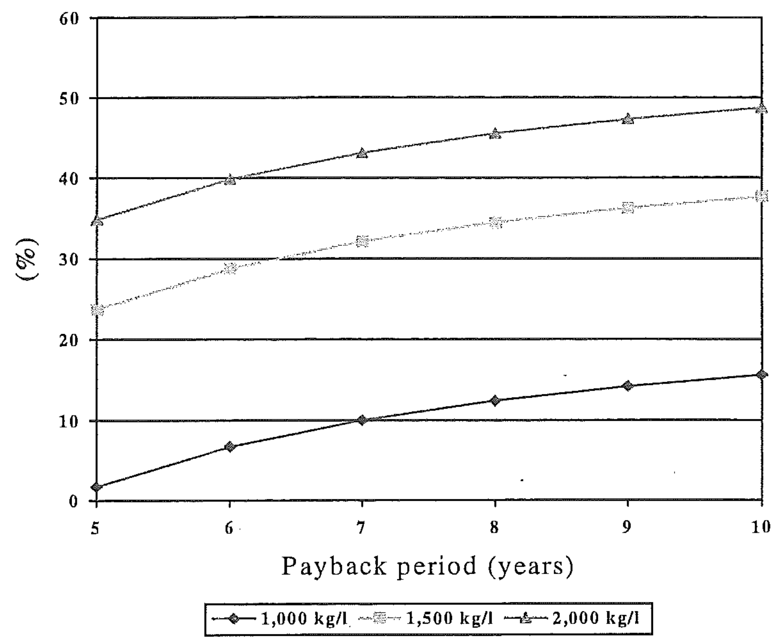

Figure 5. Real interest rate which could be possible to pay by adopting *Cratylia* + sugarcane based on alternative milk yields in Nicaragua.

Ex-ante analysis for Peru

The case of Pucallpa, Peru, is different from that in Costa Rica and Nicaragua. Annual precipitation is greater (2,000 mm vs 1,200 mm in Costa Rica and Nicaragua) and more evenly distributed with a dry season in only 3 months compared to 6 months in Esparza and Esquipulas. There is pasture growth throughout the year. Another characteristic in Pucallpa is that the production per cow is very low (3 kg/cow/d, Table 2). This may be due to several factors: (a) low genetic potential for milk production, (b) low nutrient value in grasses due to constant leaching of low fertility soils, and/or (c) a very limited market for raw milk.

With regard to the last point, the daily production of fresh milk in the area of Pucallpa is only about 2,500 kg and the cattle population was reduced from 82,000 head in 1986 to 26,000 at present as a consequence of terrorist activities of the Shining Path and cattle rustling. The city of Pucallpa, with a population of 300,000 inhabitants, does not have a milk plant. As a result, consumption of milk in Pucallpa is for the most part in the form of evaporated milk imported from outside the region. As a result, the market for raw milk is very small. Four of the nine producers who collaborate with the Tropileche Consortia considered that they would have a problem marketing the additional milk if they increased milk production. The other five producers sell their milk to the School Milk Program, a public-funded project to provide fluid milk to children.

Another factor that limits the potential to increase the milk market is the low price of fish in in Pucallpa. A the kilogram of dry matter of crude protein of fish from the Ucayali river is sold for $2.90 while milk costs $8.80/kg. That is, protein from milk is 303% more expensive than protein from fish. As a result, the market for raw milk in Pucallpa is limited to the upper-class population and possibilities for growth are very limited, that is, unless a milk plant can be established in Pucallpa to supply the demand for evaporated milk which now comes from Lima.

Figure 6 shows the cost of production of milk under different forage alternatives. Unlike the results from Costa Rica and Nicaragua, the most profitable option for Pucallpa under the current situation is the existing base scenario now found on farms. The most competitive option is to maintain the herd on existing pastures and supplement milking cows with brewers yeast during the short dry season. Brewers yeast is a viable option since it is abundant and inexpensive ($0.15/kg DM, 22% CP and 65% digestibility).

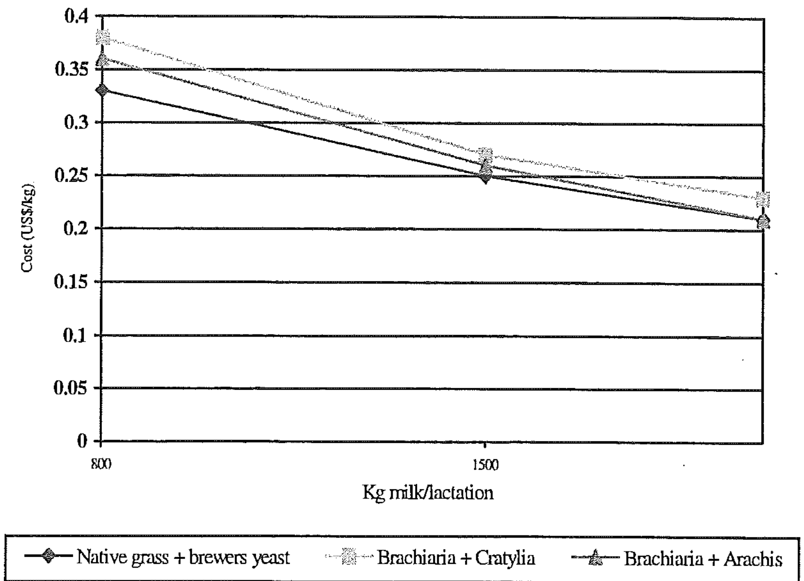

Figure 6. Cost of producing milk with different forage feeding alternatives assuming the same herd size in Peru.

With this alternative the cost of production of milk is $0.33/kg while the price received is $0.32/kg. That is, it is the income from male calves that allows the farmer to receive an income a little above the minimum wage, while milk pays for the variable costs. This alternative is also the most attractive with milk production of 1,500 and 2,000 kg/lactation. In no scenario did the forage alternatives evaluated in this study (i.e. *Brachiaria* + *Arachis* or *Brachiaria* + *Cratylia*) reduce the cost of production of milk to levels below that of the naturalized pastures supplemented with brewer's yeast.

Under the assumption that brewer's yeast ceases to be a viable option for supplementation, another option evaluated was corn at $0.23/kg. In order for the option of *Brachiaria* with *Arachis* and/or *Cratylia* to be viable, and with the current levels of production of milk of 800 kg/l, the price of corn would have to increase to $0.38/kg. Thus, it seems unlikely that producers will adopt the alternative of *Brachiaria* with *Arachis* and/or *Cratylia* having as alternatives brewer's yeast and or corn at $0.23/kg. Even with milking cows producing 1,500 kg/lactation, the price of corn would have to increase to $0.25 in order to make the improved forage options viable.

The reason that none of the improved forage options were economically better that the current management practice of naturalized/native pastures + brewer's yeast is the high capital investment required per milking cow. The low current proportion of cows in milk increases fixed costs/milking cow. In

Pucallpa the percentage of cows in milk is 41% while in Costa Rica and Nicaragua this figure is close to 60%. Thus, in order to invest in these improved forage alternatives, it would be necessary to increase this percentage of cows in milk through the year to a minimum of 53%, or increase the stocking rate of 0.9 AU/ha at present to 1.3 AU/ha through the introduction of more animals. Under this new scenario, the forage options would be viable.

From the financial point of view, Figure 7 shows the real interest rates it would be possible to pay if a producer in Pucallpa invests in the establishment of *Brachiaria decumbens* associated with *Arachis pintoi*. Peru has the highest real interest rate of 34% (44% nominal -10% of annual inflation rate) of the three countries considered in this study. Thus, even if the investment in these new forage options were economically superior, the high real interest rate currently available in Peru would not attract producers to adopt these technologies. Therefore, under the current financial scenario, producers in Pucallpa have no option for intensification, (not even with productivity per cow of 2,000 kg/l and payback periods of 10 years) because it is not possible to pay a real interest rate of 34% (the best possible scenario is 15%).

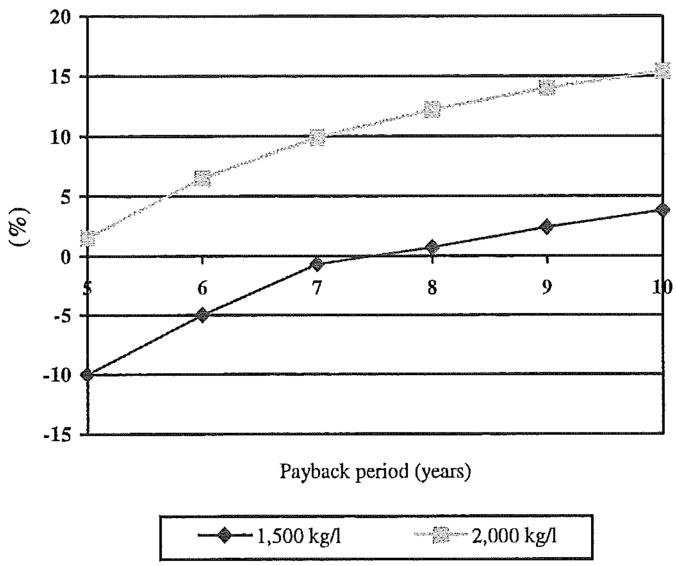

Figure 7. Real interest rate which could be paid by adopting Brachiaria + Arachis based on alternative milk yields in Peru

It has been argued that another advantage of establishing these forage alternatives in Pucallpa is that they would allow freeing up a large proportion of the area currently under grazing which could then be allocated for alternative uses such as reforestation, conservation or other crops. The area liberated is calculated at 35% (i.e. 20 ha/farm) in the case of *Brachiaria* + *Cratylia*, and 48% (i.e. 27 ha/farm) in the case of *Brachiaria* + *Arachis*. However, as land is plentiful in Pucallpa, it is unlikely that this will be a viable option.

Contributor: Federico Holmann, CIAT-ILRI, Colombia

Output 2. Integrated technology and management options for production systems

Output 2.1 Collaborative research and development partnerships

2.1.1 Collaborative partnerships for participatory technology development

Overall purpose: To develop R & D partnerships for developing component crop and livestock technologies and undertaking watershed or landscape level research.

Rationale: CIAT has limited resources in work in the development of component technologies or production systems research. Likewise there are limited resources for systems research at a landscape level where CIAT has a comparative advantage in only certain areas of expertise. Further, if the research and development efforts are to be sustained after the conclusion of a project, then it is imperative to involve local and national partners. The solution is to form collaborative partnerships in which all contribute actively towards the outcome of a particular research project.

a) DEPAM Consortium, Aguaytia watershed, Pucallpa, Peru

Highlights:

- Program coordinator and agro-industry and market specialist appointed
- Multi-institutional teams have commenced farmer participatory research on specific problems identified by the farming community.

Purpose: To facilitate the formation of a multi-institutional team to develop appropriate technologies together with farmers to increase productivity and conserve the natural resource base.

Rationale: There was a need to link strategic and applied research being conducted by the international Centers more closely to issues identified by local stakeholders, which include both the farmers and local R & D organizations and to introduce a more participatory approach to solution of problems. There was also an opportunity to facilitate closer collaboration between all organizations working in Pucallpa, which is needed to ensure efficient use of scarce resources.

Method: In collaboration with a donor, IDRC, and a local NGO, CODESU, CIAT is facilitating the formation of a multi-institutional team to carry out participatory technology development to improve farm productivity and natural resource use, in particular, to maintain/improve soil fertility and reduce gas emissions.

Priorities areas for research and a workplan were developed for the DEPAM team by the stakeholders during a three-day workshop in February 1998. A Stakeholder Committee of farmers and farmer organization representatives has been formed to continue the process of priority setting, to monitor research and adoption of the outputs. An Advisory Committee, comprised of representatives of organizations that participate in the DEPAM Participatory Technology Development team, provides technical advise and also monitors the research. CODESU provides administrative support and CIAT technical support in the areas of agronomy and participatory research and in training. Small research grants are being used as an incentive for institutions to work together in a farmer participatory approach.

Outputs: Considerable progress has been made in establishing the Participatory Technology Development (or DEPAM) team. A stakeholder consultation has been held, the project coordinator and agroindustry specialist were appointed, institutions have given their support to developing joint projects and the initial research grants have been made. A course in farmer participatory research will be held in October.

Impact: It is too early in the process to measure impact. We can report that farmers have responded positively in working in participatory approach with researchers. Most individuals from organizations involved in developing joint research proposals have seen where they can contribute to other groups' proposals. The DEPAM team now needs to be allowed space to develop its own mode of operation, independent of the sponsors, CODESU and CIAT.

Collaborators: DRAU/MAG, INIA, IIAP, UNU, AIDER, CODESU, CIAT, ICRAF, Keneth Reategui, Coordinator-DEPAM.

b) **TROPILECHE Consortium,** Latin America and the Caribbean (LAC)

"Improved legume-based feeding systems for smallholder dual-purpose cattle production in tropical Latin America" - CIAT-led consortia that operates in association with the Systemwide Livestock Program (SLP) convened by ILRI.

Highlights:

- Publication of a book on methodologies for on-farm research
- New partnerships with organizations in Nicaragua and Honduras
- Research programs in Peru and Costa Rica now well established

Purpose: To develop an on-going mechanism to work with national programs in LAC for evaluating new forage germplasm and developing sustainable forage technologies that provided solutions to feed limitations faced by small holder farmers involved in milk and meat production.

Rationale: The livestock industry has a poor image in Latin America in relation to resource degradation, such as deforestation, degraded soils and equity issues. Contrary to popular opinion, a large segment of the industry is in the hands of resource poor farmers.

Approximately 75% of the livestock population of 330 million head owned by small farmers with dual-purpose cattle that produce milk and beef. Dual-purpose cattle account for 41% of the milk produced in the region. Nevertheless, half of the 590 million ha under pasture is considered to be in an advanced stage of degradation.

The initial concept of Tropileche was developed around finding solutions of low livestock productivity and resource degradation. Initial sites were selected in Esparza, Costa Rica, to represent steep and seasonally dry hillsides, and Pucallpa, Peru, to represent a humid forest margins site. The hillsides and forest margins are priority agroecosystems within CIAT's natural resource program.

Method: A consultation was held with representatives of national organizations working in each of the sites. Priorities were set a joint workplan developed. It was agreed that strategic research at CIAT would be complemented by on-farm research by national partners at the selected sites. A coordinator was jointly by CIAT and ILRI. He has developed a common research database on dual-purpose cattle production in ALC and maintains the network. The Consortia receives funding from the Inter-american Development Bank (IDB) to execute on-farm research and from the SLP to carry strategic research.

Outputs: The research outputs are provided in detail in following sections.

Impact: Tropileche is developing into a platform that will accommodate needs of other countries in the region. Nicaragua and Honduras used the concepts developed in Tropileche to source their own funds and become active partners. Tropileche has become a vehicle for evaluating and developing forage and feeding technologies to meet specific needs, such as dry season supplementation, using new forage germplasm developed by the CIAT Forage Project (IP-5). It is an appropriate time to call a planning meeting of all interested parties to review current experience and seek input into how they visualize Tropileche as a platform for regional research collaboration.

Collaborators: CIAT, ILRI, Cornell University, Perú (IVITA, CODESU, INIA), Costa Rica (MAG, ECAG, CATIE, UCR), Nicaragua (MAG), and Honduras (DICTA).

c) Forages for Smallholders Project (FSP) and SEAFRAD network, Southeast Asia

Highlights:

- A project review in 1998 showed that there was a high rate of adoption of new forage materials by farmers
- This was attributed to a well executed program of technical input and training which had produced enthusiastic national teams at the FSP pilot sites

Purpose: To introduce improved forage germplasm into small holder systems in Southeast Asia to increase livestock productivity and contribute to soil conservation through a farmer participatory approach.

Rationale: There had been a long history of introduction of new forages materials into Southeast Asia with little impact in terms of farmer adoption of these materials. It was argued that early research had not been directed at overcoming feed problems identified by farmers and in a context where livestock are only a small component in the small farming systems and where farmer resources were limited. Hence a project was developed that would carry out all research on evaluation and technology development on-farm through national institutions using an FPR approach.

Outputs: The Southeast Asian Forages for Smallholders Project, which commenced in 1995, has developed an effective partnership with government and non-government organizations in Indonesia, Laos, Philippines and Vietnam. Research is coordinated by a country coordinator from the relevant government organization who coordinates FSP activities with a wide range of government and non-government organizations at three to six sites in each country. Regional coordination is effected through two CIAT/CSIRO staff members. Support has been given to publishing a newsletter for the SEAFRAD (South East Asia Feed Resources Research and Development) network.

Impact: National organizations, both government and non-government, have made a strong commitment of their own resources to participate in developing forage technology options for smallholder farmers in upland areas in Indonesia, Laos, Philippines and Vietnam. Nevertheless, though effective partnerships have been achieved, these require nurturing and continuing, effective coordination. Though SEAFRAD newsletters are widely disseminated by country coordinators of the FSP, the network is not active among scientists who are not directly involved in the FSP.

Contributors: Werner Stür (CIAT, FSP Philippines), Peter Horne (CSIRO, FSP Laos), Maimunah Tuhulele (DGLS, Indonesia); Ed Magboo (PCARRD, Philippines); Viengsavanh Phimphachanhvongsod (DLF, Laos), and Le Hoa Binh (NIAH, Vietnam).

d) Asian Cassava Research and Development Network

Highlights:

- Proceedings of the 5th Regional Workshop, held in Danzhou, Hainan, China, Nov 3-8, 1996, were published in April 1998.
- A Regional Stakeholders Consultation Meeting to define a new cassava strategy and to set priorities for future research in Asia, has been organized for November 1998.

Purpose: To enhance the efficiency of cassava research and development in Asia.

Rationale: Cassava producing countries in Asia have research programs in cassava of different strength relating to the importance of the crop in the economy. A network of cassava researchers was established in 1985 to improve communication of research results and experiences between the various countries, to coordinate the distribution of hybrid seed, and to help each country develop an effective cassava breeding and agronomy research program.

Methods: The CIAT cassava breeder and agronomist, stationed in the Regional Cassava Office for Asia in Bangkok, regularly visit research programs in each country. They have worked closely with cassava researchers in national programs to conduct collaborative research, and since 1994, farmer participatory research. The network organizes a Regional Cassava Workshop every three years to present research results and exchange experience. The network is coordinated by a

Cassava Research Advisory Committee comprised of representatives from each country and regional CIAT staff.

Outputs: The Proceedings of the 5th Regional Workshop, held in Danzhou, Hainan, China, from Nov 3 to 8, 1996, were published in April 1998. These have been distributed to all cassava workers in the network, as well as to about 70 libraries worldwide. Current research outputs are reported in the following sections.

A cassava strategy for Asia will be developed during a Regional Stakeholders Consultation Meeting, to be held in Bangkok, Thailand, in Nov 1998. Three key persons, from the cassava breeders, agronomists, processing specialists, and economists in each country, will develop a regional cassava strategy based on a document, prepared by IFAD, on global cassava strategies.

Impact: National cassava researchers see the network as being very important in ensuring that new cassava germplasm is distributed freely between countries. They also see it as a mechanism for maintaining close contact with CIAT cassava researchers and providing a means for attracting research grants. Network activity has depended on external donor funds and funding has not been resolved yet for 1999.

Contributors: Scientists working on cassava from China, Indonesia, India, Philippines, Thailand and Vietnam. Networking activities in Asia have been supported financially by the Japanese government and the Nippon Foundation. The Consultation Meeting will be financed by IFAD.

2.1.2 New projects for adaptive systems research

New projects

- Participatory Technology development: Desarrollo Participativo Amazónico (DEPAM): Addressing Poverty and Protecting the Environment in the Peruvian Amazon: The Interaction of Tecnological Innovation, Policy and Market Opportunities

IDRC provided US$240,000 through CODESU, a local NGO that includes most organizations in Pucallpa as members, for building a multi-institutional team to undertake FPR in the Aguaytia watershed, Pucallpa, Peru, for two years, 1998-1999.

IDRC also provided US $120,000 to CIAT for a post doctorate fellow in the area of agronomy and participatory research to work closely with the DEPAM team.

- Tropileche. Improved legume-based feeding systems for smallholder dual-purpose cattle production in tropical Latin America

The Inter-american Development Bank (BID) provided $750,000 to a CIAT-ILRI consortium for on-farm research in Costa Rica and Peru for three years, 1998-2000

- Tropileche:Optimizing Feed Supplies for Dual-Purpose cattle

ILRI provided $300,000 from the Systemwide livestock program for strategic research on optimizing feed supplies for dual-purpose cattle for three years, 1998-2000.

- Tropileche. Local funding was obtained by national organizations in Honduras and Nicaragua to participate in Tropileche

Project proposals

- To ADB for funding of a 3-year regional project, building on the outcomes of the Forages for Smallholders Project
- To ACIAR for funding of a 18 months project assessing impact of forage technologies at two FSP sites
- To the NIPPON Foundation for funding a second 5-year phase of the project "Integrated Cassava-based Cropping Systems in Asia: Farming Practices to Enhance Sustainability", to build on outcomes of the first phase
- To the Systemwide Alternatives for Slash-and-Burn Program for a 1-year project "An Indicator Framework for Use in Impact Analysis at the ASB Forest Margins Site, Pucallpa, Peru".

2.1.3 Coordination activities

Coordination has involved coordination of CIAT Activities at the agro-ecoregional site for the forest margins in Pucallpa, Peru, activities of project PE-5 and of partnerships within PE-5.

a)Forest margins ecoregional site – Pucallpa

Highlights

- A Participatory Planning by Objectives workshop was held with all stakeholders
- A multi-institutional project for participatory technology development (DEPAM) was commenced
- A joint workplan was developed for activities of CIAT, CIFOR and ICRAF
- New staff have been recruited and will be situated in an Ecoregional Center building together with ICRAF and CIFOR

Outputs: This year there has been a process of developing closer working relationships with our international and national partners based in Pucallpa. The main achievements have been:

- a work plan developed at a planning workshop to establish priorities for applied and adaptive research in the Aguaytia watershed.
- this work plan was then used as a basis for a proposal to IDRC for support in establishing a multi-institutional mechanism for adaptive research
- this resulted in the establishment of an adaptive systems project – DEPAM, which has been referred to earlier
- Office space was renovated in a common building occupied by CIAT, ICRAF and CIFOR and new office and computer equipment and vehicles purchased
- the house owned by CIAT was converted into a guest house for visitors or short-term staff
- workplans of CIAT, CIFOR and ICRAF were consolidated into one document.
- this will be the basis for a site workshop to be held in May 1999.
- a resource economist and an agronomist with participatory research experience have been recruited and will be based in Pucallpa.

Impact: CIAT now has a firm presence in Pucallpa and can contribute on an equal footing with other Centers.

Coordinator: P. Kerridge (for CIAT); R. Labarta (CIAT-Pucallpa)

b) PE-5 – Sustainable Systems for Smallholders

Highlights:

- Systems research consolidated in forest margins site, Pucallpa

Outputs: The project workplan was revised, individual workplans developed and assessed mid-year, and an annual report prepared. The Project Manager visited with scientists at sites in Asia (Indonesia, Philippines and Vietnam) and Latin America (Costa Rica, Nicaragua, Peru).

Most effort was spent on facilitating the establishment of an adaptive systems project at the forest margins reference site near Pucallpa, Peru. An effort was made to achieve greater coordination of CIAT activities in Asia and to bring PE-5 activities in Central America closer to those of the SDC and IDRC funded 'Hillsides Project'. Support was provided also for those directly responsible for coordination of Tropileche, Forages for Smallholders and Integrated Cassava Cropping Systems projects.

Impact: PE-5 has effective teams development component technologies within a systems context for forages and cassava using utilizing new germplasm from the Germplasm Improvement projects. The project has commenced on systems research at a watershed or landscape level in the forest margins reference site at Pucallpa, Peru.

Coordinator: P. C. Kerridge

c) Tropileche

Highlights

- A participatory workshop was held in Costa Rica during February of 1998 with all partners to review current research and planning of new activities
- Research programs in Peru and Costa Rica now well established and in Nicaragua and Honduras being consolidated
- Started negotiations with Venezuela for a long-term partnership with Tropileche
- Four journal articles completed and submitted for publication
- Database on livestock research results in LAC expanded

Outputs: This year the Tropileche Consortium consolidated its research activities in Costa Rica and Peru. In addition, Nicaragua and Honduras, which joined the Consortium with their own funds, have used the concepts developed in Tropileche to establish their own research agenda into this platform. Early this year a participatory workshop was held in Costa Rica to discuss and review current activities, and set up research priorities for 1998-2000.

The workshop was attended by 21 researchers from Peru, Colombia, Costa Rica, Nicaragua, Honduras, and the United States participating in the Tropileche Consortia. Proceedings from the workshop will be distributed at the end of this year to researchers in Tropileche and will be made available to other researchers when requested.

Outcomes of the meeting were:

- reports from the benchmark sites (Costa Rica and Peru) and extrapolation sites (Nicaragua and Honduras) to inform about progress and difficulties encountered to meet objectives during 1997
- new activities defined for 1998
- field visit view research in Costa Rica
- revisions of strategic and participatory research in relation to needs
- suggestions for new forms of collaboration with other institutions and other countries.

Venezuela has shown interest for a long-term partnership with Tropileche. Two trips were made to Venezuela this year to discuss a common research agenda.

Four journal articles were completed and submitted for publication this year. In addtion, two newsletters were produced and distributed to inform of progress on research activities being executed in all benchmark sites. A database on livestock research results in LAC continued to be expanded. It now contains more than 2,000 entries (65% of them with English and Spanish abstracts). The coordination also developed six project proposals/concept notes to expand and consolidate the research activities in various sites.

Impact: Tropileche has become a vehicle for evaluating and developing forage and feeding technologies to meet specific needs, such as dry season supplementation, using new forage germplasm, and application of farm-level simulation models to do ex-ante and ex-post analysis of new technologies.

Coordinator: Federico Holmann (CIAT-ILRI)

d) Forages for Smallholders Project

Highlights

- Third Annual Regional Meeting of the Forages for Smallholders Project in Samarinda, Indonesia from 22-27 March 1998
- Mid-term external review of the Forages for Smallholders Project from 19 March to 8 April 1998
- Feature article in December 1998 issue of In Focus, in-house magazine of AusAID.

Outputs:

The Third Regional Meeting of the Forages for Smallholders Project (FSP) was held in Samarinda, Indonesia from 22 – 27 March 1998. This meeting was especially important for the FSP since it coincided with the commissioned external review of the FSP, and the two reviewers attended the meeting. The meeting attracted 'high-level' participants such as the Director General of the Directorate General of Livestock Services of Indonesia (Ir. Erwin Sutirto), the

Director General of the Department of Livestock and Fisheries of Lao PDR (Dr. Singkham Phonvisay), and the Vice Director of the National Institute of Animal Husbandry of Vietnam (Prof. Le Viet Ly). The meeting was jointly sponsored by the Livestock Services of East Kalimantan and the FSP, and was attended by more than 40 participants. Sessions included

- The FSP: Where does it fit and what has it achieved?
- Livestock development in Indonesia;
- Environmental adaptation of forages;
- Developing and evaluating forage technologies with farmers;
- Seed production and other issues;
- Experiences with the FPR approach;
- Experiences with networking;
- What practical limitations have we encountered and how can we overcome them?
- Planning sessions for 1998/99.

The proceedings of the workshop will be published as a Technical Report of the FSP in December 1998.

An external review, commissioned by CIAT and CSIRO, was conducted of the Forages for Smallholders Project (FSP) between March 19 and April 9 by Mr. Ron Staples (Economist) and Dr. Walter Roder (Agronomist). The review team visited 10 project sites in Philippines, Indonesia, Vietnam and Laos and attended the project's Regional meeting in Samarinda, East Kalimantan. This enabled the review team to meet also the coordinators from Malaysia, Thailand and China who only participate in the network component of the FSP. Site visits and discussions with government authorities, project staff, staff from related projects and farmers provided the review team with the opportunity to appraise the site-specific conditions and problems and to experience the achievements and opportunities of the project.

The review report was very positive. The reviewers concluded that the project is ahead of schedule in achieving the targets or outputs set out in the PID. Useful new varieties of grasses and legumes have been identified and there is already considerable impact from the introduction of forages at the household level at several of the sites visited. The FSP is also commended for its approach and contribution to development of training materials, especially on the participatory approach. The use of the participatory approach was considered to be the key that enabled the FSP to 'bring forages to farmers'. The reviewers notes: "The enthusiasm for forage development, the understanding of FPR and the professionalism in forage agronomy displayed by the contact persons, which included researchers, extensionists and farmers was very encouraging and a strong testimony to the high standards in project management and execution". They suggested that the experience of the FSP be incorporated into design and implementation of other projects that are under consideration. They concluded that the FSP had built up an excellent base for fruitful forage research and development activities in all the participating countries. The reviewers suggested that it will be critical to continue the participatory technology development process with farmers and local technicians. This applies to the full process of forage technology development, from forage introduction through to the stage where improved forages are being more widely adopted and new problems may arise. They concluded that, to get the benefit from the capacity, the trust and the expectations that have been built up across the various sites, it is important that the project be expanded beyond 1999. They also concluded that the regional character of the project has been highly effective in use of resources, and sharing of experience and information.

Impact:
Attention to coordination has contributed to effective collaboration by national partners. The project is highly regarded in Southeast Asia and this will heighten chances of funding a follow on project.

Coordination: Asia W.W. Stur (CIAT), P.M. Horne (CSIRO); Overall P.C. Kerridge (CIAT), J.B. Hacker (CSIRO).

e) Integrated Cassava-based Cropping Systems in Asia

Highlights:

- End of Project Review which stated that the project had met its objectives and that the outcomes formed a sound basis for a new project.

Outputs: A review was undertaken by an external review panel, consisting of Dr. John Lynam, agricultural economist of the Rockefeller Foundation in Nairobi, Kenya; and Dr. Keith Ingram, agronomist at the University of Georgia, USA. They visited all but one of the FPR pilot sites in four countries from June 28 to July 19, 1998, after which they wrote a Project Evaluation Report.

The report the review panel endorsed the accomplishments of the present project and strongly recommended that a second phase be supported. They made many useful suggestions to enhance the effectiveness of the new project which were incorporated into the new project proposal mentioned above.

The CIAT agronomist visited all FPR sites during the year to provide support to national partners.

Impact: The coordinator was honored by the Government of the PR China in September for this contribution to development of .Public recognition had previously been received from the Government of Vietnam.

Coordination: R. Howeler

Output 2.2 New crop and livestock technologies for production systems

2.2.1 Increased efficiency in utilizing forage resources

a) Supplementation with Cratylia argentea and sugarcane

Highlights

- Response in milk yield to legume supplementation of sugarcane and a basal grass diet was greater in the dry than wet season

Purpose: To determine the effect of supplementing a basal diet of sugarcane with the legume, *Cratylia argentea,* during the dry and wet seasons.

Rationale: Results from short-term grazing experiments with milking cows indicate that milk yield response to legumes in association with grasses is greater in the dry than wet season. Sugar cane is widely used as a feed supplement for dairy cows. It is high in energy but low in protein. Thus, in developing feeding strategies where sugar cane is used as a supplement, it is important to know when there is an advantage of feeding a legume supplement.

Methods: The experiment was set up using a 4x4 latin square design. All feed was fed ad lib. There were two breed groups of four cows each (Brahman and Holstein x Brahman crossbred). Each of the four feeding periods lasted 14 days (7 days to adjust feed ration and 7 days of measurements). Milk yields were recorded daily during the 7-day measurement period.

Outputs: Table 1 contains the fat corrected milk of crossbred cows supplemented with different protein to energy ratios from forage sources and biomass availability, digestibility, and crude protein content of *Brachiaria decumbens* used as basal grass during the dry and rainy season at Quilichao experiment station, Cali, Colombia. There was no response in milk production to legume supplementation by the Brahman cows.

As observed, milk yield increased as supplementation with the legume *Cratylia argentea* was proportionately increased with respect to sugarcane during the dry season when the basal grass was limiting (i.e. lower biomass availability) and lower quality (i.e. lower digestibility and crude protein). On the contrary, when the treatment was run during the rainy season, there was no significant effect on milk yield due to legume supplementation, which suggests that basal grass was supplying enough energy and protein to maintain milk production.

Impact: These results suggest that legume supplementation should be used strategically, especially during the dry season when basal grass is limiting and of lower quality with respect to the rainy season. It is only likely to be successful with crossbred cows. Nevertheless, this technology has excellent potential for adoption given the fact that the capital investment required to establish it is low. There remains a need to evaluate legume supplementation with cows with even higher genetic potential for milk production and to test the results under on-farm conditions.

Table 1. Fat-corrected milk yield of crossbred cows supplemented with different protein to energy ratios from forage sources and biomass availability, digestibility, and crude protein content of *Brachiaria decumbens* used as basal grass during the dry and rainy seasons.

Treatments	Milk yield during dry season (kg/cow/day)	Milk yield during rainy season (kg/cow/day)
100% Sugarcane	6.0 b	7.9 a
75% Sugarcane + 25% *Cratylia*	7.0 a	7.5 a
50% Sugarcane + 50% *Cratylia*	7.2 a	7.7 a
25% Sugarcane + 75% *Cratylia*	7.8 a	8.3 a
Basal grass composition	Dry season	Rainy season
* Biomass availability (kg DM/ha)	2164	2502
* Digestibility (%)	63.4	66.6
* Crude Protein (%)	4.4	7.1

Contributors: Patricia Avila and Carlos Lascano, CIAT, Colombia.

b) Supplementation with Cratylia argentea and sugarcane during the wet season

Highlights

- *Cratylia argentea* increased milk production in cows with a high potential for milk production when fed as 100% of the supplement

Purpose: To investigate the effect of supplementation with *Cratylia argentea* during the wet season.

Rationale: During the dry season milk yields of grazing cows are drastically reduced because biomass availability and quality of grass is reduced due to lack of rainfall. Producers have been adopting the use of sugarcane as a supplementary feed. However, sugarcane is a poor source of protein, which is also needed to increase milk yield. Most research has investigated the effect of supplementing cows in the dry season when both quantity and quality of pastures are limiting. Thus, we were interested in examining milk yield responses to increasing levels of *Cratylia argentea* fed as a forage-based supplement fed to cows grazing pasture in the wet season.

Methodology: A 4x4 latin square design was used to estimate milk yield from legum e supplementation using 7 days of adjustment to treatment, and 7 days of measurement with crossbred cows. Treatments were: T1 = 100% *Cratylia*; T2 = 75% *Cratylia* and 25% sugarcane; T3 = 25% *Cratylia* and 75% sugarcane; and T4 = 100% sugarcane. Basal diet consisted of *Brachiaria decumbens* which was grazed. Legume and sugarcane were supplemented at 1.5% of BW.

Outputs: Table 2 contains milk yield, fat content, and biomass availability of basal grass used for all treatments in Quilichao, Colombia. As observed, there was no difference in milk yields or fat content when *Cratylia* was fed with sugarcane, but milk yield and fat content were significantly increased when *Cratylia* was fed as a 100% supplement.

Impact: These results suggest that supplementing with C. argentea may be an alternative for farmers in the wet season when using cows of high genetic potential and thus, high protein requirements. This is interesting because it provides an option to use this legume during the wet season in a cut-and-carry system in addition to ensiling which has been an option put forward by some producers in Costa Rica.

Table 2. Milk yield and fat content for all treatments in Quilichao, Colombia.

Treatment	Milk yield (kg/cow/day)	Fat content (%)
100% Cratylia	6.3 a	4.2 a
75% Cratylia – 25% Sugarcane	5.6 b	3.9 b
25% Cratylia – 75% Sugarcane	5.6 b	3.8 b
100% Sugarcane	5.7 b	3.7 b

Contributors: Harold Martinez (COLCIENCIAS fellow) and Carlos Lascano

c) Use of Cratylia argentea for dry season supplementation of sugarcane supplementation

Highlights

- It was shown that *Cratylia argentea* can be used to replace purchased protein supplements for cows of medium-high potential for milk production.

Purpose: To determine the effect of replacing commercial protein supplements with *Cratylia argentea.*

Rationale: Concentrate feeds in Costa Rica and other countries are often very expensive in relation to milk price. It is important to find feeding alternatives with the potential for substituting for purchased concentrates without sacrificing milk yield or income.

Methodology: Two experiments of 3x3 latin square design were run simultaneously to evaluate milk yield and composition to substitution of a protein source from commercial concentrates to a protein source from the shrub legume *Cratylia argentea* using sugarcane as basal diet. Treatments were: T1 = Sugarcane (0.6% BW) + Rice bran (0.5% BW) + Concentrate (1.5% BW) + Urea (0.017%); T2 = Sugarcane (0.6% BW) + Rice bran (0.5% BW) + Concentrate (0.975% BW) + *Cratylia* (0.525% BW); and T3 = Sugarcane (0.6% BW) + Rice bran (0.5% BW) + Concentrate (0.45% BW) + *Cratylia* (1.05% BW). The estimated daily dry matter consumption was 2.6% of body weight.

Outputs: Table 3 shows dry matter intake, milk yield, and total solid contents for all treatments. During the experiment there was an increase in dry matter intake greater than estimated for all treatments (i.e. 3.5%, 3.7%, and 3.4% vs 2.6% estimated). Thus, it was necessary to increase the amount of supplements offered. The dry matter intake was similar for all treatments, which suggests that *Cratylia argentea* has good palatability and acceptability. Milk yields were similar for the first two treatments but significantly lower when *Cratylia* was substituted 70% for the concentrate.

Table 3. Dry matter intake, milk yield, and total solids from treatments substituting concentrate by *Cratylia argentea* in Atenas, Costa Rica.

Treatment	Dry matter consumption (kg /cow/day DM)	Milk yield (kg/cow/day)	Total solids (%)
All concentrate	11.29	12.56	12.25
65% concentrate-35% *Cratylia*	11.94	12.15	12.83
30% concentrate-70% *Cratylia*	11.19	10.70	12.35

Impact: These results suggest the shrub legume *Cratylia argentea* can be used to substitute up to 35% the use of purchased concentrates without sacrificing milk yield. A greater substitution level may result in a lower milk yield than with purchased concentrates but this needs to be balanced with the lower cost of purchasing concentrates. It is planned to develop an appropriate economic model to allow farmers and technicians to determine if the reduction in feeding costs is greater than the reduction in milk income.

Contributors: Francisco Romero and Jesús Gonzalez, ECAG, Costa Rica

d) Use of Stylosanthes guianensis hay as a supplement for increasing milk yield

Highlights

- Low quality legumes make cannot make a contribution to increasing milk yield.

Purpose: To evaluate the effect of feeding increasing levels of hay made from the legume *Stylosanthes guianensis* with sugarcane on milk yield.

Rationale: One of the objectives of on-station research at ECAG in Atenas, Costa Rica, is to generate information of milk yield responses to different forage resources to calibrate the Cornell Net Carbohydrate and Protein System model under tropical grazing conditions. Hence a series of experiments are being planned with different forage supplements.

Methods: Treatments consisted of a basic ration of *B. decumbens* hay at 1% of body weight (BW, dry matter basis) plus 1.7% of BW of supplement. (T1 = 75% sugarcane + 25% stylo; T2 = 50% sugarcane + 50% stylo; and T3 = 25% sugarcane + 75% stylo). In addition, all cows received 0.3% of BW of a commercial concentrate feed (14% CP with 2.7 Mcal ME).

Outputs: The chemical composition of offered feeds is shown in Table 4. Table 5 shows dry matter consumption, and milk yield of cows under the different treatments. There were no significant differences in milk yield among treatments. Average daily means for milk yield/cow and total solids were 7.5 kg/cow/d and 12.75%, respectively. Dry matter consumption per cow was 9.31, 8.66, and 7.93 for treatments 1, 2, and 3, respectively. These figures indicate a reduction in dry matter intake as the proportion of Stylo supplemented increased.

Table 4. Chemical composition of offered feeds. Atenas, Costa Rica.

Feed	Crude Protein (%)	IVDMD (%)	Metabilizable Energy (Mcal/kg DM)
Sugarcane	2.4	56.7	2.1
Stylosanthes guianensis	7.4	51.5	1.8
Brachiaria decumbens	4.5	54.5	2.0
Concentrate	14.0	70.0	2.7

Table 5 Dry matter consumption, average milk yield and total solids by treatment in Atenas, Costa Rica.

Treatment	Dry matter consumption (kg)	Milk Yield (kg/cow/day)	Total Solids (%)
75% Sugarcane + 25% stylo	9.31	7.08	12.77
50% Sugarcane + 50% stylo	8.66	7.25	12.78
25% Sugarcane + 75% stylo	7.93	7.08	12.88
Control[1]	9.10	7.51	12.53

[1] 1% of BW of *B. decumbens* hay + 1.7% BW of sugarcane + 60 gr urea

Impact: The lack of difference among treatments was due to the poor quality of the legume hay, both low protein and low digestibility. There was a similar amount of crude protein consumed in the different treatments because dry matter consumption was reduced with increasing amounts of stylo hay. Poor quality legumes will not increase dry matter consumption and may reduce the efficiency of utilization of energy in the ration. It is necessary to ensure that there is both a high protein content and digestibility, for legumes or legume hay to increase milk yield.

Contributors: Francisco Romero and Jesús Gonzalez, ECAG, Costa Rica.

e) Legumes as protein sources for supplementing sugarcane in feed rations for milking cows

Highlights

- Legumes with crude protein composition of <12% are not an appropriate substitution for chicken manure for milking cows

Purpose: To investigate the use of tropical legumes as a protein source for feeding milking cows

Rationale: During the dry season, milk production under grazing conditions is reduced significantly due to a shortage of feed. The quality of grass is lower where the forage is wet and dried intermittently. Thus, supplementing milking cows with other feed resources is essential in order to maintain milk production and income. The most common protein supplement used in Costa Rica during the dry season is chicken manure, but its availability is limited and its cost in real terms is increasing. Legumes could be an important to substitute for chicken manure.

Methods: An experiment to compare the feeding value of two legumes was set up using a 3 x 3 latin square design with three Jersey cows and three dual-purpose crossbred cows. The three treatments were: T1= sugarcane (0.9% of BW as DM) + molasses (0.6% of BW) + chicken manure (1.5% of BW); T2 = sugarcane (0.9% of BW) + *Stylosanthes guianensis* (1.8% of BW) + chicken manure (0.3% of BW); and T3 = sugarcane (0.9% of BW) + *Centrosema* spp (1.8% of BW) + chicken manure (0.3% of BW). The feed rations were offered after each milking in individual pens in confinement.

Outputs: Table 6 contains the chemical composition from the different feeds offered in the experiment in Atenas, Costa Rica. The legumes had similar crude protein content, 12.1% and 11.2% CP, with digestibility of 44.2% and 44.7%, for *Stylosanthes* and *Centrosema*, respectively. Thus, both legumes offered in the diet were inferior in quality to chicken manure, 21.5% CP and 67.2% digestibility, which was used as control. Table 7 shows that when the protein source was chicken manure, milk yield was significantly higher than that obtained with legume supplementation. There were no observed differences in total solid content with treatments. On the other hand, milk yield from the diet containing *Centrosema* was higher than with stylo. This could be due to a lower degradability of protein from *Centrosema* compared to stylo (Table 8).

Table 6. Chemical composition of feeds offered, Atenas, Costa Rica

Feed	Dry Matter (%)	Crude Protein (%)	Digestibility (%)	Metabolizable Energy (Mcal/kg)
Sugarcane	35.0	2.7	51.2	1.9
Chicken Manure	92.1	21.5	67.2	2.5
Stylosanthes guianensis	95.2	12.1	44.2	1.5
Centrosema spp.	94.6	11.6	44.7	1.5

Table 7. Milk yield and total solids of milking cows under different treatments, Atenas, Costa Rica.

Treatment	Milk yield (kg/cow/day)	Total Solids (%)
Chicken manure	8.1	12.1
Stylosanthes guianensis	6.6	12.7
Centrosema spp.	7.2	12.3

Table 8. Efficiency in the use of dry matter (DM), crude protein (CP), and metabolizable energy (ME) of milk yield by breed, Atenas, Costa Rica.

Breed	Chicken manure			*Stylosanthes*			*Centrosema*		
	DM	CP	ME	DM	CP	ME	DM	CP	ME
Jersey	0.92	5.74	0.37	0.97	11.0	0.54	1.23	15.1	0.68
Crossbred	0.75	5.04	0.32	0.52	6.15	0.29	0.59	6.63	0.40

Impact: The legumes used in this study were inferior in quality (<12% CP and <45% digestibility) to most legumes and to chicken manure and therefore, the response in milk yield was low. It is necessary to improve the management conditions of legume production in order to improve its quality to as a substitute feed for protein sources such as chicken manure.

Contributors: Francisco Romero and Jesús Gonzalez, ECAG, Costa Rica.

f) Milk urea nitrogen as an indicator for devising feeding strategies for milk production

Highlights

- Milk urea nitrogen (MUN) concentration is a good indicator of the protein to energy ratio in the diet, responses to protein supplementation being expected below <10 mg/dl MUN.
- MUN concentration could be a useful indicator in increasing the efficiency of use of on-farm feed resources

Purpose: To determine the applicability of milk urea nitrogen (MUN) as a nutritional indicator of the energy/protein status of milking cows fed tropical forages

Rationale: When there is an excess of nitrogen relative to energy in the rumen, ruminal ammonia concentration increases. Unused ruminal ammonia enters the portal blood through the rumen wall and is transferred to the liver where it is detoxified by conversion to urea. The liver also produces urea from deamination of amino acids rising from postruminal digestion and systemic protein turnover. Urea then circulates in the blood to the kidneys and is excreted with the urine or it can be diffused from the blood into milk. When there is a deficiency of dietary proteins, ruminal ammonia concentrations are relatively low and the proportion of nitrogen recycled back to the rumen as urea increases. As a result of these metabolic transactions, blood urea nitrogen (BUN) is highly correlated with ruminal ammonia and milk urea nitrogen (MUN). Therefore, in healthy ruminants, MUN concentrations could be a good indicator of the protein to energy ratio in the diet.

Methodology: There were two breed groups of four cows (Brahman and Holstein). Each of the periods lasted 14 days (7 days to adjust feed ration and 7 days of measurements). Milk yields were recorded during the 7-day period and milk samples for urea content were taken on days 1, 4 and 7 of each period. The design used was a 4x4 Latin square.

Outputs: Figure 1 shows the relationship between milk yield increase and MUN of cows supplemented with *Cratylia argentea* and sugarcane. Four groups can be identified, i.e. one for each quadrant: (i) those cows which showed an increment in milk yield to legume supplementation when the level of urea in milk was <10 mg/dl. These observations were mostly from crossbred cows; (ii) those cows which did not respond to legume supplementation even when the urea level was <10 mg/dl. This group was composed of crossbred and Brahman cows in similar proportions; (iii) those cows with urea level >10 mg/dl which showed a modest increase in yield. This group was composed of both crossbred and Brahman cows in similar proportions; and (iv) those cows which did not respond to an increase in milk yield due to legume supplementation with urea level in milk >10 mg/dl. This group was mostly composed of Brahman cows.

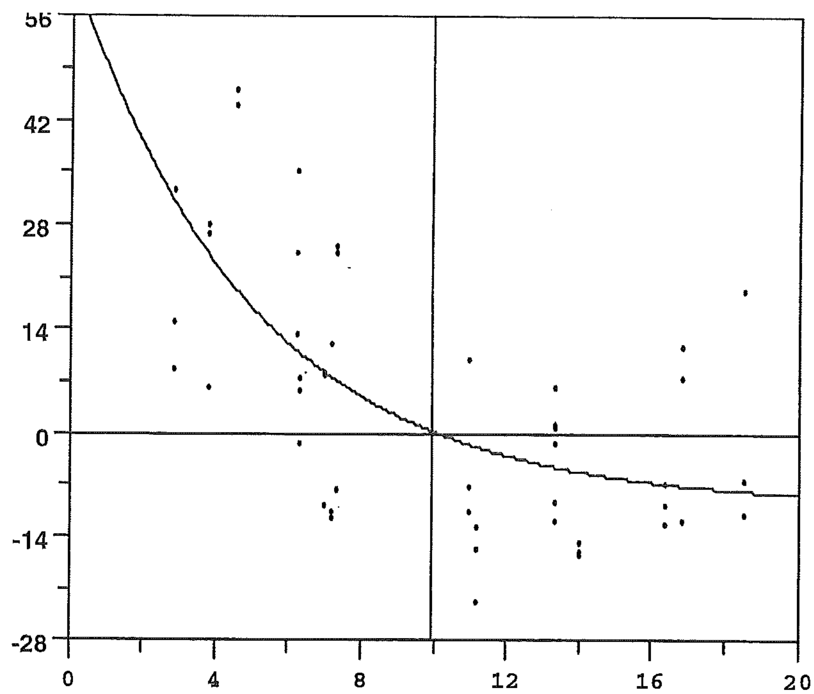

Figure 1. Relationship between milk yield increase (in relation to the sugarcane control) and the level of urea in milk of grazing cows supplemented with *Cratylia argentea* and sugarcane

Impact: These results suggest a urea level in milk of about 10 mg/dl could be used as a critical value below which there is a high probability that there will be a response in milk produced to protein supplementation by cows with a high genetic potential for milk production. While crossbred cows respond to legume supplementation at <10 mg/dl levels, this is not the case for most Brahman or Zebu-type of cows.

Contributors: Patricia Avila and Carlos Lascano, CIAT, Colombia

2.2.2 Legume-based pasture technologies for dual-purpose cattle production in Latin America

a) Use of an Arachis pintoi-Brachiaria decumbens association for milk production, Athenas, Costa Rica

Highlights

- *Arachis pintoi* associated with *Brachiaria decumbens* increased milk production from 9.7 to 10.7 l/d even when concentrates were being fed.

Purpose: To evaluate the production and composition of milk from cows grazing *Brachiaria decumbens* vs. *B. decumbens* associated with the legume *Arachis pintoi.*

Rationale: Tropical grasses during the rainy season have adequate amounts of energy but the protein content is usually low, especially in unfertilized pastures. Legumes, on the other hand, are tropical forages with a high protein content when in the young stage of growth. Thus, providing a diet of tropical grasses in association with legumes should lead to increases in milk yield.

Methods: Two paddocks of *B. decumbens* and *B. decumbens* associated with *Arachis pintoi* were subdivided in two paddocks of 1.25 ha each. In each paddock, there was a 7- day grazing period to adjust to cows to the treatment, and then milk yield was measured over the next 7 days. A resting period of 35 days was followed between grazings. Chemical composition, biomass availability, and forage quality were also measured.

Outputs: Table 1 shows the availability and quality of the forage under evaluation during 1997. As observed, the grass-legume association produced 8% more biomass and 15.5% more crude protein content than *B. decumbens* alone with no significant difference in digestibility.

Table 2 shows milk yields under two levels of supplementation with concentrate feeds (i.e.a high and low level). Tthe grass-legume association with *Arachis pintoi* produced 9% and 11.4% more milk than the *B. decumbens* alone pasture.

Table 1. Availability and quality of *Brachiaria decumbens* offered with and without *Arachis pintoi* during 1997 in Atenas, Costa Rica.

Attribute	*B. decumbens*	*B. decumbens* + *Arachis pintoi*	Difference (%)
Availability (mt DM/ha)	7.5	8.1	8.0
Crude Protein (%)	11.6	13.4	15.5
DMIVD (%)	62.4	62.0	-0.5

Table 2. Milk yield (kg milk/cow/day) of cows under two levels of supplementation with concentrate feeds grazing *B. decumbens* with and without *Arachis pintoi* in Atenas, Costa Rica.

Supplementation level	*B. decumbens*	*B. decumbens* + *Arachis pintoi*	Difference (%)
High [1]	11	12.0	9
Low [2]	8.3	9.3	11

[1] 1kg concentrate for every 3 kg milk produced; [2] 1 kg concentrate/cow/day

Impact: These results show that milking cows under grazing showed a response in milk yield to legume supplementation even when concentrates were fed. This technology would be most useful during the rainy season as the legume *Arachis pintoi* is not as tolerant to water stress as shrub legumes. This 9-11% increase in milk yield is consistent with results from other sites, e.g. the forest margins. However, the genetic potential for milk production will be a key factor in determining the feasibility of this technology. A 10% increase when cows are only producing 3 kg/day will not pay for itself, but if cows are producing 8 kg/day, a 10% increase will result in profits from investing in this technology.

Contributors: Francisco Romero and Jesús Gonzalez, ECAG, Costa Rica

b) Grass-legume associations in the forest margins, Ucayali, Peru

Highlight

- Initial results of the role of legumes in increasing milk production are inconclusive

Purpose: To evaluate the role for legume-grass associations for milk production in the forest margins, Ucayali, Peru.

Rationale: There is little management input of pastures in the Ucayali region of the Peruvian Amazon. They are often degraded in terms of weed ingress and loss of planted species. Livestock productivity is low. As more pressure is exerted towards conserving natural forest resource in this agricultural frontier, there is a need to find alternatives to intensify livestock production and release marginal areas for forest regrowth.

Methods: Five dual-purpose farms were selected for this study. In each farm, 5 ha of *Brachiaria decumbens* were established (2.5 ha as the control treatment and 2.5 ha associated with a legume cocktail containing *Stylosanthes guianensis* + *Arachis pintoi* + *Desmodium ovalifolium*). Milk production was recorded of cows were grazing both paddocks alternatively during a one-year period, from August 1997 to August 1998.

Outputs: Table 3 shows the average milk yield obtained in each of the five farms in the control and legume-mixture pastures in comparison with the milk yield obtained from the naturalized grasslands found in each farm. As observed, milk yields were, on average, 10.5% higher in grass-legume mix than *B. decumbens* alone and 14.5% than naturalized grasslands. However, the additional increase in milk yield (0.40 kg/cow/day) compared to naturalized grasslands does not justify the investment in the grass-legume mix (see Activity 3.1, ex-ante analysis of new forage alternatives in dual purpose farms in Peru, Costa Rica, and Nicaragua).

Table 3. Average milk yield of cows grazing *B. decumbens* alone (control), grown with a mixture of legumes (Stylosanthes guianensis + Arachis pintoi + Desmodium ovalifolium) and from naturalized grassland, Pucallpa, Peru.

Farm	Milk yield on individual farms (kg/cow/day) 1	2	3	4	5	Average milk yield
B. decumbens	3.5	2.2	3.7	1.5	3.4	2.9
B. decumbens + legume	3.7	2.2	3.9	2.7	3.3	3.2
Native grass	3.2	2.3	3.9	1.7	NA	2.8

Impact: Improved grasses and legumes appear to have potential to increase milk production. However, their use will only be economic where milk yield response to legume supplementation is in the order of 0.75-1.0 kg milk/cow/day. Additional information on the role of legumes in relation to carrying capacity and pasture persistence is needed before their role in intensification can be assessed. Complementary research is also needed on the interaction between response to legume association by cows of different genetic potential for milk production. There is potential to increase milk production by improving general livestock management in the Ucayali region.

Collaborators: Keneth Reategui (DEPAM) and Geiner Romero (CIAT)

c) Stylosanthes guianensis *for strategic supplementation of pre-weaned calves*

Highlight

- Use of a legume to feed pre-weaned calves increased the collection of milk from dual-purpose calves with the potential to increase farmer cash income

Purpose: To evaluate the use of *Stylosanthes guianensis* for feeding pre-weaned calves in dual-purpose cattle systems

Rationale: Pre-weaned calves consume about 15-20% of milk production from dam (the residual milk after hand milking). Therefore, developing a legume supplement for calves that would reduce the amount of residual milk consumed could have an impact on milk collected by the farmer. Preliminary results were presented in the Annual Report for 1997. The results are now reported in an economic context.

Methods: Treatments were:
T1 = calves on native grass 8 hours/day with dam, the remainder grazing a paddock of *Stylosanthes guianensis* + residual milk; T2 = calves on native grass 8 hours/day with dam, the remainder grazing a paddock of *Stylosanthes guianensis* + residual milk + concentrates; and T3 = control (calves grazing native grass 24 hrs/day + residual milk).

Outputs: Table 4 shows milk yield and income, weight gain and beef value, and total value from milk and beef for all treatments. Average daily gain of calves grazing stylo were similar to the traditional system, but milk sales increased by 23% (0.89 kg additional milk/cow/day). This was reflected in a 25% increase in income. The treatment with stylo + concentrate had a similar quantity of milk for sale as stylo without concentrate, but higher daily weight gains. However, the variable cost was also higher, resulting in similar total net income as the treatment of stylo without concentrate.

Table 4. Average milk sold per cow/day, weight gain from calves, and cash value from milk and beef for each treatment.

	stylo	stylo + concentrate	Control
Milk sold/cow/day (kg)	4.73	4.71	3.84
Milk price ($/kg)	0.31	0.31	0.31
Milk income ($/cow/day)	1.47	1.46	1.19
Daily weight gain (gr/calf)	540	760	530
Beef price ($/kg)	1.03	1.03	1.03
Beef income ($/calf/day)	0.56	0.78	0.55
Total value of production ($/cow-calf/day)	2.03	2.24	1.74
Total variable cost ($/cow/calf/day)	0.58	0.80	0.58
Net income ($/cow-calf/day)	1.45	1.44	1.16

Impact: Feeding *Stylosanthes guianensis* to pre-weaned calves could have significant impact on farmer income if some other alternative can be found to increase the weight gain of the calves during the same period.

Collaborators: Jorge Vela, IIAP, Peru

2.2.3 Forage-based systems for dry season supplementation in tropical Latin America

a) Evaluation of Cratylia argentea *as a new legume-based forage alternative*

Highlights

- Forage systems for strategic supplementation during the dry season reduce the need to buy concentrate feeds and increases income in dual purpose farms
- The use of legume fodder with an energy source during the dry season maintains milk yield

Purpose: To evaluate the effectiveness of *Cratylia argentea* as a dry season feed supplement through on-farm experimentation

Rationale: During the dry season milk yield is significantly reduced due to lower quantity and quality of forage on offer. Producers overcome this constraint by feeding agro-industrial by-products. Among them, the cheapest feed source available in the dry hillsides region of Costa Rica is chicken manure. However, its availability is limited and its cost in real terms is increasing. It is urgent to identify a low cost alternative. *Cratylia argentea* has been shown to be a well-adapted and persistent shrub legume that maintains its leaf under the dry season conditions experienced in the Pacific zone of Central America. It is know to have a high feeding value.

Methods: We are working with a number of farmers in Costa Rica and Nicaragua to evaluate *Cratylia argentea* as a dry season supplement. It has been established on a number of farms in large blocks (or fodder banks). It will usually be fed in conjunction with sugar cane. The following are some initial results from one farm. We commenced the investigation by gradually replacing the chicken manure supplement with *Cratylia argentea* over a six week period. Milk yield from seven dual-purpose cows was determined during six weeks at the farm of Fernando Castro, a producer collaborating with Tropileche in Esparza, Costa Rica. During the first two weeks cows received a daily feed ration containing 12 kg of sugarcane, 6 kg of *Cratylia*, and 3 kg chicken manure (as fed basis). During weeks 3 and 4 the amount of chicken manure fed was reduced by half, to 1.5 kg/cow/day. During the last two weeks chicken manure was totally eliminated. Cows were grazing a *Hyparrhenia rufa* pasture.

Outputs: Table 1 shows the average daily milk yield during the six weeks of the experiment. Milk yield/cow was maintained despite the reduction and then elimination of the chicken manure supplement. As the feeding cost per cow was reduced as a result of the substitution, the benefit/cost ratio increased from 1.57 to 2.14. Thus, the producer was better off because his cash flow would improve.

Impact: *Cratylia argentea* shows great potential as a legume-based feeding alternative for the dry season since it can reduce or eliminate the need to buy feed by-products for locally produced feed resources. Milk production was not increased but because the feed is produced on the farm, the benefit/cost ratio is increased. Results are needed over the longer-term. However, it is likely to become an attractive investment for producers. These are the first on-farm results of feeding *Cratylia* and it is likely that technology will be further modified and adapted by farmers. One example, is conservation of wet season production as silage for subsequent feeding back in the dry season.

Table 1. Milk yield, and benefit/cost ratio from dual-purpose cows receiving sugarcane, *Cratylia argentea*, and diminishing amounts of chicken manure in Esparza, Costa Rica.

Supplement –manure	Weeks 1 & 2 (3 kg/cow chicken manure)	Weeks 3 & 4 (1.5 kg/cow chicken manure)	Weeks 5 & 6 (no chicken manure)
Milk yield/cow/day	3.48	3.35	3.41
Feed cost/cow/day	0.60	0.51	0.43
Milk income/cow/day	0.94	0.90	0.92
Benefit/cost ratio	1.57	1.76	2.14

Contributors: Marco Lobo and Vidal Acuña, MAG, Costa Rica

b) Use of legumes for supplementing calves during the dry season

Highlights

- *L. leucocephala* is an alternative option for supplementing pre-weaned calves on higher fertility soils during the dry season.

Purpose: To evaluate *L. leucocephala* for supplementing calves

Rationale: During the dry season, weight gains of pre-weaned calves are reduced due to low quality of forage and a low milk supply from the dams. Thus, finding a low-cost alternative to supplement calves during the dry period would improve their nutritional status and weight gain.

Methods: Two groups of 10 pre-weaned calves each were selected at a farm in Esparza, Costa Rica. The first group average 132 kg/calf and the second group 128 kg/calf. The first group was traditionally managed, consisting of consuming the dam's residual milk plus ad libitum consumption of *Digitaria decumbens* hay. The second group grazed *Leucaena leucocephala* for two hours a day during 22 days, as a supplement to the traditional feeding management.

Outputs: The group consuming leucaena obtained greater weight gains, from 128 to 138 kg, than the group under the traditional system, from 132 to 139 kg. Calves consuming *L. leucocephala* gained 109 gr/day more than the control group.

Impact: The use of legume supplementation to feed pre-weaned calves during the dry season appears to be a beneficial option for small milk producers. It's adoption would be limited to medium-higher fertility soils.

Collaborators: Marco Lobo and Vidal Acuña, MAG, Costa Rica

2.2.4 Forage species evaluated for intensive mixed-systems for beef and milk production in the Piedmont, Llanos

Renovation of degraded pastures using Arachis pinoti

Highlights

- Four new accessions of Arachis pintoi are being evaluated under grazing on four farms

Objective: To evaluate four accessions of *Arachis pintoi* planted at low seeding rates in degraded brachiaria pastures for their contribution to restoration of the pasture.

Rationale: Large areas of improved brachiara pastures have been sown in the eastern plains (Llanos Orientales) of Colombia but there has been little adoption of brachiaria –*Arachis pintoi* associations even though such associations have been shown to be more productive and persistent in experiments on research stations. This is partly because there is a 15-fold increase in productivity with pure brachiaria pasture sown alone over the that of the native pasture and in part because of the high cost of seed and slow establishment of *Arachis pintoi.* Nevertheless, pure grass brachiaria pastures degrade over time due to no or low fertilizer input and heavy grazing pressure. There are now some new accessions of *Arachis pintoi* available that establish more rapidly and have better dry season tolerance. Further, the rate of establishment might be increased with application of some fertilizer.

Methods: During 1998, four farms were selected on the basis of interest of the farmer in contributing financially as well as participating in an evaluation, the farm had degraded pastures, and there was good access. Four *A. pinoti* accessions (CIAT 17434-the released variety Mani Forrajero, CIAT 18744, CIAT 18748 and CIAT 22160) were planted at a seeding rate of either 3 or 6 kg/ha in two replications on each farm in August 1998. Plot size is 0.5 ha. On three farms there was still a high frequency of *B. decumbens*, the fourth was planted with *B. humidicola* because of the absence of improved grasses.

Outputs: There has been good germination but on one farm there has been considerable damage to young seedlings by goats. This experiment will need to run for at least 3 years to obtain some idea of the contribution of the legume. It is planned to fence off additional paddocks of the degraded control, with and without the basal fertilizer treatment.

Contributors: Camilo Plazas, Carlos Lascano

2.2.5 Improved feed supplies for smallholder farmers in Southeast Asia

Highlights

- Established 18 on-farm sites in Indonesia, Laos, Philippines, Thailand and Vietnam, where the Forages of Smallholders Project is developing forage technologies with farmers and national partners
- Forage technology development is in transition at the more-advanced sites. Farmers are adapting the technologies they initially selected (frequently, productive species used for cut & carry feeding) to suit their individual needs
- At the more-advanced sites, farmers are beginning to utilize significant areas of forage

Purpose: To develop forage technology options for smallholder upland farms in Southeast Asia to improve feed resources and resource management

Rationale: In addition to providing food products, livestock are often essential for cash flow and capital accumulation of households in upland areas of SE Asia. Larger animals can be walked long distances to market and, unlike most crops, can be converted to cash at any time. They also provide draught power and contribute substantially to nutrient cycling through manure. Productive animals are essential components of productive, diversified farming systems in the uplands.

Traditionally, farmers have used freely available local feed resources for their livestock, such as residues from crop fields and communal grasslands, forests and roadsides. With increasing human and animal populations, the communal feed resources are becoming scarcer, and, degraded by over-use. This is stimulating a high and increasing demand for planted forages in resource-poor upland areas.

Outputs: Planted forages (grasses, herbaceous legumes and tree legumes) have a strong role to play in improved livestock production systems for the uplands. They improve feed supply for animals (and thus animal production) and produce other significant benefits. These include:

- controlling soil erosion (eg. contour hedgerows, gully stabilisation)
- improving soil fertility through manure and nitrogen fixation (eg. protein banks of legumes),
- controlling weeds (leguminous cover crops)
- reducing labour requirements for tending animals (eg. cut & carry plots near barns), and
- improving animal control (forage tree legumes as living fences).

A summary of the forage technologies that are either existing or emerging at each site is presented in Table 1. At most sites farmers chose to evaluate more than one technology. Intensively managed grass plots near houses or animal sheds are being evaluated at almost all sites. Often farmers identified a lack of labour as a limitation and they see intensively managed plots as an attractive way of reducing the demand on labour of keeping livestock. In many cases farmers intend to use these intensively managed plots only at specific times. Examples are days when they have to go to the market, some family members are sick, or during periods of peak labour demand by other agricultural activities.

The range of technologies tested by farmers increases as they become familiar with forages and they see more opportunities on their farms. Some technologies aimed at better resource management are emerging at several sites (in particular, forages in contour hedgerows, grasses for stabilising gully erosion and forages in fencelines)

A list of the main forage species evaluated by farmers is presented in Table 2. Several other *Brachiaria* lines are now being tried on-farm at Pakchong but it is still only a very small activity (18 farmers with small plots).

Impact: Forage technology development is an on-going process not a one-off injection of species into farming systems. At the first stage of this process, farmers almost always plant small areas for cut & carry feeding to simply observe the new species without taking major risks. Once farmers become convinced by the potential of the species and have built up confidence in the FSP, they are adapting the species and management systems to suit their specific needs. The initial selection of forages on the basis of their value for cut & carry feeding is being superseded at many sites by subsequent selection of species to fit other needs (both feeding and resource management needs).

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Table 1. Forage technologies evaluated by farmers in Southeast Asia

Sites	Forage technology option						
	Intensively managed cut plots	Protein bank	Tree legumes in fence lines	Erosion control (hedgerows, gully stabilization)	Legumes in fallows or grown in association with crops	Cover crops	Grasses and legumes for grazing
Indonesia							
Gorontalo, North Sulawesi	⚐		⚐				✔
Makroman, East Kalimantan	✔				✔		
Marenu, South Tapanuli	✔	✔					
Pulau Gambar, North Sumatra		✔	⚐				
Saree, Aceh	✔	⚐	⚐				✔
Sepaku II, East Kalimantan	✔					✔	⚐
Laos							
Luang Phabang	✔		⚐✔	⚐	⚐		
Xieng Khouang	✔				⚐		
Philippines							
Cagayan de Oro, Mindanao	✔			⚐	⚐		
M'lang and Carmen, North Cotabato	✔					⚐	
Davao, Mindanao	✔						
Guba, Cebu		⚐		✔	⚐	✔	
Malitbog, Bukidnon	✔	⚐		✔			⚐
Matalom, Leyte	✔	⚐		⚐			⚐
Vietnam							
Xuan Loc, Hue	✔		⚐				
M'Drak, Daklak	✔						✔
Vietnam-Swedish project (northern prov.)	✔			⚐			
Thailand							
Sung Nuen	✔						✔

✔ = forage technology adaptation and adoption is already advanced
⚐ = forage technologies that are emerging or have potential

Table 2. Main forage species under evaluation by farmers

Species	Forage technology options: Intensively managed cut plots, and	Protein banks	Tree legumes in fence lines	Erosion control (hedgerows, gully stabilisation)	Legumes in fallows or grow in association with crops	Cover crops	Grasses and legumes for grazing
a) Grasses							
Andropogon gayanus CIAT 621	✔						
Brachiaria brizantha CIAT 6780	✔			⚐			✔
Brachiaria brizantha CIAT 16835 or 16827	✔						
Brachiaria brizantha CIAT 26110	✔						
Brachiaria decumbens cv. Basilisk	✔						✔
Brachiaria humidicola CIAT 6133, cv. Tully				⚐			✔
Panicum maximum T-58	✔						⚐
Panicum maximum CIAT 6299	✔						
Paspalum guenoarum BRA 3824	✔						
Paspalum atratum BRA 9610, Pantaneira	✔			⚐			
Setaria sphacelata cv. Kazungula							⚐
Setaria sphacelata var. Splendida	✔			✔			
Pennisetum purpureum	✔			✔			
Pennisetum hybrid cv. Mott (dwarf napier)				✔			
Pennisetum hybrids (tall growth habit; e.g. King grass)	✔			✔			
b) Legumes							
Centrosema pubescens CIAT 15160, cv. Cardillo	✔				✔	⚐	✔
Desmanthus virgatus				⚐			
Stylosanthes guianensis CIAT 184		✔		⚐	✔	⚐	✔
c) Tree Legumes							
Calliandra calothyrsus CPI 115690		✔					
Desmodium rensonii CPI 46562		⚐					
Gliricidia sepium Retalhuleu, Monterrico, Belen Rivas		✔	✔				
Leucaena leucocephala K636		✔	✔				✔

✔ = existing uses for each species
⚐ = emerging or potential uses

2.2.6 Legumes and grasses adopted by farmers for multiple uses

a) Participatory evaluation and strategic targeting multipurpose germplasm in the hillsides of Central America

Highlights

- In 1998, sites were selected and forage germplasm nurseries established at four sites in Honduras where legumes will be evaluated with farmers for multiple uses.

Purpose: To evaluate forage legumes with farmers to better ascertain how they might be utilised on diversified farms in the hillsides.

Rationale: Forage germplasm in its multiple uses - for example as feed, for the suppression of weeds, for maintenance and improvement of soil fertility, for erosion control can play an important role in improving the farm productivity of the small and medium size farmers in the Central American hillsides. In addition, it is likely that such germplasm will have also a positive effect on the conservation of natural resources and the environment in general. However, adoption, particularly of forage legumes, has been limited, possibly due to lack of direct interaction with the farmers.

Therefore it is necessary to develop forage germplasm technologies with the farmers, using a participatory approach. The work will also contribute to the development of an overall strategy to i) guide future research and ii) aid in the diffusion and finally adoption of forage based technology. The interaction with interested national partners, working with farmers, will be of paramount importance to the success of the approach.

Results from this study are expected to be useful for strategic targeting of forage germplasm using GIS tools (see section 3. 2), targeting both environmental as well as socio-economic parameters. The initial primary focus will be on hillsides in Yoro, Honduras, but an extension to sites in the Olancho and Atlantida regions of Honduras is planned.

Methods: A combination of agronomic evaluation techniques, participatory technologies, soil indicators, socio-economic studies and GIS tools will be employed. The work links closely with the Tropileche project, using some of the same germplasm and potential germplasm originating from this project for studies on early adoption of technologies and linking to Tropileche for dissemination.

Outputs: Germplasm nurseries have been established at four sites in Honduras and a strong collaboration within CIAT staff in Central America and with DICTA (Dirreccion de Ciencia y Technologiá Agropecuaria) Honduras formed. Staff are being trained in farmer participatory research and techniques selected for participatory evaluation.

Impact: It is aimed to have a list of accessions selected by farmers according to their needs and methodology for further studies available by 2000. GIS tools will be used to integrate and disseminate results.

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Collaborators: Ann Braun (SN-3), Glen Hyman (PE-4), Miguel Ayarza/Richard Thomas/Edmundo Barrios (PE-2), and Carlos Lascano (IP-5), Peter Kerridge, Federico Holmann (PE-5)

b) Legumes as green manures in cassava-based systems in Asia

Highlights

- Short-term use of green manure (2-4 mths) increased cassava yields but not as high as the yield obtained with high rates of fertilizer
- Long-term green manuring (18 mths) resulted in very high yields of cassava.
- Green manures have a role where there is no shortage of land and/or labour.

Purpose: To maintain or improve long-term soil productivity through the use of various legumes as intercrops, green manures or alley crops, and to determine the most effective way of combining these legumes with cassava, so as to maximize total land productivity.

Method: Soil fertility maintenance through the use of green manures. On rather fertile soil at Hung Loc Research Center in south Vietnam an experiment was initiated in 1992 to study the long-term effect of intercropping and alley cropping on cassava yield and soil fertility.

Output: In 1998, after six consecutive cassava cropping cycles, there was still no significant effect of any treatment on cassava yield (Table 1). Intercropping of cassava with *Canavalia ensiformis,* which was pulled up and mulched at 2 months after planting (MAP), or alley cropping with *Gliricidia sepium,* slightly increased cassava yields over the control.

Table 1. Effect of intercropping and alley cropping on plant height, yield and root dry matter content of cassava, KM60, grown in Hung Loc Agric. Research Center in Dong Nai province of Vietnam, 1997/98 (6th year).

Treatments	Plant height (cm)	Top yield (t/ha)	Root yield (t/ha)	RDMC[1)] (%)
1. Cassava (C) monoculture	171	13.85	18.54ab[2)]	37.8a[2)]
2. C+C for forage	172	12.76	17.81b	39.7a
3. C+C for mulch	172	13.75	17.71b	39.6a
4. C+peanut	177	15.84	18.11b	39.4a
5. C+cowpea	170	14.58	18.23b	39.0a
6. C+*Canavalia ensiformis* (mulch)	172	16.88	21.77a	38.3a
7. C+*Leucaena leucocephala* hedgerows	203	19.89	18.67ab	39.1a
8. C+*Gliricidia sepium* hedgerows	197	20.56	19.73ab	38.3a
F-test			NS	NS

[1)]RDMC=root dry matter content
[2)]DMRT (5%)

Method: Another green manure trial was initiated at Rayong Research Center in Thailand in 1994, using *Crotalaria juncea, Canavalia ensiformis,* pigeon pea and cowpea as the green manures. Three methods of green manure management were tested: M1) green manures were intercropped with cassava, pulled out at 2 months after planting (MAP), and mulched between cassava rows; M2) green manures were interplanted into a mature cassava stand at 7 MAP; they were pulled up and mulched at the time of next cassava planting; or M3) green manures were grown as a conventional green manure crop before being pulled up at 3-4 MAP and mulched, after which cassava was planted without further land preparation and left to grow for 18 months. The last method resulted in a two-year crop cycle.

Output: The results in Table 2 indicate that *Crotalaria juncea* usually produced the highest DM production, followed by pigeon pea or cowpea. Pigeon pea was particularly productive as a green manure crop when interplanted at 7 MAP, in which case the green manure remained in the field during the dry season. Because of their high DM production, *Crotalaria* and *pigeon pea* were the most effective in recycling nutrients.

In the first cycle almost all green manure treatments increased cassava yields compared with the check without green manure (T_1); however, these yields were still below those obtained with a higher fertilization rate (T_2). In the second cycle, intercropping or interplanting of the green manures had no significant effect on cassava yields, which were again considerably below that obtained with a higher rate of fertilization (T_2). Leaving cassava grow for 18 months after a conventional green manure crop (T_{11}-T_{14}) resulted in very high yields while having little effect on root starch content. This may be an effective way for farmers to reduce production costs, since land preparation, weeding and harvesting is done only every two years, while total production from one 2-year cycle was only slightly lower than that of two 1-year cycles.

There was no consistent effect of any of the green manure treatments on soil pH, organic matter (OM), available P or exchangeable K. Thus, while green manuring may have long-term benefits in terms of soil productivity and yield, these effects are not clear in the short-term. Whenever labor is scarce or expensive, such as in Thailand, farmers will prefer to maximize their yields through the use of chemical fertilizers instead of green manures.

Impact: The results so far obtained with green manures have not been too promising. Nevertheless, in areas where animal manures are not available or are used on other crops, or where fertilizers are too costly or too difficult to obtain, farmers can improve soil fertility and increase crop yields by the use of green manures. This is of interest mainly for subsistence farmers with either abundant land or labor resources. A detailed economic analysis is still needed to determine whether the benefits are greater from intercropping (with incorporation of crop residues), from green manuring, or from alley cropping.

Contributors: Mr. Nguyen Huu Hy of IAS, Ho Chi Minh city, Vietnam, and Mr. Anuchit Tongglum of the Field Crops Research Inst. of DOA, Thailand, Reinhardt Howeler, CIAT.

Table 2 **Effect of fertilizer application, three alternative green manure practices and four different species on green manure production and nutrient uptake, as well as on cassava yield when cv Rayong 90 was grown for two consecutive cropping cycles at Rayong Research Center in Thailand from 1994 to1998.**

Treatments[1]	Green manure DM (t/ha)		Nutrient content in green manure (kg/ha): N		P		K		Cassava yield (t/ha)	
	1st[2]	2d	1st	2d	1st	2d	1st	2d	1st	2d
1. Cassava without green manure, with 156 kg 13-13-21/ha	-	-	-	-	-	-	-	-	17.56	30.06
2. Cassava without green manure, with 468 kg 13-13-21/ha	-	-	-	-	-	-	-	-	29.78	40.39
3. Cassava intercropped with *Crotalaria juncea*, mulched at 2 MAP	1.92	4.74	44.7	94.9	3.0	12.7	27.6	31.1	23.75	29.19
4. Cassava intercropped with *Canavalia ensiformis*, mulched at 2 MAP	0.94	1.84	20.1	51.7	2.4	6.6	14.6	25.9	26.94	27.75
5. Cassava intercropped with pigeon pea, mulched at 2 MAP	1.09	2.09	27.0	48.7	2.2	6.7	12.5	19.0	21.39	26.97
6. Cassava intercropped with cowpea, mulched at 2 MAP	-	2.77	-	53.7	-	7.2	-	27.1	20.28	18.75
7. Cassava interplanted with *Crotalia juncea* at 7 MAP and mulched	9.89	1.15	262.1	21.7	23.7	4.6	102.9	7.4	8.75	31.44
8. Cassava interplanted with *Canavalia ensiformis* at 7MAP and mulched	1.54	0.65	36.6	16.0	4.1	3.1	28.0	8.2	22.83	24.17
9. Cassava interplanted with pigeon pea at 7 MAP and mulched	8.92	2.32	221.7	45.5	20.0	7.3	108.8	15.9	15.86	28.81
10. Cassava interplanted with cowpea at 7 MAP and mulched	-	0.72	-	14.2	-	2.9	-	7.6	17.25	27.02
11. *Crotalario juncea* green manure, mulched, cassava for 18months	1.44	4.36	39.9	79.9	3.6	17.7	14.7	31.6	46.17	49.04
12. *Canavalia ensiformis* green manure, mulched, cassava for 18months	0.93	1.41	18.4	45.7	2.3	7.2	15.8	17.2	42.98	43.81
13. Pigeon pea green manure, mulched, cassava for 18months	1.05	2.68	25.6	68.7	2.3	13.2	12.8	21.7	38.81	45.97
14. Cowpea green manure, mulched, cassava for 18months	-	2.92	-	68.2	-	12.6	-	31.0	38.86	46.32

[1] In T3-T14 cassava received 156 kg 13-13-21/ha (like T1).
In T3-T6 cassava is intercropped with 1 row of green manure, which is pulled out and mulched at 2 MAP; cassava is harvested at 11 months for a total crop cycle of 12 months.
In T7-T10 the green manures are interplanted in the cassava stand at 7 MAP; they remain after the cassava harvest and are pulled up and mulched at time of next cassava planting; cassava is harvested at 11 months for a total crop cycle of 12 months.
In T11-14 the green manures are planted, pulled out and mulched at 3-4 months, after which cassava is planted and remains in the field for 18 months for a total crop cycle of 24 months.
In the first cycle, T6, T10 and T14 had *Mucuna pruriens* as the green manure, but this species did not germinate well and was replaced by cowpea in the 2d cycle.
[2] 1st and 2d refer to the two cropping cycles.

c) Grasses for use as contour barriers to control erosion in cassava-based systems

Highlights

- *Paspalum atratum* was the most promising hedgerow species, as it is less competitive than other grasses and is highly drought tolerant.

Purpose: To evaluate various grass species for their efficiency as contour barriers to control erosion when cassava is grown on hillsides.

Rationale: Numerous erosion control trials have shown that planting contour hedgerows of vetiver grass (*Vetiveria zizanioides*) at about 1 m vertical distance between hedgerows is one of the most effective ways to reduce erosion when cassava is grown on slopes. These barriers also conserve soil, water and fertilizers through natural terrace formation. However, few farmers have adopted this technology because vetiver grass has no commercial value or alternative uses (as green manure or animal feed), it is difficult to find planting material and it is expensive to establish, as it can be propagated only vegetatively. Thus, other grass species were compared with vetiver grass with the aim of identifying species that are equally effective in controlling erosion, but that are easier to establish, more useful to farmers, and that do not compete with neighboring cassava plants or become a weed.

Methods: A trial was established to determine the competitive effect of 12 grass species, in comparison with three ecotypes of vetiver grass, on cassava yield when these grasses were grown as contour hedgerows between every third cassava row, planted along the contour on about 5% slope.

Outputs: Figure 1 shows the effect of various grass species planted as contour hedgerows on cassava yield during the second year in Khaw Hin Sorn, Thailand. Since 1997/98 was an exceptionally dry year, there was strong competition for water between the grass hedgerows and the neighboring cassava plants. This was particularly noticeable during the early growth stage when cassava still lacked a good root system, and when the hedgerows were already well established. Thus, many cassava plants next to the hedgerows died or produced very low yields. For very aggressive grass species, such as sugarcane, dwarf or normal elephant grass (*Pennisetum purpurium*) or king grass (*Saccarum sinense*), this competitive effect extended even to the center cassava row, 1.5 m away from the grass. However, in case of *Paspalum atratum*, the center cassava row actually produced a higher yield than in the check plot without an adjacent hedgerow, while the yields of the two cassava rows bordering the grass were reduced less than in the case of most other grasses. Thus, it appears that *P. atratum* has a vertical and deep root system, which results in good drought tolerance and little competition with neighboring crop plants. Moreover, this species has an erect growth habit and good tillering capacity, which makes it very effective in trapping eroded soil particles. It is also very suitable as an animal feed (see Section 2.2.5 and below) and can be propagated either from vegetative planting material or from seed, which makes establishment easier and cheaper than in case of vetiver grass. As long as the grass is cut before flowering and seed set, it will not become a weed problem. A similar trial has been established at CATAS in Hainan, China, to corroborate these results.

Impact: If the promising results obtained so far with *Paspalum atratum* are confirmed in other locations, this could greatly enhance the adoption of contour hedgerows for controlling erosion. The cost of establishment would be significantly reduced, while those farmers having cattle would benefit from the grass as a high quality animal feed, which is much less competitive than the currently used elephant grass.

Contributors: Dr. Somjet Jantawat, Kasetsart University, Thailand; Reinhardt Howeler and Werner Stur, CIAT.

c) Multiple use of forage legumes and grasses in smallholder systems in Asia (FSP project)

see also section 2.2.5

Highlights

- In on-farm sites in Southeast Asia where farmers are selecting forages for feed improvement, they also select them for resource management such as erosion control and soil improvement.

Impact: There was no new activity to that reported last year, except that there is more widespread use of grasses and legumes by farmers for multiple purposes.

Forage technologies often have more than one benefit and it is difficult and, in many cases impossible, to separate forages grown for NRM purposes from those grown for improved feed supply. Farmers growing, for example, contour hedgerows are looking to obtain feed for their animals in the same way as intensively-managed plots, as well as limiting erosion. The relative importance of the two benefits varies from farm to farm, but no farmers at FSP sites are growing contour hedges purely for erosion control. The use of legumes and grasses in farm resource management is covered in Section 2.2.5.

Contributors: Werner Stür (CIAT, Philippines)

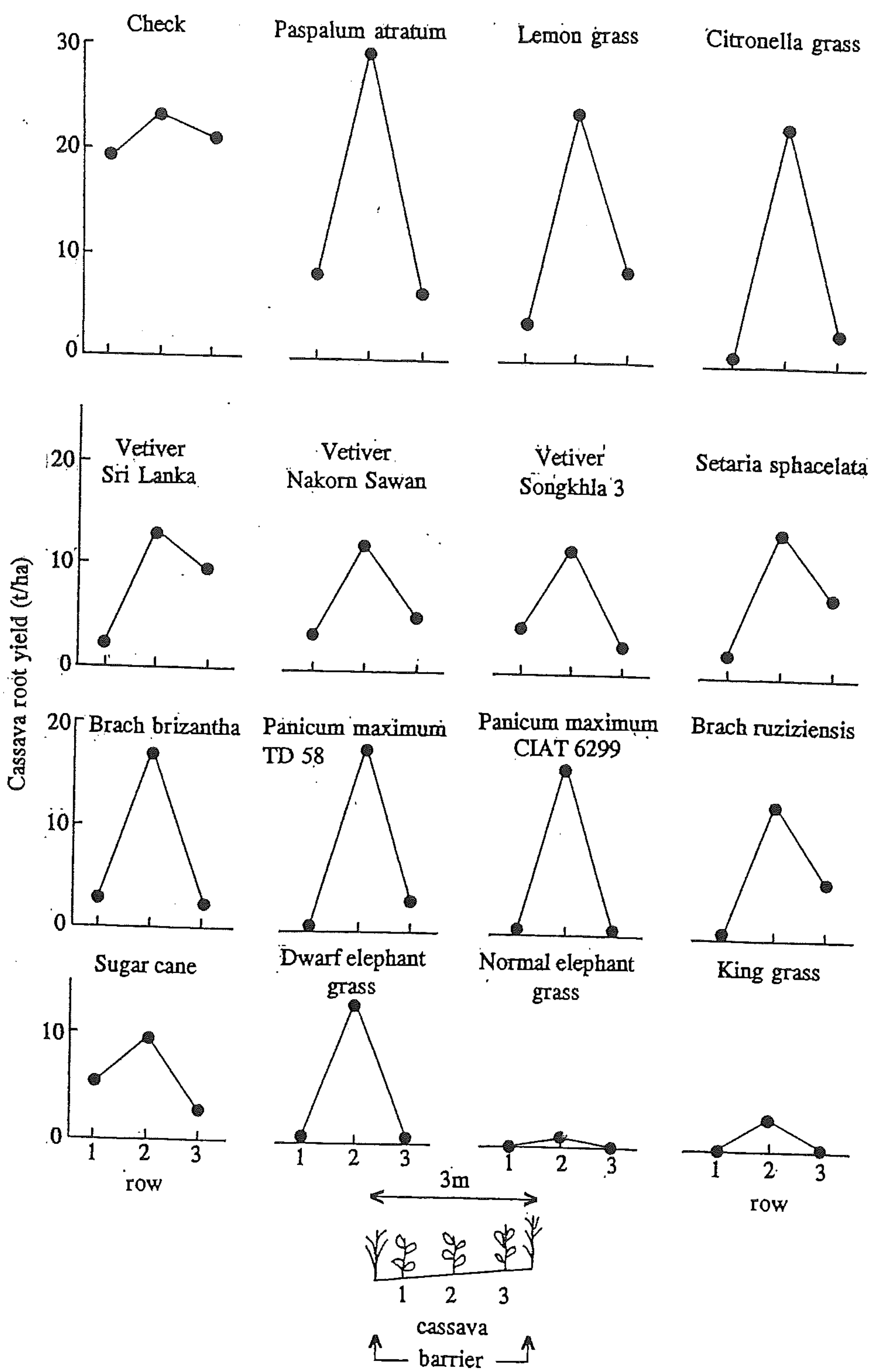

Figure 1. The effect of different grass species used as contour barriers on the fresh root yield of cassava, cv KU 50, grown in three rows between barriers in Khaw Hin Sorn, Chachoengsao, Thailand in 1997/98.

2.2.7 New cassava options for Asia

a) Varietal testing

Cassava varietal improvement in Asia is coordinated by project IP-3, but new varieties and promising breeding lines, developed by national cassava breeding programs in collaboration with CIAT, are further tested, evaluated and disseminated as part of the farmer participatory research (FPR) variety trials of the Nippon Foundation Project (see Section 2.3.4).

b) The nutrient requirements of cassava

Highlights

- High yields of 20-30 t/ha can be maintained during continuous cropping for 6-10 years with annual applications of 80-100 kg/ha N, 17-20 kg/ha P and 60-80 kg/ha K.

Purpose: To maintain or improve soil productivity in cassava-based cropping systems to optimize the efficiency of fertilizer inputs and obtain high cassava root and starch yields.

Rationale: While cassava is well adapted to grow on acid and infertile soils, continued production of the crop on these soils without adequate inputs of nutrients will lead to nutrient depletion and a deterioration of the soil's productive capacity. Thus, it is important to establish which nutrients are removed and how to replenish these nutrients most efficiently.

Methods: Soil fertility maintenance through the application of NPK fertilizers

Since 1987, 19 long-term fertility trials have been conducted in seven countries in Asia. Of these, 11 trials were conducted for four or more years; in 1998 only four of these trials are being continued. These trials use a fairly uniform incomplete factorial design with 3-4 replications to study the effect of four levels of N, P and K in various combinations on cassava yield and starch content. Soil and tissue analyses results of several trials are combined to determine the relation between yield response to a given nutrient and the concentration of that nutrient in the soil or in leaf tissue, so as to enable the diagnosis of nutritional problems from soil or tissue analyses.

Outputs: Figure 1 shows an example of the response of two cassava varieties to annual applications of combinations of N, P and K during the sixth year of continuous cropping at CATAS in Danzhou, Hainan, China. In this experiment there was a significant yield response to N for both varieties, no significant response to P, and a highly significant response to K only for SC205. Both varieties showed a highly significant response to the combined application of NPK, which increased the yield from 16.9 to 44.3 t/ha. The response in terms of starch content was not statistically significant, but the trend was negative to N with a positive response to K.

Figure 2 shows the change in yield response to N, P and K during six consecutive cropping cycles in another experiment conducted in Tamanbogo, Lampung, Indonesia. In this case, cassava was intercropped with upland rice and maize. The response to application of all three nutrients increased over time, but during the sixth cycle there were highly significant responses to N and K, while there was only a significant response to P.

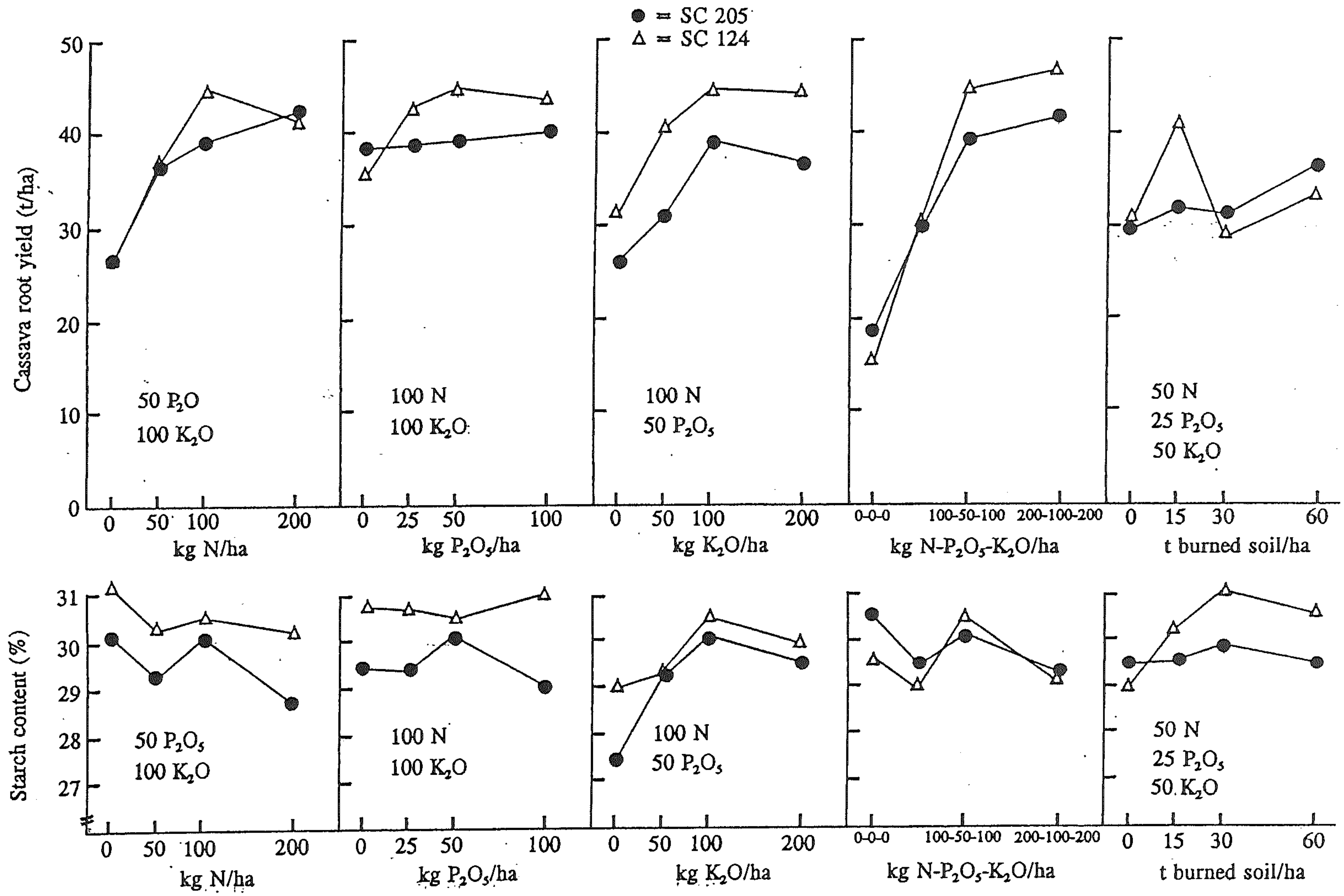

Figure 1. Effect of annual applications of various levels of N, P and K as well as "burned soil" on the yield and starch content of two cassava cultivars grown in CATAS, Hainan, China in 1997 (6th year).

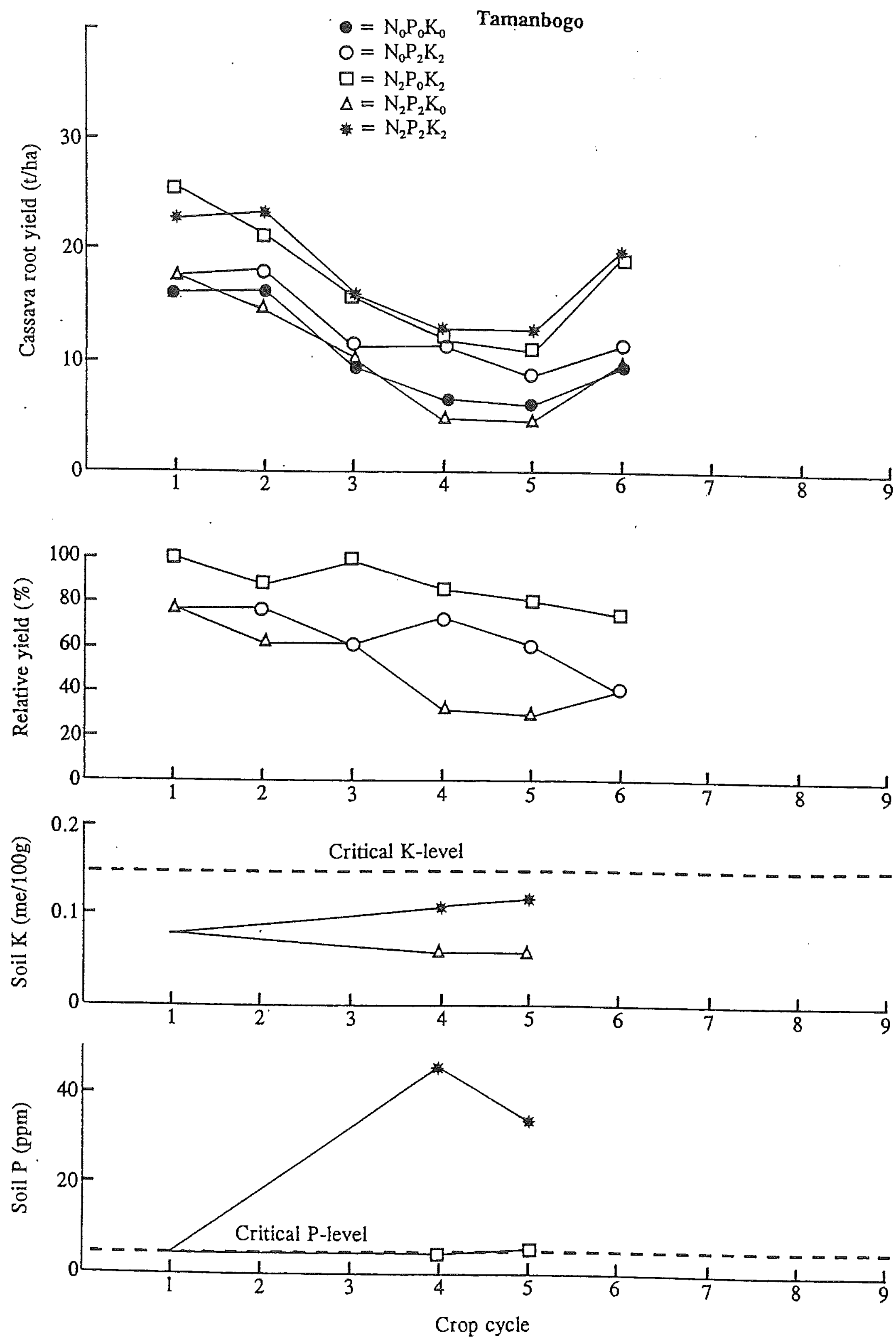

Figure 2. Effect of annual applications of N, P and K on cassava root yield, relative yield (yield without the nutrient over the highest yield with the nutrient) and the exchangeable K and available P (Bray 2) content of the soil during six years of continuous cropping in Tamanbogo, Lampung, Indonesia.

The exchangeable K content of the soil was far below the critical level and decreased over time if no K was applied. The soil available P content remained around the critical level due to a relatively low removal of P in the annual root harvest.

Table 1 shows a summary of the responses to each nutrient after continuous cropping for 4-10 years in 11 locations. There was a significant response to N in eight, to P in four, and to K in seven of the eleven sites. This indicates that in most cassava growing areas of Asia, cassava responds mainly to applications of N and K, while a response to P is much less likely, due to the crop's effective association with native mycorrhiza in the soil.

Table 1. Response of cassava to annual application of N, P or K after several years of continuous cropping in long-term fertility trials conducted in various locations in Asia.

Country-location		Years of cropping	Response to N	Response to P	Response to K
China	-Guangzhou	4	**[1]	**	**
	-Nanning	8	**	**	NS
	-Danzhou	6	**	NS	*
Indonesia	-Umas Jaya	10	NS	NS	NS
	-Malang	8	**	NS	**
	-Lampung	6	**	*	**
	-Yogyakarta	4	NS	NS	NS
Philippines	-Leyte	6	NS	NS	NS
	-Bohol	4	**	NS	**
Vietnam	-Thai Nguyen	8	**	**	**
	-Hung Loc	8	**	NS	**

[1] NS = no significant response
* = significant response (P<0.05)
** = highly significant response (P<0.01)

Impact: The importance of N, and especially, K fertilization in most cassava soils in Asia was confirmed by many FPR trials on fertilization practices conducted by farmers on their own field (see Table 10 Section 2.3.4). Farmers in the FPR pilot sites are already starting to adopt these improved practices (see Table 11 Section 2.3.4), obtaining higher yields at lower input costs. If the efficiency and reliability of soil testing laboratories in many Asian countries could be improved, fertilizer recommendations based on soil analyses could further enhance fertilizer use efficiency.

Contributors: Mr. Nguyen Huu Hy of IAS in Vietnam, Dr. Nguyen The Dang of the Agro-forestry College in Thai Nguyen, Vietnam; Mr. Zhang Weite and Mr. Huang Jie of CATAS in Hainan, China; and Mr. Wargiono of CRIFC in Bogor, Indonesia.

c) The effect of planting date on cassava production and on erosion

Highlights

- Under the soil and climatic conditions of Rayong Research Center in Thailand the best time for planting cassava is in December; this resulted in the highest root and starch yield, as well as the lowest level of erosion.

Purpose: To determine whether planting time has a significant effect on cassava productivity and on soil losses due to erosion.

Rationale: Among the many agronomic practices that help reduce erosion, changing the date of planting may be one of the simplest. Nevertheless, this has seldom been studied. Many experiments have shown that in cassava cultivation, most erosion occurs during the first 3-4 months after planting (MAP) when the crop canopy has not yet fully covered the soil. Thus, if we can plant and establish a canopy during the dry season, before the onset of heavy rains, erosion is likely to be lower than when we plant at the beginning of the rainy season, as is usually done. The question in that case is: is soil moisture adequate for good plant establishment and yield?

Methods: Cassava, cv. Rayong 90, was planted at bimonthly intervals in plots on 4.2% slope at Rayong Research Center in Thailand. Each plot was harvested at 11 months and prepared again for replanting. Soil loss due to erosion was determined monthly by weighing the sediments collected in plastic-covered channels which had been established along the bottom end of each plot. The experiment was continued for three complete cropping cycles for each planting date treatment.

Outputs: Table 2 shows the average over 3 cycles of the effect of planting date on total rainfall received during the 11 month crop cycles, the erosion losses, and various plant growth and yield parameters, as well as gross income. Total rainfall received was highest when the crop was planted in December and harvested in November of the following year; it was lowest when planting in October. When planting in December, i.e. in the middle of the dry season, the final plant stand was still 90%, indicating that soil moisture was generally adequate for germination. This planting date also resulted in the highest root yield, a rather high starch content, highest starch yield and lowest level of erosion. Alternatively, planting in February and harvesting in January resulted in a slightly lower plant stand and yield, but in the highest starch content and starch yield, as well as a slightly higher level of erosion. These data indicate that planting during the dry season (Nov-April) has clear advantages, both in terms of yield and income and in terms of reducing erosion. It also allows the harvest during the dry season when starch content is highest, drying is quickest and labor is more available. In most sandy loam or sandy clay loam soils, land preparation and planting is possible in the dry season since soils do not harden excessively. Planting during the dry season is now a common practice in cassava growing regions of Thailand, with March being the most popular month for planting in the southeastern region.

Correlating root yield, starch content, starch yield and erosion losses with rainfall received during certain periods of the cropping cycle (Table 3), reveals that both root and starch yield were best correlated with the amount of rainfall received during the 4th to 11th month. Starch content was best correlated with rainfall during the 6th to 9th month and was negatively, but not significantly, correlated with rainfall during the last two months before harvest. As might be expected, soil loss was best correlated with rainfall during the first three months of planting. These relationships are shown in Figure 3.

Impact: From these results it can be concluded that cassava is best planted 3-4 months before the onset of heavy rains and harvested 2-3 months after the onset of the dry season, when starch content is highest.

Contributors: Mr. Anuchit Tongglum, Field Crops Research Institute, DOA, Thailand.

Table 2. Effect of different planting dates on the average rainfall received, soil losses due to erosion, cassava growth and yield, as well as the gross income obtained when cassava, cv Rayong 90, was grown for three consecutive cycles on 4.2% slope at Rayong Field Crops Research Center in Thailand from 1994 to 1998.

Month of planting[1)]	Total rainfall[2)] (mm)	Dry soil loss (t/ha)	Canopy cover[3)] (%)	Final plant stand (%)	Root yield (t/ha)	Starch content (%)	Gross income[4)] ('000B/ha)
June	1402	15.64	77.3	97	23.32	21.27	19.25
August	1409	18.21	55.0	97	18.92	22.33	16.02
October	1267	15.73	55.0	91	24.56	25.73	22.46
December	1665	12.88	82.0	90	32.18	25.07	29.01
February	1633	13.05	89.2	88	27.92	30.35	28.11
April	1616	14.30	87.8	87	25.67	26.13	23.68

1)roots were harvested after 11 months
2)rainfall received during the 11 month growth cycle
3)percent canopy cover averaged over all months of the growth cycle
4)assuming a price of B 1.0/kg fresh roots with 30% starch, and a reduction in price of B 0.02/kg for each per cent drop in starch content

Table 3. Correlation coefficients between cassava root yield, starch content and starch yield, as well as dry soil losses due to erosion and rainfall during certain periods in the cropping cycle when cassava, cv Rayong 90, was planted at bimonthly intervals for three consecutive cropping cycles on 4.2% slope in Rayong Research Center in Thailand from 1994 to 1998.

Parameters	Correlation Coef. (r)	%P
Cassava root yield vs rainfall from the 4th-11th MAP[1)]	0.7025	0.001
Cassava root yield vs rainfall from the 3rd-11th MAP	0.6726	0.002
Cassava root yield vs rainfall from the 2nd-11th MAP	0.6005	0.008
Cassava root yield vs rainfall from the 1st-11th MAP	0.5115	0.030
Cassava root yield vs rainfall during the 1st MAP	-0,4258	0.078
Cassava root yield vs rainfall from the 1st-2nd MAP	-0,4146	0.087
Root starch content vs rainfall from the 6th-9th MAP	0.8298	0.000
Root starch content vs rainfall from the 5th-9th MAP	0.7981	0.000
Root starch content vs rainfall from the 6th-8th MAP	0.7966	0.000
Root starch content vs rainfall from the 10th-11th MAP	-0.1290	NS
Root starch content vs rainfall during the 11th MAP	-0.0772	NS
Starch yield vs rainfall from the 4th-11th MAP	0.7411	0.000
Starch yield vs rainfall from the 4th-10th MAP	0.7096	0.001
Starch yield vs rainfall from the 5th-11th MAP	0.7090	0.001
Starch yield vs rainfall from the 5th-10th MAP	0.6950	0.001
Dry soil loss (erosion) vs rainfall from 1st -3rd MAP	0.6016	0.008
Dry soil loss (erosion) vs rainfall from 1st -4th MAP	0.5515	0.018
Dry soil loss (erosion) vs rainfall from 1st -5th MAP	0.5290	0.024
Dry soil loss (erosion) vs rainfall from 1st-2nd MAP	0.5087	0.031

Note: cassava was harvested after 11 months
1) MAP = month after planting

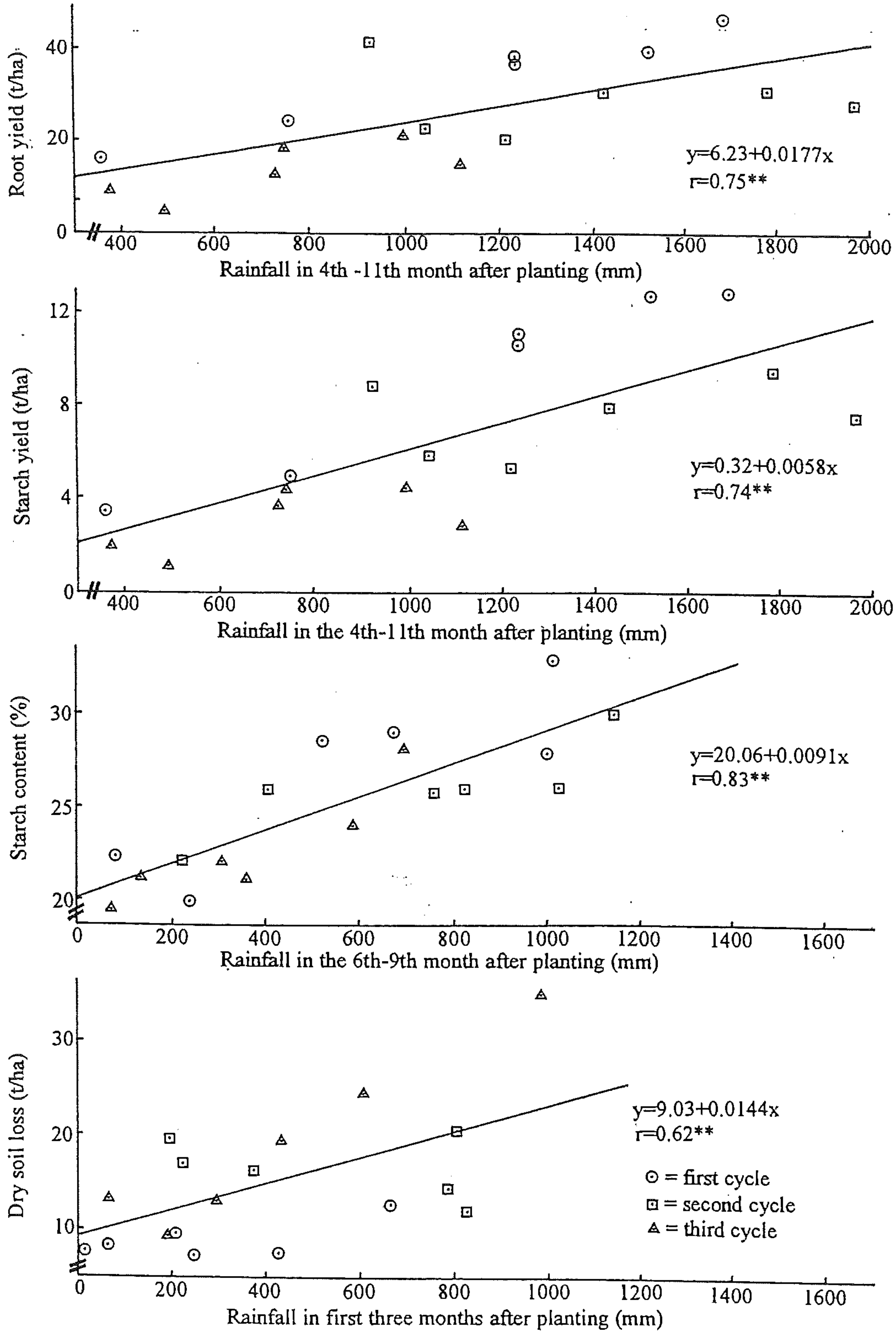

Figure 3. Linear regressions between cassava root yield, starch yield, starch content and dry soil loss due to erosion and the rainfall received during certain periods of the crop cycle when cassava, cv Rayong 90, was grown at bimonthly intervals for three complete cropping cycles on 4.2% slope at Rayong Research Center in Thailand from 1994 to 1998.

Output 2.3 Integrated soil, water and management practices

2.3.1 Integrated technologies developed with farmers in Pucallpa (DEPAM)

a) Farmer participatory testing of new rice varieties

Highlights:

- Farmers tested new rice varieties. Yields of two introduced varieties were equal or slightly superior to farmers' varieties; and yields of three introduced varieties matched or were slightly lower than the lowest yielding farmer variety. The growing season was subject to severe drought stress. Farmers are enthusiastic to continue testing.
- Participatory research methods involve farmers in a new relationship with researchers in the technology development process.
- Local institutions are testing new methods to work with farmers.

Purpose: To respond to farmers' expressed concerns about low and declining rice yields as a major problem; to introduce farmer participatory research to collaborating institutions in Pucallpa; to determine farmers' levels of interest in participatory research; to identify rice varieties superior to those now sown by farmers.

Rationale: Farmers in Pucallpa face a range of problems. They identified rice as a major, important crop for consumption and sales of surplus, and prioritized rice problems as very high. The project started work with farmers on rice because of that interest, but with the intention of later continuing in FPR to other crops, to improved land and fallow management, and eventually to more integrated land and resource management systems.

Technology development in the past was based on researchers' perceptions about farmers' problems and on technology alternatives developed on-station. Adoption and impact were low without farmers' inputs. Participatory research is expected to improve problem-solving impacts.

Methods: Eighteen individual farmers in four communities were interested in upland rice varietal testing. Each decided on respective experimental design: farmers established simple trials totaling 400 to 1400 m^2 testing from two to seven varieties including farmers' varieties. Most frequently, each variety was sown on a 10 x 10 m plot. Twelve of the trials were replicated. Crop management matched each farmers' normal slash-and-burn rice cultivation practices. Researchers visited farmers and field trials over the growing season to discuss progress, problems, concerns, and observations. Yield corrected to 14% moisture and yield parameters were measured and discussed with farmers at harvest.

Outputs: Table 1 shows the rice yields from the farmer participatory trials.

Table 1. Mean rice yields (t/ha), Pucallpa, Peru, 1998

Variety	Yield	Number of farmers
CT-11253-6-1-M-M	1.2	8
Porvenir 95	1.2	11
Chancabanco*	1.1	6
Carolino*	1.1	18
Aguja Blanco*	0.8	7
Ucayali 91	0.8	8
Capirona	0.6	18
Uquihua	0.6	11

* Farmers' varieties

Farmers understood that the researchers' varieties for 1998 were not necessarily the most suited to upland, slash-and-burn systems. More appropriate varieties were identified and multiplied for farmer testing in the 1998-99 season. All varieties suffered from severe drought, which farmers also acknowledged as being considerably worse than what they perceived as "normal".

We conducted a rapid survey of participating farmers to capture their perceptions and suggestions to improve the methodology:

- 80% thought that the methods were very good
- 87% saw that they could apply the methodology to other crops and systems
- 73% will continue experiments in the next growing season
- 53% named the climate (drought) as the negative aspect of the experiment
- 47% named seed not appropriate to local conditions as a negative

Impact: Farmers were pleased with their experiments and participation. Many other farmers are interested in similar participatory research in the 1998-99 growing season. This initial work served to introduce many researchers in the Ucayali region to farmer participatory research.

Contributors: Sam Fujisaka, Ricardo Labarta, Jhon Aviles, Herman Usma, CIAT; Arnoud Braun, ICRAF, Peru; Keneth Reategui, DEPAM, Peru; Isaias Gonzalez, UNU, Pucallpa

b) Inputs into the design of inter-institutional farmer participatory research projects

Highlights:

- CIAT is providing inputs into multi-institutional projects proposed for DEPAM funding. Inputs contribute to the nature of research (as opposed to extension), farmer participation, and inter-institutional collaboration.

Purpose: To contribute to the design of small-grant projects funded by DEPAM in terms of the nature of the research, farmer participation, and inter-institutional collaboration

Rationale: DEPAM seeks to solve farmers problems while maintaining the natural resource base through research which is farmer participatory and strongly collaborative in terms of the institutions working in Pucallpa. CIAT's inputs are meant to strengthen individual project proposals in their meeting these objectives

Outputs: The review of proposals led to several recommendations. Recommendations were based on the DEPAM goals that the funded projects: a) are farmer participatory, b) represent real inter-institutional collaboration, and c) actually conduct new research.

Origen botánico de la miel de Pucallpa en los bosques secundarios proposed by AIDER and AMUCAU with collaboration from ICRAF, IIAP, IVITA, and MADEBOSQUES-CNF could best use DEPAM support in: a) the identification of productive secondary forest species in terms of pollen and nectar, b) work with farmers' already collaborating in honey production on identification of such species and understanding of the species' utility in honey production, and c) work with the same farmers in the management of these species in their secondary forest or fallow areas. "Management" can mean from not cutting and burning in the course of slash-and-burn to the nursery sowing and planting of the indicated species.

Plantas biocidas de la region Ucayali proposed by IIAP with collaboration by IVITA and INIA could best use DEPAM support in: a) a diagnostic survey (using participatory diagnosis, survey, and RRA) of farmers current pest and disease management practices and knowledge, and b) based on the appropriateness indicated by the diagnostic survey, farmer participatory testing of the best bet plant species using traditional methods. Other more basic research should continue to be conducted by IIAP.

Cultivo de pesces Amazonicos integrado al desarrollo agropecuario proposed by IIAP with collaboration by IVITA, DIREPE, and AMUCAU could best use DEPAM funds in: a) a diagnostic survey of the actual use of the many fish pond structures totaling 138 ha of infrastructure in the Aguaytia watershed and, based on the results, b) possible FPR testing of farmer-appropriate innovations. The diagnostic work needs to determine what has happened to the fish-pig infrastructure initially constructed with government incentives and assistance, infrastructure constructed by individuals without assistance, and natural water bodies used by farmers for fish production. Uses include integrated production of fish and pigs, fish production, and no use. Data needs to include surface areas, reasons for current production or no production, management practices, costs and benefits, and comparison of cases.

Sistemas de producción con manejo de especies forestales de bosques secundarios proposed by INIA with collaboration by IIAP, IVITA, and CNF would benefit from collaboration by ICRAF and CIFOR. DEPAM funding would be best utilized in the farmer participatory selection, management and testing of multi-purpose tree species in their secondary forest areas. The project needs to closely coordinate with the project on soil/fallow management and the agroforestry project proposed for the Von Humbolt area.

Evaluación participativa de variedades promisorios de arroz y plátano en campos de pequenos agricultores de la region Ucayali proposed by CIAT, INIA, UNU, DRAU, and Winrock initiated pilot FPR with interested farmers in the region in 1997-8. The proposed project will apply lessons learned in further testing with more farmers. The possibility of helping to form and working with local agricultural research committees will be explored.

Evaluación participativa en manejo agronómico del cultivo de maíz Marginal 28 Tarapoto, restinga proposed by INIA, CODESU, and UNU would best use DEPAM funds in the simple testing by (20 to 30) individual farmers of plant density and, possibly, weed control. Plots should be a part of farmers' larger fields, with the smaller experimental plots managed the same as the larger plots with the exception of the trail variables.

Investigación participativa agrícola Ucayalino: una evaluación económica de cultivos tradicionales y promisorios a nivel del fundo proposed CIAT, INIA, DRAU, CODESU, and ICRAF can best use DEPAM funding to: a) help provide economic analysis to the other DEPAM projects, b) help provide economic and market analyses of the various "promising" (camu camu, palmito, others) and traditional (rice, yuca, banana) crops, and c) work on the proposed simple model for use by farmers. Although the authors proposed use of computers by farmers, they could also work with farmers on white boards and paper to develop spread sheets, enter data from participating farmers and from secondary sources, and work with farmers on the tabulation and analysis of such data. A Winrock consultancy produced market studies for camu camu and palmito: these can be used, in part, as models for other product market studies.

Evaluación participativa del manejo adecuado de suelos en campos de pequeños agricultores de la region Ucayali proposed by ICRAF, CIAT, and INIA with collaboration by DRAU and CNF should first include DRAU and CNF as proponents. This FPR project can be improved by encouraging farmer "mixing and matching" of the fallow species tested and in greater farmer choice in how such species might be managed.

Rehabilitación de ecosistemas degradados por efectos de corte y quema y conservación de suelos con sistemas agrofroestales con participacion de agricultores de la zona Alexander von Humbolt-Macuya proposed by INIA, DRAU, and CRP needs to work with 20-30 interested farmers in the proposed multi-strata systems. Although it appears that the project intends to directly support the establishment of multistrata systems, it would better fit the goals of participatory research if farmers were supported in terms of information and some planting materials, but not in land preparation and planting.

Contributors: Sam Fujisaka, CIAT, as member of the Comite Asesor that advises DEPAM

2.3.2 Integrated soil conservation strategy for cassava-based systems in Cauca

Case studies of evaluation of technologies for soil conservation

Highlights:

- Adoption of soil conservation technology sharply increased when short-term value could be added to the conservation components
- Partiña grass, a local source of raw material for brooms fabrication and blackberry-grass strips, a technology based on market opportunities, were evaluated and identified as new technology options for soil conservation in Cauca, Colombia.
- An interdisciplinary project on the introduction of blackberry – a market opportunity selected for better soil conservation was set up in CIAT's pilot watershed in southern Colombia.

Purpose: To evaluate component cropping technologies that will lead to the adoption of erosion control barriers by farmers

Rationale: Work on soil conservation in the northern Cauca Department of Colombia has focused on alleviating the problems associated with growing of cassava on marginal, low fertility hillsides. Local cassava starch processing units created an incentive for farmers to expand cassava cropping in a fragile environment. There are few other alternatives for farmers to diversify land use and to make it more sustainable, other than growing beans on slightly more fertile soils and extensive cattle grazing. Over the past years, work on technology options for soil conservation concentrated on better crop management, forage legume inter-cropping, grass barriers, cut-and-carry fodder barriers and on rotations with improved grassland, with and without minimum tillage. The last two options showed the most promise in terms of potential area impacted and conservation effectiveness (see reports from previous years).

Nevertheless, there was poor adoption of these technologies, except for use of improved varieties. This can be attributed to the fact that the benefits of adopting soil conservation technologies are not immediate, only becoming obvious after one or two decades. This is too long a period to be of importance to a small farmer in his planning and decision making which is oriented towards satisfying the most urgent needs. But there were also technical reasons impeding adoption, e.g. limited promotion of participatory technology development with only two or three farmer groups, lack of legume seed and appropriate sowing equipment. Lack of dairy cattle and markets for milk and milk-derived products were reasons for limited adoption of cut-and-carry fodder and grass-legume ley rotations. This was especially the case in typical cassava growing areas.

On the other hand, recommendations of the project team to plant barriers of Citronella grass (*Cymbopogon nardus*) on low fertility hillsides were readily accepted by farmers, when an effort was undertaken to combine it with a local processing unit for the extraction of essential oils. Complementary funds for this activity were provided by GTZ, the German Agency for Technical Cooperation. Technical cooperation and support from FIDAR an NGO working in applied research and rural development was essential for the planting of grass barriers and for establishing the oil extraction plant with the rural community. Today more than 27 ha in the hamlet of "El Pital" are protected with Citronella barriers and a group of "Campesinas"

(AMCAPI) is generating local employment and a moderate additional income by running the extraction plant and selling pure essential oil and derived products like scented candles and floor cleaners.

Based on these experiences further efforts have been undertaken to identify and evaluate new technology options for soil conservation which have a high technical and economic feasibility.

Outputs:

Developing a soil conservation technology based on a local opportunity.– the case of Partiña grass.

In Buenos Aires, a municipality in the northern Cauca Department of Colombia (1000 – 1200 m.a.s.l.), soils in the lower part of the municipality are of low fertility, degraded by soil erosion and high in aluminum content. Cassava is the main crop grown in the area. Limited scope exists for introducing conservation components due to constraints like poverty, lack of infrastructure, limited access to markets, lack of farm diversity and very few and extensive cattle raising.

The use of "Partiña" (*Leptocoryphium lanatum* (H.B.K.) Nees), a grass readily growing on fallow land of recently burned and degraded hillsides offers an opportunity for combining a local resource with soil conservation, generating environmental and economic benefits. This grass is harvested on fallow land, dried, packed and sold to craftsmen for manufacturing brooms. Growing the grass in contour hedgerows or strips would allow farmers to increase labor productivity in the collection process at the same time protecting their cassava fields from severe erosion. An effort was, therefore, undertaken by the project team to develop a conservation technology based on this local opportunity.

In trials done with a farmers group over three years, it was demonstrated, that the grass is easy to transplant, regrowth is rapid after being cutting, it resists fire and tolerates periods of competition by surrounding weed fallow. Biomass production per ha is 1-1.5 t/ha when planted in double rows. As a consequence little competition to the cassava crop is likely and transportation requirement/ha is low compared to other barrier grasses (Table 1).

Once the technical requirements and the design for its application in soil conservation were determined, an ex-ante assessment of the economic viability at the farm level was made. According to the analysis, farmers would have to invest 145 $ US/ha to plant 1000 m of a double row barrier and could make a net benefit of 47 $ per cut(1-2 times year) or 11.5 $ US a day, which is about twice the salary of a day laborer. In other words, soil conservation with Partiña barriers allows the farmer to pay his labor and earn extra money.

With respect to the broom manufacturing, ex-ante analysis also suggested very promising results. In small processing units costing USD500, 4-5 good quality, biodegradable "Partiña" brooms can be produced per hour (6750 units per year). After expenses for raw material and salaries are deducted, a net gain of 3.300 $ US can be obtained if brooms can be sold at USD1.10 per unit. Nevertheless limitations exist with respect to actual market volumes and hence the applicability of the technology to larger areas. Parallel to the planting and processing of Partiña, an activity presently undertaken with the collaboration of two NGOs , (CETEC; FIDAR) and the farmer association "La Lucha, a campaign has been started to promote the "green brooms" in schools and in public to increase the potential impact of the area protected by "Partiña".

Table 1. Summary of yield trials with Partiña-grass barriers (*Leptocoryphium lanatum* (H.B.K.) Nees) grown in contour lines at 10 m distance on a cassava field in "La Brijida" municipality of Buenos Aires/Cauca. Data are from 5 consecutive harvests.

	Dry matter yield in kg/1000 m of barrier (ha) [1)]				
Growth interval (mth)	6	6	10	4	7
Row type	One row	One row	One Row	Double row	Double row
Fertilizer treatment at planting					
No fertilizer	120 a	170 a	390 a	330 a	550 a
20 g m^{-1} N, P, K	120 a	210 a	470 a	350 a	540 a
40 g m^{-1} N, P, K	190 a	240 a	500 a	330 a	660 a
50 g m^{-1} Tomas slake	140 a	200 a	440 a	350 a	380 b
Biomass/year	350	530	590	1130	1000
Commercial yield /year	290 (15%)[2)]	410 (30%)	540 (10%)	1020 (10%)	910 (15%)

[1] Planting distance 0.22 m. ; [2] % droppings

Development of soil conservation technology based on market opportunities – the case of "Protective – Productive Strips" with blackberry and Imperial grass.

As pointed out above, greater adoption of conservation technology is feasible if conservation technology can be successfully combined with income generation.

Selection of options and farm households

Using this rationale, research was initiated in 1996 by an MSc student. From biophysical and socioeconomic studies in the CIAT pilot watershed "Rio Cabuyal" in the Cauca Department (contribution of CIAT project PE-3), market opportunities for agricultural crops and products were identified, discussed and selected with farmers. After this process, selected options were subject to a more detailed ex-ante analysis of market risks, profitability and to some extent agronomic risks (contributions made from project SN-1 on Rural Agroenterprise Development). In a further step data were fed into a linear programming model for individual farm households, including environmental parameters such as slope steepness to optimize economic and environmental benefits.

As a result of these preliminary studies, Blackberry (*Rubus glaucus*) was selected for the upper part of the watershed with mean slopes of 30%, 1700-2200 m altitude and a population density of 56-97 people per km^2. (There are now also opportunities for milk and milk products, after a small dairy was installed in the lower part of the watershed.)

In the next step, two districts in the upper part of the watershed with relatively high levels of poverty, steep lands and a small percentage of coffee area were identified and selected for evaluating this market opportunity with potentially high economic and environmental benefits.

A farmer with a reputation as a local "opinion leader" and some experience in blackberry cultivation and marketing was identified. The project idea was discussed and further developed with him to obtain his support in promoting a project of "Soil conservation through market opportunities" among the poorest farmers in the district. An incentive for this leading farmer to participate was the prospect of obtaining a 10 percent share of the profits from his neighbors and being able to offer larger quantities for sale in the market.

Meetings were held with a group of 26 farmers to explain the reasons for the selection of blackberry, the procedures for financing the plantations, the modus operandi of the reimbursement of the "credits" (20% of gross income from planted blackberries for 3 years) and the technical designs for conservation farming.

Farmers interested in participating in the project were visited and their farms analyzed for the potential of obtaining environmental benefits (sloping fields with annual crops, high erosion risks) and social benefits (poor, underemployed family labor). Finally, an agreement was reached with 12 farmers stratified in three well-being groups (Table 2).

Table 2. Stratification of blackberry-conservation farmers after well-being levels, Ravnborg (1997)* (contribution of project PE-3)

Level of well being	%
High	14
Medium	29
Low	57

* Some could not be classified due to the lack of data.

Planting and Implementation

In May/June 1997 the planting of blackberry was organized and coordinated in close collaboration with Pedro Herrera, the leader of the group. Inputs such as chicken manure, plastic bags, fertilizer, and capital for layers was provided together with 500 plants. Farmers were expected to plant the blackberry in "Productive and protective contour strips (PPS)", consisting of one row of blackberry and a double row of Imperial grass (Figure 1).

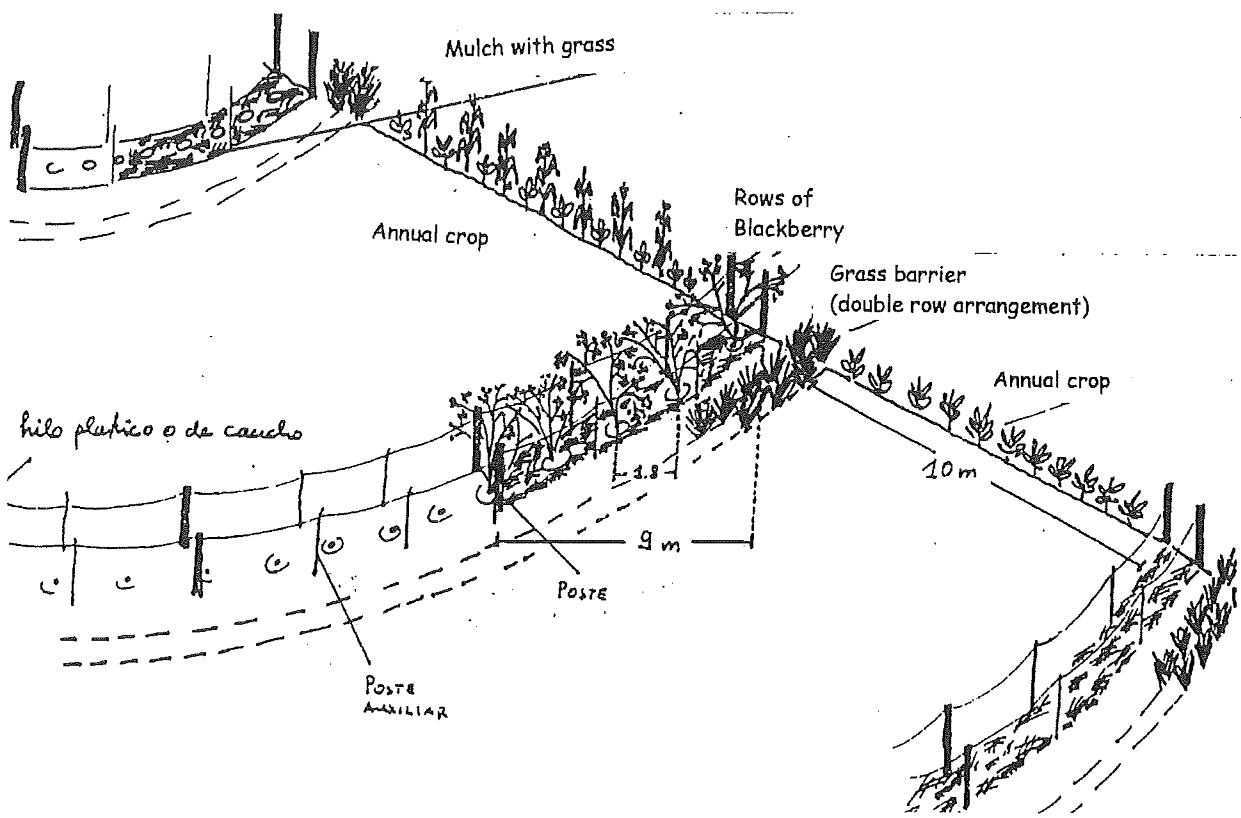

Figure 1. Design of "Productive and Protective Strips" for cultivation of Blackberry on hillsides of tropical mid-altitudes of 1800-2300 m.a.s.l. Planted in a contour arrangement.

Compared to the traditional way of planting blackberry as a sole crop in small plantations and then only protecting a small area with a perennial crop, where weed is managed with "machete", an arrangement in "productive and protective strips" leads to a five- to eight-fold increase in the area protected against erosion and excessive water runoff. The double row of Imperial grass was recommended to reinforce the conservation properties of the blackberry contour rows at the same time producing mulch for the blackberry rows (yield and quality enhancement) and providing cut-and-carry fodder for milking cows.

Nevertheless when team members visited the farmers in mid June all farmers had planted blackberry, but none of the farmers had implemented the contour technology exactly as it was discussed and proposed in the previous meetings.

The reasons for not implementing the blackberry conservation strips were the following:

- Not all farmers had understood the relatively complex design.
- Preparing land for a contour strip arrangement would have needed 4-6 times more labor for land cleaning in a period of relative labor shortage.
- In addition, the opening of more land between the contour strips would have required inputs for the planting of annual crops which were not available.

- Most farmers had only prepared a small piece of land and wanted to plant as much blackberry as possible to take advantage of the opportunity offered by the project within a limited time period.
- Some farmers (3) were willing to plant in the strip arrangement but were put under pressure by neighbors not to do it, so all would have a unified concept and position.
- Some of them felt insecure in adopting a new, unknown planting arrangement and wanted to avoid risks related with the new cropping design.

In order to meet the expectations of the project team and fulfill their commitments, nearly all farmers had introduced double-row barriers of Imperial grass in their plantations at the suggested distance. However, in doing this they created a risk of causing too much competition and complicating work in the blackberry plantation which already is quite sustainable by itself and does not require additional soil conservation technology.

It was concluded, that the unknown, the lack of time to prepare more land, the pressing time schedule of scientists, and a traditional preference for concentrating perennial crops such as blackberry on a small piece of land were the main reasons for only partial adoption of this conservation technology.

In response to farmer reactions and in order to give farmers more time to decide and to evaluate the hypothesis of economic and environmental benefits, that come with the strip arrangement, it was decided to establish runoff plots on five farms. Three treatments a) blackberry alone, b) annual crop alone, and c) annual crop with blackberry grass strip were selected. Farmers will be given the ability to decide on the adoption of the conservation technology on the basis of their own experiments and experience.

Evaluation of the various systems by farmers has been in process since October 1997. Farmers take data on labor requirements, yield, fruit quality, erosion and maintenance needs and will evaluate them together with project staff. In addition some farmers are planning to implement the protective strips by extending the grass barriers and planting blackberry at the top when preparing land for annual crops on adjacent fields in the next season and when more time is available for planning and implementing the proposed technology.

As an intermediate step towards optimizing the environmental impact of introducing and promoting blackberry cultivation and as a reaction to farmer attitudes a strip farming approach is also under consideration. In this arrangement annual crops and blackberry are cultivated as sole crops in contour strips of 10 to 20 m across the slope thus allowing farmers to manage the plant stands as a sole crop but reducing soil losses by alternating erosive and non erosive strips. On slopes of more than 15 %, the planting of a grass hedgerow at the lower end of the annual crop separating the two strips is strip is recommended.

Besides showing the need for participating with farmers and not trying to lead them, this example also shows that the promotion of soil conservation technology via the introduction of a market opportunity is not a valid option if a sustainable system depends on the adoption of a specific arrangement or planting system. The market opportunity or newly introduced crop itself should contribute to a more sustainable system. The planting arrangements and other management practices area only likely to have an influence on the area planted.

Impact: The case studies presented of integrated approaches to soil conservation in hillside agriculture have been implemented and practiced, at this stage by a limited number of farmers, because they have been developed in collaboration with locally active NGOs and farmer groups. The extent to which they will further expand depends to a high degree on markets, further development and refinement of technologies with farmers and the inputs from the NGOs actually engaged in implementing these technologies with farmers. Irrespective of this development, the principles associated with these cases are of general applicability and can be applied in many situations. The three principles of: (a) adding value to an introduced component (Citronella), b) developing an existing opportunity to a soil conservation option (Broom grass), and (c) implementing a market opportunity in a way that it optimizes environmental benefits will be published in order to stimulate similar activities at other sites. This should increase the impact and outreach of these local experiences. Hopefully, it will contribute to multiple local solutions to a global problem of soil erosion.

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References:

Barbier, F.B. 1990. The farm level economics of soil conservation: The uplands of Java. Land Economics 66(2):199-211.

Hudson, N. 1990. A study of the reasons for success or failure of conservation projects. FAO, Soils Bulletin No. 64, 65pp.

Müller-Sämann, K. 1997. Propuesta técnica para la producción de mora (*Rubus glaucus*) y de Pasto Imperial (*Axonopus scoparius*) como componentes de conservación en laderas. Documento de Trabajo No. 3. Proyecto de Conservación de Suelos. CIAT/Universidad de Hohenheim. 16 pp.

Müller-Sämann et al. 1999. Casos y cosas para aprender. – Estrategias integrales en la conservación de suelos y agua en el minifundio de la zona Andina. – in preparation.-

Ravenborg, H. 1997. Evaluación de pobreza rural: un método práctico para extrapolar y cuantificar percepciones locales. Publicación CIAT, No. 291, 47pp.

2.3.3. Diversified cassava agroecosystems for ecologically sound crop production in the andean hillsides

The PhD project described here is part of the Cassava Priority Programme of the Center for International Agriculture (ZIL) at the Swiss Federal Institute of Technology, Zurich, Switzerland. It has been developed in collaboration with the Centro Internacional de Agricultura Tropical (CIAT) in Colombia.

Highlights

- Cassava yields are heavily affected by undersowing and intercropping.
- Additional soil cover and biomass production by the intercrops are not sufficient to compensate for the loss in total cassava biomass, either biologically or economically.
- Farmer's reactions to on-farm trials indicate that short-term economic benefits are of higher priority than long term sustainability considerations.

Purpose: To develop sustainable cassava production systems for use by farmers in the Andean hillsides through on-station and on-farm field trials to assess the potential of varietal and species mixtures with cassava for improved resource use and erosion control.

Rationale: Cassava *(Manihot esculenta)* is the most important root crop in the tropics. In marginal areas, many farmers depend on its ability to produce reasonable yields on poor soils. Often planted on steep slopes, cassava cultivation contributes to erosion and depletion of soil fertility because of its slow initial growth and poor soil cover. Cassava cultivation under these circumstances can start a vicious cycle which leaves further cassava planting as the only option. In the Colombian hillsides, poverty prevents testing and application of strategies that would make cassava production more sustainable.

The project aims to identify ways to break the vicious cycle of continuous cassava cultivation. Over the last three years, I have studied potentially more sustainable production systems for use by farmers in the Colombian Hillsides. The main objectives are: i) to improve of erosion control and soil fertility with low external inputs and through diversification and ii) to identify constraints and opportunities for the local application of diversified cassava production systems.

Field experiments at experimental station Santander de Quilichao, 1995-1998

Starting in 1995, on-station field trials were carried out over three seasons to investigate the effects of two levels of cassava cropping system diversification: varietal and species mixtures with and without additional undersowing. I tested the performance of different cassava varieties complementary in plant architecture and disease resistance in pure stands and mixtures with and without undersowing the legume *Chamaechrista rotundifolia*. The work included various soil preparation methods, planting patterns, strategies of soil cover management and mixing ratios. In species mixture trials, sorghum (*Sorghum bicolor*), cowpea (*Vigna unguiculata*), bush bean *(Phaseolus vulgaris)* and the legume *Canavalia brasiliensis* CIAT 17009 were tested as intercrops for cassava.

Outputs: Though there are differences among varieties, cassava appears to be a generally weak competitor and yields of the cassava variety mixtures only were rarely significantly higher than the mean of the respective pure stands. Cassava yields were severely reduced by undersowing and intercropping green cover legumes. For example *C. rotundifolia* caused yield losses between 26% and 42%, while *C. brasiliensis* caused a 64% reduction of root production three months after planting. Of all the legumes tested, only *C. brasiliensis* significantly enhanced soil cover during the critical phase at the beginning of the cassava cultivation cycle. Additional soil cover and biomass production by the green covers were not sufficient to compensate for the loss in total cassava biomass, either biologically or economically. Only in the cassava-cowpea mixture total biomass production was higher compared to the cassava pure stand.

Field experiments in the Rio Cabuyal watershed, 1996-1998

All the above trials were carried out on the CIAT experimental station in Santander de Quilichao where soil fertility is high and slopes are moderate. Such conditions are not representative for the target group of hillside farms. It is also well known that the outcome of competitive interaction depends on environmental conditions, thus, it is impossible to predict the effects of diversified cropping systems from the on-station trials. Therefore in 1996 a series of on-farm trials were established in typical hillside environments in the Rio Cabuyal watershed with slopes up to 45%. The trial setup in Rio Cabuyal offers the possibility to investigate the potential for erosion control and yield stabilization of varietal and species mixtures over a range of environments relevant to small farmers. Involving farmer participation is a main objective of the project and a key factor for successful development of sustainable systems. I actively sought farmers' participation by working together with them in the experimental plots and spending time with them on their farms.

Two cassava varieties, CG 402-11 and SM 526-3 were grown in a randomized complete block design as pure stands, as variety mixture and inter-cropped either with upland rice or with the forage legume *Canavalia brasiliensis* CIAT 17009. The trial was replicated twice at each of four farms. The trial sites vary greatly in plot history, pest proneness, soil fertility and stability of soil structure. Depending on these factors, performance of the two cassava varieties and the intercrops also vary widely across the trial sites. Investigating the effects of site conditions on the interactions among partners in mixed cropping systems is a relevant new perspective is made possible through the on-farm trials.

Outputs: While greatly reducing cassava growth and yield, *C. brasiliensis* produces a large amount of biomass, protecting the soil. In cassava pure stands, soil protection depends on the degree of branching. Rice performed well under good growing conditions and had no significant competitive effect on cassava. The ears could be harvested 100-120 days after planting. Despite dying off after harvest, the rice plants visibly reduce levelling-in of the furrows left by ploughing, which may indicate reduced soil erosion. Under less favourable conditions, rice suffers from competition by cassava. Feed-back from farmers was positive, but indicated that short-term benefits of the intercrops such as additional income or availability of food are of higher priority than long term sustainability effects. More work will be needed for the development of rice and *C.brasiliensis* as potential intercrops in cassava production systems.

Impact: Results from the on-farm trials in Rio Cabuyal indicate a high degree of variability across sites and even replications. In temperate zones, varietal and species mixtures are well known for producing stable yields over non-uniform environments. Investigating their potential for yield stabilization in the Rio Cabuyal environment is highly relevant as the watershed has characteristics representative for the Andean hillsides region. Rio Cabuyal is actually a focus of interest of different CIAT programs oriented to strategic research and of several governmental organizations and NGOs supported internationally. This provides an excellent opportunity to disseminate results from the site specific field trials carried out in this project applicable and valuable over a wider area.

Contributors: Georg Daellenbach, CIAT, Colombia, Edilberto Bonilla (field work Qulichao), Luis Eduardo Guastumal, Merardo Muñoz (field work Rio Cabuyal).

2.3.4. Improved management practices for cassava production in Asia

Demonstrations on farmers fields and FPR trials

Highlights:

- During 1997/98 105 farmers conducted FPR trials on erosion control, varieties, fertilization and intercropping practice at nine pilot sites in four countries.
- Many farmers at the FPR pilot sites have now adopted new cassava varieties, better fertilization practices (applying higher levels of N and K and lower levels of P, in combination with farmyard manure), intercropping with peanut or maize, and contour ridges hedgerows of sugarcane, vetiver, *Tephrosia candida* or *Gliricidia sepium.*

Purpose: To develop appropriate integrated crop/soil management practices for more sustainable cassava-based cropping systems, as well as a farmer participatory research (FPR) methodology for the testing and selection of suitable soil conservation practices, in order to enhance the acceptance and adoption of these practices.

Rationale: It has been shown that while cassava is often grown on poor and sloping land, improper management of the crop often results in high levels of erosion and depletion of soil nutrients, which makes the cropping system unsustainable. Research has shown that better management practices can markedly reduce erosion as well as increase yields or income. Few of these practices, however, have been adopted by farmers, either because they are unaware of the effect of erosion on soil productivity, they don't know which practices are effective, or the recommended practices are not suitable for the local conditions, or they are too costly or difficult to implement. It is more likely that farmers will adopt soil conservation practices if they themselves are directly involved in the testing and selecting of the most suitable practices for their region by conducting FPR trials on their own fields.

Methods: The FPR methodology developed for the testing and selecting of suitable soil/crop management practices involved the following steps:

a. Establish demonstration plots to show farmers a wide range of soil/crop management options, aimed at reducing erosion and increasing income.

b. Let farmers evaluate the treatments and select the most useful options.

c. Help farmers conduct FPR trials on their own fields to test some of the selected options on erosion control, varieties, fertilization practices, intercropping practices and any other issue they choose to investigate.

d. Help farmers harvest these trials, collect and present the data to the farmers, and let farmers again evaluate and select the best options.

e. Help farmers further test, select, adapt and finally adopt those selected practices they

f. Consider most suitable for their specific conditions.

g. Facilitate the extension of these practices to neighbors and other communities.

Outputs:

a) Demonstration plots.

Table 1 shows an example of demonstration plots conducted at Agro-forestry College in Thai Nguyen, Vietnam, in 1997. The demonstrated crop/soil management practices had a marked effect on cassava and intercrop yield, on gross and net income, as well as on erosion. Farmers selected four treatments they considered most useful, including contour hedges of *Tephrosia candida* and vetiver or contour ridging; applying a combination of fertilizers and manures; intercropping with peanut and/or closer plant spacing. These practices resulted in a higher net income and lower levels of erosion.

b) FPR trials on farmers fields.

During 1997/98 a total of 105 FPR trials were conducted in eight pilot sites of the four participating countries, i.e. China, Indonesia, Thailand and Vietnam. Tables 2-5 are examples of FPR trials on erosion control, varieties, intercropping and fertilization practices conducted by farmers on their own fields.

Table 2 shows that farmers in Kieu Tung village in Phu Tho province of Vietnam selected treatment six, i.e. intercropping cassava with peanut, applying 10 t/ha of pig manure plus 60 kg N, 40 P_2O_5 and 120 K_2O/ha, and planting contour hedgerows of vetiver grass. This treatment has consistently produced the highest net income and lowest levels of erosion during three years of FPR trials on the same plots. In 1997, in this treatment net income was almost double, and soil losses were about one third of those obtained with the farmers' traditional practices. While many farmers in the village have now adopted intercropping with peanut and better fertilization practices, few have adopted the new varieties or vetiver hedgerows, mainly due to lack of planting material.

Table 3 shows average results from four FPR variety trials conducted in Kongba village of Hainan province, China. Because of lack of planting material not all varieties could be tested by all four farmers. Farmers in the village clearly preferred SC8013 over their own local variety, SC205, because of its higher yield and typhoon resistance. They did not like SC8002, a preferred variety in Guangdong province, because of its tall growth habit and susceptibility to typhoons.

Table 4 shows the average results of ten FPR intercropping trials, using peanut as the intercrop, in Pho Yen district, Thai Nguyen, Vietnam. Intercropping cassava with either one or two rows of peanut were the options preferred by farmers, as these treatments resulted in high yields of both cassava and peanut, and thus a higher gross and net income. Still, their local practice of planting short peanut rows across the cassava ridge produced the highest peanut yields and a relatively high net income; this treatment, however, requires a higher input due to the higher peanut seed requirement. In the same district, farmers experimented with four fertilizer practices. Table 5 shows that a combination of 10 t/ha of pig manure with 120 kg N, 40 P_2O_5 and 120 K_2O/ha produced the highest yield and net income. Nevertheless, a majority of farmers preferred a somewhat lower rate of fertilizers ($80N+40P_2O_5+80K_2O$) because of the reduced cost and the lower risk involved.

Table 1. Effect of various soil/crop management treatments on cassava yield, gross and net income as well as on dry soil loss due to erosion when cassava, cv Vinh Phu, was grown on 18-24% slope in the FPR demonstration plots at Agro-forestry College of Thai Nguyen Univ., Thai Nguyen, Vietnam in 1997. The last column indicates the farmers' preference for each treatment.

Fertilizer	Spacing	Intercrop	Tillage	Residue	Green manure	Hedgerow	Cassava yield (t/ha)	Intercrop yield (t/ha)	Gross income[1] <——	Product. cost[1] (mil.d/ha)	Net income ——>	Dry soil loss (t/ha)	Farmers' preference[2]
1. no	1.0x0.8	no	plow	removed	no	no	2.65	-	1.33	3.25	-1.92	27.51	0
2. NPK[1]	1.0x0.8	no	plow	removed	no	no	16.73	-	8.37	4.56	3.80	20.74	0
3. FYM[2]	1.0x0.8	no	plow	removed	no	no	18.17	-	9.08	5.42	3.66	24.17	0
4. NPK+FYM	1.0x0.8	no	plow	removed	no	no	22.85	-	11.43	6.72	4.71	27.12	57
5. NPK	1.0x0.8	no	plow	removed	*Tephrosia*	no	18.12	-	9.06	4.69	4.37	22.12	0
6. NPK	1.0x0.8	peanut	plow	removed	no	*Teph*+vetiver	16.78	0.57	11.24	7.21	4.03	0.70	91
7. NPK	1.0x0.8	no	contour ridge	removed	no	no	20.25	-	10.13	4.86	5.27	6.15	71
8. NPK	1.0x0.8	peanut	plow	removed	no	*Tephrosia*	15.16	0.41	9.63	6.98	2.65	13.51	0
9. NPK	1.0x0.8	peanut	plow	removed	no	*Flemingia*	15.73	0.45	10.11	7.37	2.74	8.73	0
10. NPK	1.0x0.8	peanut	plow	removed	no	vetiver	16.23	0.42	10.22	7.30	2.92	1.98	0
11. NPK	1.0x0.8	black bean	plow	removed	no	*Tephrosia*	17.50	0.10	9.35	6.92	2.43	8.76	0
12. NPK	1.0x0.8	no	plow	incorp.	no	no	23.76	-	11.88	4.60	7.26	17.15	0
13. no	1.0x0.8	no	plow	incorp.	no	*Tephrosia*	3.82	-	1.90	3.25	-1.35	12.18	0
14. NPK	1.0x0.8	no	plow	removed	*Tephrosia*	no	18.72	-	9.36	5.12	4.25	20.21	0
15. NPK	1.0x0.8	no	no tillage	removed	no	no	17.21	-	8.60	4.30	4.30	16.85	0
16. NPK	0.8x0.6	no	plow	removed	no	no	20.85	-	10.43	4.94	5.45	18.10	42

[1]Prices:

cassava:	d 500/kg fresh roots	urea (45%N)):	2,800/kg
peanut:	5,000/kg dry pods	SSP (17%P_2O_5):	1,000/kg
black bean:	6,000/kg dry grain	KCl (50%K_2O):	2,500/kg
labor:	15,000/day	pig manure:	200/kg
Flemingia seed:	50,000/kg seed	1 US $ = approx.	13,000/dong
vetiver grass:	20/plant		
Tephrosia seed:	5,000/kg seed		
peanut seed:	7,000/kg seed in pods		
black bean seed:	7,000/kg seed		
cassava stake:	50/stake		

[2]Percent of farmers (out of 35) considering the treatment as "good"

Table 2. Effect of various crop management treatments on the yield of cassava and intercropped peanut, as well as the gross and net income and soil loss due to erosion in an FPR erosion control trial conducted by six farmers on about 40% slope in Kieu Tung village of Thanh Ba district, Phu Tho province, Vietnam in 1997.

Treatments[1]	Dry soil loss (t/ha)	Yield (t/ha)		Gross income[2]	Product. costs	Net income	Farmers' ranking
		cassava	peanut	<------------	(mil.dong/ha)	------------>	
1. C monoculture, no fertilizers, no hedgerows (TP)	106.1	19.17	-	9.58	3.72	5.86	6
2. Cassava+peanut, no fertilizers, no hedgerows	103.9	13.08	0.70	10.04	5.13	4.91	5
3. C+P, with fertilizers, no hedgerows	64.8	19.23	0.97	14.47	5.95	8.52	-
4. C+P, with fertilizers, *Tephrosia* hedgerows	40.1	14.67	0.85	11.58	5.95	5.63	3
5. C+P, with fertilizers, pineapple hedgerows	32.2	19.39	0.97	14.55	5.95	8.60	2
6. C+P, with fertilizers, vetiver hedgerows	32.0	23.71	0.85	16.10	5.95	10.15	1
7. C monoculture, with fertilizers, *Tephrosia* hedgerows	32.5	23.33	-	11.66	4.54	7.12	4

[1]Fertilizers=60 N+40 P_2O_5+120 K_2O; all plots received 10 t pig manure/ha
TP=farmer traditional practice

[2]Prices: cassava: d 500/kg fresh roots
peanut: 5,000/kg dry pods
1US $ = approx. 13,000 dong

Table 3. Results of four FPR variety trials conducted by farmers in Kongba village, Baisha county, Hainan, China in 1997.

	Cassava yield (t/ha)					Farmers' preference[2]
	A[1]	B	C	D	Av.	
SC 205	-	16.93	14.32	20.83	17.36	9
SC 8002	-	-	20.83	-	20.83	0
SC 8013	36.46	21.48	19.53	27.99	26.36	14
SC 8639	28.65	-	-	36.46	32.55	14
ZM 9036	-	15.62	-	-	15.62	0
ZM 9244	27.02	-	-	47.53	37.27	10
ZM 9247	-	23.44	-	26.04	24.74	13
ZM 9315	-	18.23	-	31.25	24.74	10
ZM 94107	19.53	19.53	-	33.85	24.30	0
OMR 33-10-4	26.69	18.23	20.83	-	21.92	5
OMR 34-11-3	25.06	16.93	18.23	28.65	22.22	4
OMR 35-70-7	29.95	-	-	29.30	29.62	13

1) A = Mr. Lu Huan Cheng
B = Mr. Zhou Yong Ming
C = Mr. Tan Yin Chai
D = Mr. Fu Yong Quan

2) Number of farmers liking variety (out of 14 farmers)

Table 4 Average results of ten FPR trials on planting arrangement in intercropping cassava with peanut conducted by farmers in Tien Phong and Dac Son villages of Pho Yen district, Thai Nguyen province, Vietnam in 1997.

	Yield (t/ha)		Gross income[1]	Production costs[2]	Net income	Farmers' preference
	cassava	peanut	(mil.dong/ha)			(%)
1. Farmer's practice[3]	20.87	0.64	13.64	3.82	9.82	10
2. Cassava+1 row of peanut[4]	27.23	0.32	15.22	3.34	11.88	55
3. Cassava+2 rows of peanut[5]	21.64	0.49	13.27	3.52	9.75	52
4. Cassava+3 rows of peanut[6]	19.02	0.58	12.41	3.70	8.71	0

1)Prices: cassava: d 500/kg fresh roots
peanut: 5000/kg dry pods
peanut seed: 6000/kg dry pods
1 US $ = approx. 13,000 dong

2)Peanut seed requirements: T_1=120, T_2=40, T_3=70, T_4=100 kg/ha

3)Cassava on ridges spaced at 1.0-1.2m between ridges, peanut planted cross-wise on ridge in short rows, 0.6-0.8m between rows (to reduce excess moisture)

4)Cassava at 1x0.6m; peanut between cassava rows at 0.1m between plants

5)Cassava at 1x0.8m; 2 rows of peanut at 0.35x0.1m

6)Cassava at 1.2x0.8m; 3 rows of peanut at 0.35x0.1m

c) Adoption of improved practices.

In 1997 and 1998 many farmers participating in the FPR project started to try out some of the selected practices on their production fields. Table 6 shows that the new cassava varieties were the first and most widely adopted component. In the two pilot sites in Thailand, the new higher-yielding varieties have now completely replaced the local variety, Rayong 1. In China and Vietnam participating farmers are changing to their newly selected varieties as rapidly as they are able to multiply the planting material. In Indonesia, however, most farmers still prefer their traditional varieties, as these are well adapted to the local conditions and taste preferences, while the new varieties were only marginally better in yield and starch content.

Better fertilization practices were readily adopted after participating farmers saw their economic benefits. Unfortunately, in Indonesia chemical fertilizers have become extremely expensive, while KCl has practically disappeared from the market.

Intercropping with peanut has been readily accepted by farmers in the three pilot sites in Vietnam. In Indonesia, intercropping with maize and upland rice, followed by peanut or soybean is already a traditional practice; this was improved, however, by the introduction of new maize hybrids and soybean varieties. In China and Thailand intercropping treatments with peanut, pumpkin, mungbean or sweet corn were less successful, due to frequent periods of drought or excess water, as well as rat damage of peanuts in China. In Thailand, due to labor scarcity, it is not likely that intercropping will be widely adopted.

Adaption of soil conservation practices *per se* is still rather limited, partially because planting material or seed of hedgerow species, such as vetiver grass and *Tephrosia candida,* were not readily available, while the setting out of contour lines, as well as the planting and maintenance of these hedgerows is still rather difficult and expensive. Moreover, these hedgerows permanently occupy some space (often 10% or more) in the field, while they also compete with neighboring cassava plants, resulting in a reduction in yield. Table 7 shows that when vetiver (or sugarcane) hedgerows were tried out by five farmers on small areas (1600 m^2) of their production fields in Thailand, the cassava yields decreased on average 18% while gross income declined about 15% compared with nearby fields without hedgerows. Only in case sugarcane was used in alternate hedgerows with vetiver grass by Mrs. Champaa, did the additional income from the sale of sugarcane stalks (for chewing) compensate for the reduced production of cassava. Thus, it is very important for farmers that the hedgerows used for erosion control either have commercial value (like sugarcane) or have an alternative usage, such as green manure (*Tephrosia candida* and *Gliridicia sepium*) or animal feed (*Gliricidia sepium,* elephant grass and *Paspalum atratum*). Alternatively, the use of contour hedgerows to control erosion should be combined with other income-enhancing practices, such as intercropping, better fertilization, and higher yielding varieties, so that the total "improved" crop/soil management package produces a higher net income than the farmers' traditional practices. An example of this would be treatment 6 in Table 2, where the combination of various management components nearly doubled net income compared with the traditional practice.

Table 5. Average results of five FPR fertilizer trials conducted by farmers in Tien Phong and Dac Son villages of Pho Yen district, Thai Nguyen province, Vietnam in 1997.

Treatments	Cassava yield (t/ha)	Gross income[1)]	Fertilizer costs[1)]	Net income	Farmers' preference (%)
		<---------(mil. dong/ha)--------->			
1. Farmer's practice[2)]	18.50	9.25	3.31	5.94	0
2. 10 t/ha FYM+40N+40K_2O	19.87	9.44	2.43	7.01	32
3. 10 t/ha FYM+80N+40P_2O_5+80K_2O	22.37	11.19	3.10	8.09	64
4. 10 t/ha FYM+120N+40P_2O_5+120K_2O	28.00	14.00	3.54	10.46	61

[1)]Prices:
- cassava: d 500/kg fresh roots
- pig manure: 200/kg
- urea (45%N): 3000/kg
- SSP (17%P_2O_5): 1000/kg
- KCl (50%K_2O): 2600/kg
- 1 US $ = approx. 13,000 dong

[2)]Average farmer application: 12.8 t/ha of FYM+58 kg N+31 P_2O_5+34 K_2O/ha

Table 6. Technological components selected and adopted by participating farmers from their FPR trials conducted from 1994 to 1998 in four countries in Asia.

Technology	China	Indonesia	Thailand	Vietnam
Varieties	SC8013***[1)] SC8634* ZM9247* OMR35-70-7*	Faroka*** 15/10* OMM90-6-72*	Kasetsart 50*** Rayong 5*** Rayong 90**	KM60*** KM94* KM95-3*** SM1717-12*
Fertilizer practices	15-5-20+Zn +chicken manure 300kg/ha*	FYM 10 t/ha (T)+ 90 N+36 P_2O_5+ 100 K_2O**	15-15-15 156 kg/ha***	FYM 10 t/ha (TP)+ 80 N+40 P_2O_5+ 80 K_2O**
Intercropping	monoculture(TP) C+peanut*	C+maize(TP)	monoculture(TP) C+pumpkin* C+mungbean*	monoculture(TP) C+taro(TP) C+peanut***
Soil conservation	sugarcane barrier*** vetiver barrier*	*Gliricidia* barrier** *Leucaena* barrier* contour ridging**	vetiver barrier*** sugarcane barrier**	*Tephrosia* barrier*** vetiver barrier* pineapple barrier*

[1)]
- * = some adoption
- ** = considerable adoption
- *** = widespread adoption
- TP = traditional practice; FYM=farm yard manure.

Table 7 **Efect of contour hedgerows of vetiver and/or sugarcane on cassava yield and gross income when planted in production fields of 1600m² of five farmers in Soeng Saang and Wang Nam Yen districts in Thailand in 1997/98.**

Farmer	Hedgerows	Cassava yield (t/ha)		Gross income ('000B/ha)[1]	
		With hedgerows	Without hedgerows	With hedgerows	Without hedgerows
Mrs. Naakaew[2]	vetiver	25.72	31.31	38.58	46.96
Mrs. Champaa[2]	sugarcane and vetiver	9.26	12.45	18.71	18.67
Mr. Sawing[3]	vetiver	15.99	19.05	23.98	28.57
Mr. Somkhit[3]	vetiver	16.39	21.66	24.58	32.49
Mr. Phuem[3]	vetiver	23.81	26.25	35.71	39.37
Average		**18.23**	**22.14**	**28.31**	**33.21**

[1] Prices: cassava: B 1.50/kg fresh roots
sugarcane: 3.0/stalk (for chewing)
[2] In Soeng Saang district of Nakorn Ratchasima province.
[3] In Wang Nam Yen district of Sra Kaew province.

Another constraint to the adoption of contour hedgerows is that they may interfere with other practices, especially with mechanized land preparation, weeding and harvesting, which, in general, are more conveniently done in straight lines and parallel to the longest side of the field. Thus, in Thailand contour hedgerows established by farmers were sometimes damaged or plowed under by tractor drivers preparing the land under contract. In addition, curved contour hedgerows make it impossible to plant cassava in straight lines using a tight string as a guide. In Thailand this work is often done under contract, so efficiency in planting is an important consideration. In that case, planting hedgerows in straight lines approximately across the slope may be a necessary compromise.

Impact: Farmers who have participated in the FPR project are now adopting several technology components (Table 6). During the project evaluation conducted in June/July 1998 (see Project Evaluation Report), many farmers indicated that the use of these practices had resulted in higher yields and income and less erosion. So far, however, adoption has been limited mainly to the eight pilot sites. The proposed second phase aims to extend the project to many more pilot sites, especially in Thailand and Vietnam, and to develop an efficient and participatory methodology for the dissemination of the best results to other farmers, so as to greatly enhance the impact of the project.

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2.3.5 DSSAT model adapted for smallholder systems

Highlights

- Brachiaria decumbens option added to DSSAT
- DSSAT linked to the soil-organic-matter and crop-residue module of CENTURY.

Purpose: To analyze smallholder systems in Honduras through biophysical-model analysis, in order to better understand their strengths and weaknesses, and to identify opportunities for improvement. This holds particularly for the maize-mucuna rotational system.

Rationale: Agronomic simulation models can play an important role in analyzing a wide range of agricultural management options (e.g. crop rotations, scheduling fertilization or irrigation, etc.) in relation to environmental conditions. For smallholder systems in Central America – beginning with Honduras – such a model may help in analyzing different options of land use and farm management. This involves aspects of [i] the production of maize-based crop rotations, as they vary with weather and soil conditions, [ii] system sustainability, and [iii] an economic analysis of different management options. It will result in a better understanding of how crop production varies with environmental conditions (weather, soil), and of which management strategies (e.g. fertilization, green manure) are best under different conditions. This will allow the designing of management strategies at the plot or whole-farm level that pay maximum care at the biophysical sustainability of the agricultural system and its economic viability.

The maize-mucuna system is widely used in the Atlantic zone of Honduras, where farmers see it as something close to a "miracle solution" to many problems: it results in an up to a 100% increase in maize yield, improved soil condition and strong erosion control, drastic reduction or complete elimination of N-fertilizer use, less labour demand, and weed control. Talking to the farmers in the area and looking at complete hill slopes covered with mucuna, one is impressed and wonders why this system is so successful and widely accepted here but not in other areas of Honduras. Earlier research from others raises a number of questions that are not easily dealt with in field studies but are very suitable for model approach: e.g. aspects of N cycling though mucuna litter, optimizing management to limit mucuna-maize water/light competition, environmental ranges where the system can be used.

Methods: The Decision Support System for Agrotechnology Transfer (DSSAT) is a widely used agronomic model, which allows to evaluate germplasm-by-environment interactions without the need to do expensive and time-consuming multi-site, multi-treatment experiments. Experimental data from one site can thus be extrapolated to other areas, having a different soil type or climate, or where farmers use other crop varieties. For the application of DSSAT to low-input agricultural systems of Central America, some modifications are needed, that will be addressed in this project:

i) Many crop rotations in Central America involve a legume green-manure / cover crop phase. Presently, such crops are not included in DSSAT. However, because the model has options for various legumes (dry bean, soya, peanut), amplifying this to other legumes does not involve much new model development. Mucuna pruriens and Arachis pintoi are being added.

ii) Similarly, many crop rotational systems involve a ley pasture phase. Presently the model includes a Bahia grass option, which, however, is not the most common grass species used in the area. The model has been modified to include a Brachiaria decumbens grass option.

iii) In low-input agricultural systems, plant nutrients mainly come from soil-organic-matter (SOM) decomposition. DSSAT does have a module for the simulation of SOM dynamics, but, since the model was developed in countries with high-input agriculture where SOM is not considered of great importance for the nutrient supply to a crop, this module cannot be considered very detailed; there are better modules available from other models. The principal candidate for this is the CENTURY model, which already has proven its great value. The CENTURY SOM module has now been incorporated into DSSAT.

Outputs: DSSAT has successfully been expanded with a new option for the perennial tropical forage grass *Brachiaria decumbens*, a species of major importance in the South/Central-American savannas and hillsides. The new model option was calibrated with four data sets from different sites in Colombia that were part of the International Network for the Evaluation of Tropical Pastures (RIEPT; see Figure 1), and then validated with two additional data sets from other sites in the RIEPT network.

The simulated dry-matter production of the pasture with cutting intervals of 3, 6, 9, or 12 weeks, was on average between 96 and 101% of the observed values for one of the validation experiments, and between 82 and 100% for the other. However, excluding the data from the first cutting at the latter site, which relates to pasture establishment during a period of drought stress when the observed dry-matter production stayed far behind the simulated production, would result in a tight validation range of 98-101% for this experiment also.

It is concluded that the new model option accurately estimates the pasture production of *B. decumbens* with grass-cutting management under different soil and climate conditions. Further calibration for higher-latitude sites may be needed for obtaining a more general validity for the area where this species is commonly grown. The study has demonstrated that DSSAT can be developed as a decision support tool for management of *B. decumbens* pastures, provided that the model is calibrated under conditions of grazing.

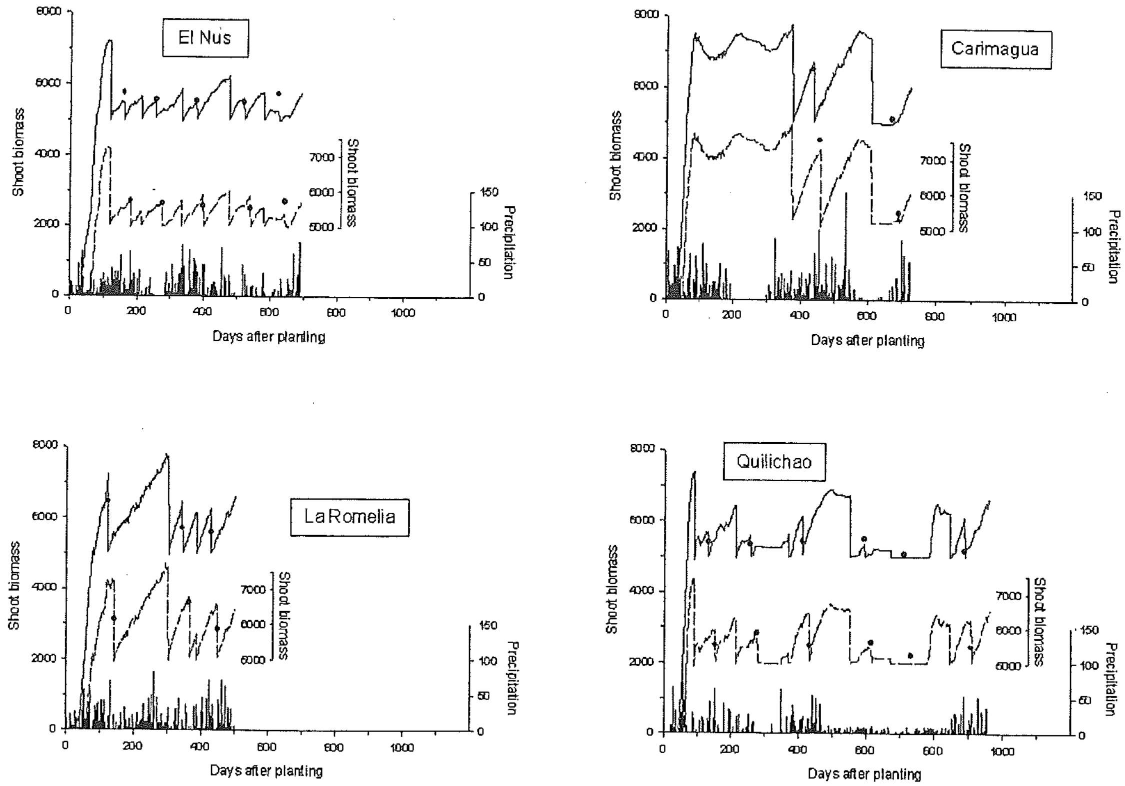

Figure 1 Result of model calibration at four experimental stations, showing the simulated grass yield (kg/ha) at cutting intervals of 6 weeks (continuous line) and 9 weeks (discontinuous line), compared to the observed values (points). For Carimagua, the simulated results refer to cutting intervals of 9 and 12 weeks. The lower part of the graphs indicates the daily rainfall (mm).

With the modifications that have been made already or are under way, the DSSAT model will be ready to be applied to low-input smallholder systems where most nutrients come from N_2 fixation by legumes or plant residue decomposition. It will first be applied to the maize-mucuna rotational system in the north coast of Honduras in order to understand the basis of its success, its limitations, and the potential for application of mucuna systems to other areas. This may result in recommendations how system management might be modified in areas where, particularly, rainfall is more limiting. Other cropping systems will follow in the analysis.

Accurate estimates of crop yields under various environmental and management conditions are an important input parameter for designing farm-level management strategies. With CIAT having a new economist based in Honduras, DSSAT can play a central role in providing such data, enabling him to better evaluate different options.

Impact: The great success of the maize-mucuna system in northern Honduras, but yet limited adoption in the rest of the country, makes one wonder "why?". Biophysical analysis of the environmental and management conditions through model application may clarify this and open the way for designing modified mucuna (or other legume) based cropping systems for other zones.

Agronomic field studies inevitably cannot cover the wide range of natural conditions that one encounters in an area. An important question then that remains open is how experimental results from one site can be interpreted for other sites with different soil, climate or management conditions. Agronomic simulation models such as DSSAT can play an important role here to ensure that recommendations that follow from research are not of a "blanket" type for a wide area, but are well targeted to the specific local conditions.

Contributors: CIAT project PE-5: Arjan Gijsman, Luís Horacio Franco

Collaboration:

- ✓ University of Caldas (Colombia): Two student groups of two each for adding *Brachiaria decumbens* and *Arachis pintoi* to DSSAT.
- ✓ University of Georgia and University of Florida (USA): Modifying the source code of DSSAT to incorporate the adaptations needed for applying the model to low-input smallholder systems.
- ✓ International Fertilizer Development Center (IFDC; USA): Modifying the soil-organic-matter and plant residue module of DSSAT.
- ✓ ILRI (Kenya) and Univ. of Georgia (USA): How to get a livestock grazing option into DSSAT ?
- ✓ CIMMYT (Mexico): Carrying out experiments in Colombia, Honduras and Mexico for measuring parameters needed to add the legume *Mucuna pruriens* to DSSAT.
- ✓ CIAT project PE-2 (Dennis Friesen): Collaboration on adding a soil P module to DSSAT and on validating the new soil-organic-matter module.
- ✓ CIAT project PE-3 (Rubén Darío Estrada): Collaboration on adding the *Arachis pintoi* option to DSSAT, as Estrada is setting up an *Arachis* seed production project with small farmers.
- ✓ CIAT project PE-3 (Hector Barreto): Applying DSSAT to analyze Honduran smallholder systems.
- ✓ CIAT project PE-3 (Bruno Barbier): Collaboration on applying DSSAT to estimate crop yields under various environmental and management conditions, which will be input for evaluating farm-level management strategies and doing economic analyses.
- ✓ CIAT project PE-4 (various): Interfacing DSSAT with GIS-georeferenced data on soil and weather conditions.
- ✓ CIAT project IP-5 (I.M. Rao): Identifying parameters needed for adding the grass *Brachiaria decumbens* and the legume *Arachis pintoi* to DSSAT.
- ✓ CIAT project IP-5 (Michael Peters): Carrying out an experiment in Honduras for measuring parameters needed to add new legumes to DSSAT.

Output 2.4 Socio-economic and environmental impact of new technologies

2.4.1 Potential impact of new technologies developed through Farmer Participatory Research (FPR)

An indicator framework for use in impact analysis at the Forest Margins Eco-Regional Site, Pucallpa, Perú

Highlights

- Set in place a plan to develop indicators for different research issues that are being undertaken by the Ecoregional Center for the forest margins, Pucallpa

Purpose: to develop a common framework of indicators to monitor research and analyze impact. This framework follows a common research vision and workplan of organizations working in the ASB Forest Margins site of Pucallpa, Peru. The framework also provides an accountability mechanism for donors and serves as an information source for policymakers.

Rationale: Comparable indicators to assess, monitor and evaluate changes and impact upon the state of environment are often lacking even though economic and social indicators have been widely adopted and routinely influence national, regional and global policy decisions. Similarly, a dearth of reliable information has plagued the validity of research in many developing countries (Barrett 1998). An indicator framework for impact analysis allows the organization and integration of data sets for use in the decision-making process at different scales (farm, watershed and agro-ecosystem), thus facilitating the exchange and use of information. This framework relates social, economic and environmental data to meet policy-making and management needs at different (local and national) levels.

The indicator framework for impact analysis provides a general mechanism with which to determine the benefits of research and technology interventions. One component of the analysis is to measure the impact of new technologies developed through Farmer Participatory Research methods.

Methods: We aim to modify and apply the Sustainability Indicators model that is under development in CIAT with World Bank/CIAT/UNEP funding for the Hillsides of Central America. This model uses a Pressure-State-Impact-Response (P-S-I-R) framework for impact analysis (Winograd 1996, 1998). It can be targeted at particular issues and will integrate scales from the farm to agro-ecosystem level. The P-S-I-R framework comprised four distinct categories of indicators. The first category, *Pressure*, refers to the causes of environmental and land use problems whereas the second category, *State*, monitors the quality of the environment resulting from human activity. These two indicator categories, Pressure-State are also described as flow-stock variables commonly used in natural resource economic and biology/ecology literature. The third category, *Impact*, relates the effect of human activity on the environment and the converse effect of the environment on society. The fourth, *Response*, refers to the policy and technological responses of society on the environment.

The P-S-I-R framework will be integrated with the *Best Bet* framework of the CG Systemwide Alternative to Slash and Burn Program (Vosti, et al.1998, Tomich et al. 1998). The *Best Bet* procedure employs a framework with which to examine profitability, food security, labor availability and agronomic sustainability of individuals along with global concerns of climate change, biodiversity and carbon stocks and greenhouse gas absorption. It is an approach to balance both private rural household concerns at a farm-level/local scale with and public concerns at a global scale.

Vosti et al. (1997) have identified the need for information at the mid- or landscape level as an area for further research. They consider this landscape level of data and analysis as one of the most important facing developing country policymakers. For example the policy issues of income/wealth equity of a community can only be well defined at the landscape level. The P-S-I-R indicator framework for impact analysis contains this previously omitted mid-level dimension.

Definition of issues will be carried out within the context of the Inter-Center Workplan developed for the Eco-Regional site, Pucallpa. There will be individual consultations with those who will use the framework to seek their input on particular issues. Informal workshops will be then be arranged. Priority issues will then be finalized at a Working Group Meeting during the Inter-Center Planning Workshop 10-14 May 1999.

Specific issues to be incorporated in the indicator framework (and collaborating institutions):
- The impact of technology developed through Farmer Participatory Research (CIAT, ICRAF, INIA, DRAU)
- The effect of alternative land use systems on preservation of biodiversity in the forest margin (CIAT, CIFOR, ICRAF, INIA)
- The effect of different land use systems on carbon stocks and greenhouse gas emissions (ICRAF, CIFOR, INIA)
- Economic development of colonist farmers (CIAT, ICRAF, CIFOR, DRAU)

Outputs:
1999
- Working document of the information
- Diskette of the compiled data

Proposed
- An interactive GIS presentation (CD-ROM) with associated maps

Impact: The framework and its development can serve as a model for use at other Eco-Regional sites in planning, prioritizing, monitoring and assessing research. National partners will be involved in the development and validation of the framework and receive training in its use. Furthermore, dissemination of baseline data regarding particular issues of policy makers and researchers will be completed within the first year.

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References:

Barrett, Chris. *Summary: Agricultural Intensification, Economic Development and the Environment.* 31 July 1998. Salt Lake City, Utah: AAEA Pre-Conference.

Tomich, Thomas P. Meine van Noorwijk, Steven A. Vosti and Julie Witcover. "Agricultural development with rainforest conservation: methods for seeking best bet alternatives for slash-and-burn, with applications to Brazil and Indonesia." *Agricultural Economics.* forthcoming 1988.

Vosti, Stephen A. et al. *Socioeconomic Issues Linked to Best Bet Land Use Systems* IFPRI, draft of meeting proceedings, February 9-13, 1998.

Winograd M., Uribe F., Raynales J. et al. (1996) *Desarrollo y Uso de Indicadores para la Planificación y la Toma de Decisiones en la Corporación Autonoma Regional del Risaralda (CARDER): Marco Conceptual y Aplicación*, CARDER/CIAT, Documento de Trabajo 160, Cali, Colombia: CIAT.

Winograd M., A. Farrow, and J. Eade. (1998) *Atlas de Indicadores Ambientales y de Sustentabilidad para America Latina y el Caribe.* Cali, Colombia: CIAT y UNEP, CD-ROM version 1.

2.4.2 Analysis of trade-off in private vs. public benefits with alternative land use systems in Pucallpa

No activity in 1998

2.4.3 Potential and environmental impact of new forage technologies assessed

Early adoption of Arachis pintoi in the humid tropics: The case of dual purpose cattle systems in Caqueta, Colombia

Highlights

- 85% of the 68 producers using *Arachis pintoi* from the 229 interviewed expression satisfaction of growing the legume in association with a grass.
  Advantages were given as stocking rate, milk yield, and/or increased weight gain.
- Concurrent economic analysis during the process of adoption or adaptation of a new technology is useful to identify constraints that might be addressed.
- Adoption will be enhanced by a reduction in the cost of seed or planting material, management practices that increase the rate of establishment and providing more information to farmers.

Purpose: To identify possible limitations to adoption of a new grass-legume technology and to facilitate the design of strategies for the acceleration of the adoption process.

Rationale: The region of Caquetá, Colombia, is representative of the prevailing environmental and economic situation to a great extent of the Colombian Amazon region. The development of Caquetá dates from the beginning of the century and has gone through various phases up to the present mix of agricultural and cattle production systems. These remain extensive, but there is tendency towards intensification.

CIAT, associated with Nestlé, has been monitoring the evolution of livestock systems in Caqueta in two areas of common interest for both institutions: 1) the adoption of forage technologies and 2) the production and productivity of current livestock systems. CIAT has been investigating the transfer and adaptation of grass-legume association technology by farmers with focus on the forage legume A*rachis pintoi*, or perennial forage peanut. *A. pinoti* was released commercially by the government of Colombia in 1992.

The processes of adoption and transfer of new forage technologies, in particular legume-based technologies are complex and slow. The decision to adopt an improved pasture involves the investment of capital of considerable magnitude, not only in the establishment of the pasture, but also in greater requirements of livestock, since forage technologies of this type increase the stocking rate. This is a critical point for small and medium farmers which predominate in Caquetá, with little capital and limited access to financial institutions. The present study was designed to analyze the early adoption of *A. pintoi* that is being promoted by CIAT and Nestle.

Methodology: Data was collected through surveys taking the set of supplier milk farms to the Nestle plant in Caqueta as the basis for the sample. Two sampling strategies were utilized: (a) a random sample whose size was estimated utilizing the conventional statistical methods, and (b) an additional sample of 52 farms of producers who are using the new material. This makes it possible to generate sufficient information with regard to the experiences, difficulties, and prospects of those producers who are experimenting with *Arachis*.

Results: Available information shows a great dynamism in land use patterns in Caqueta. This can be seen when comparing the results of a study conducted in 1986 by Ramírez and Sere (1990) with results observed in the present work. Tables 1 and 2 show this comparative analysis. The most relevant aspects are: (i) reduction of the relative importance of natural grasses of low productivity observed in 1986 and a greater use of improved pasture in 997, (ii) greater diversification of the forage germplasm used, resulting in a lower relative importance for *Brachiaria decumbens* cv Basilisk, for other varieties of *Brachiaria,* and (iii) the presence of associations of grasses with legumes as a new forage alternative in comparison with the absence of this in 1986.

Table 1. Dynamics of land use in dual-purpose farms, Caqueta, Colombia during 1986 and 1997.

Land use	1986 Survey		1997 Survey	
	Area (ha)	%	Area (ha)	%
Total farm area	131	100	158	100
Total pasture area	95	73	129	82
- Natural	62	47	38	24
- Improved	33	26	91	58
Crop area	4	3	3	2
Fallow area	22	17	10	6
Forest area	9	7	16	10

Table 2. Changes in area of improved pastures in Caqueta between 1986 and 1997.

	1986	1997	(%)
B.decumbens	76.0	64.1	-11.9
B humidicola	0.6	13.8	13.3
Alemán	3.8	11.9	8.1
B brizantha	0.0	4.7	4.7
Arachis mixed	0.0	2.7	2.7
Arachis alone	0.0	0.1	0.1
B dictyoneura	0.0	1.0	1.0
Imperial	5.0	0.7	-4.3
Other brachiarias	0.0	0.3	0.3
B ruziziensis	0.0	0.1	0.1
Puntero	7.9	0.3	-7.6
Micay	1.2	0.0	-1.2
Guinea	2.1	0.0	-2.1
Pará	1.2	0.0	-1.2
Elefante	2.3	0.0	-2.3
Others	0.0	0.3	0.3
Total	100.0	100.0	0.0

Of a total of 226 producers interviewed, most of them (179) have heard about the existence of this new forage alternative in the region. Of this group, 171 have seen the material (76% of total producers). At the time of the interview, 68 of them (30% of the total) were using it. Two types of pastures with *Arachis* are in use: i) seed banks with an average area of 1.3 ha/farm and ii) pastures of grasse-*Arachis* associations with an average area of 9.6 ha/farm. About 82% (57 livestock owners) of those who are experimenting with *Arachis* are using it in association with grasses.

Out of a total of 68 early adopters, 21 of them (31%) have had problems with the establishment of peanut. The main problems are related to the low germination rate of the grass (8) and the slow establishment of the peanut (7). The degree of satisfaction with the experience of the Arachis can be regarded as high. About 82% declared they were satisfied with the obtained results so far. It is significant the fact that more than half of the adopters (55%) have been grazing the legume.

Producers who are grazing *Arachis* have identified its capacity to increase the productivity of the pasture as important attribute. About 63% of them have detected one or more of the Other positive attributes of the peanut identified by producers were: weed control, and better palatability. Table 3 summarizes the assessment by producers of their experience of grazing *Arachis*.

Table 3. Ranking of satisfaction by producers who have grazed *Arachis pintoi* in Caqueta, Colombia, in 1997.

Ranking	Producers (68)	%
Excellent	10	26.3
Good	19	50.0
Regular	4	10.5
Bad	1	0.6
Do not know yet	4	1.5
Total	38	100.0

12% of producers which have experimented with peanut (8 out of 68) are not satisfied with the results obtained. Table 4 summarizes the causes of dissatisfaction.

Table 4. Causes of dissatisfaction of producers who have used *Arachis pintoi* in Caqueta, Colombia, in 1997.

Cause of dissatisfaction	Producers (#)	%
Benefits are not clearly identified	4	50.0
No progress is observed	2	25.0
Cattle do not consume it	1	12.0
Tends to disappear	1	12.0
Total	8	100.0

Current Adoption Rate

The current rate of adoption of *A.pintoi* in Caqueta, expressed as the proportion of producers utilizing this material, is around 9.2% (16 early adopters out of a random sample of 174 producers). Based on this adoption rate a preliminary estimate of the total area planted with *A. pintoi* is about 3000 ha. in the 2973 dairy farms supplying milk to the Nestle plant. Of this area, 2626 ha (88%) are associations of *A. pintoi* with grasses and the rest seed banks of *A. pintoi*.

Of a total of 68 early adopters, 58 of them (85%) affirmed to be willing to expand the planted areas. On average, in the next three years they would increase the area with *Arachis* by 11 ha/farm in Year 1, by 10 additional ha/farm in Year 2, and 11 ha more during Year 3.

Technical and Economic Viability of the technology based on *A. pintoi*

The technology of pastures mixed with *A. pintoi* is economically attractive in view of the fact that its profitability, expressed as internal rate of return, is substantially greater than the profitability of the traditional technology of improved pastures based on grass alone (Table 5).

Table 5. Profitability of *A. pintoi* mixed with different species of Brachiarias in Caqueta, Colombia during 1996

Type of Pasture	Cost of Establishment ($/ha)	Milk Yield (kg/cow/day)	Stocking Rate (AU/ha)	Internal Rate of Return (%)
B. decumbens	158	3	1	12.0
B. decumbens +. *A .pintoi*	282	3.5	1.5	19.3
B. humidicola + *A. pintoi*	337	3.5	2.0	21.8
B. dictyoneura + *A. pintoi*	368	3.5	2.0	21.1

The change of the traditional technology to a grass-legume mix with *Arachis* implies a substantial increase of the cost of establishment, increasing from $157/ha (*B. decumbens* only) to $368/ha (*B. dictyoneura* + *A. pintoi*). In addition to the substantial increase in the cost of establishment, the increase in stocking rate also implies the need to invest in more cattle.

Considering the current situation of Colombia, where high real interest rates prevail, it is imperative to find new alternatives of low cost financing that facilitate the cost of establishing improved forage alternatives.

The market for commercial seed in Caqueta is high-quality with regard to purity and germination. However, the local price is higher compared to neighboring countries such as Bolivia. The cost per kilogram of *A. pintoi* in the region ranges between $ 20–25/kg and the Bolivian seed costs around $15/kg in Colombia. Despite the attributes of *A. pintoi*, the cost of seed is substantially higher that that of other forage legumes utilized in the region as *P. phaseoloides* (Kudzú), *C. macrocarpum* or *D. ovalifolium*, that are in the range of $ 12 - 15/kg.

A greater effort on dissemination of information on the use, management, and potential of *Arachis* as well as a reduction in the seed cost to reduce the establishment cost is needed in order to accelerate the adoption. This is particularly true in the current circumstances of reduced economic activity in Colombia, and limited knowledge of producers in other regions of this new forage legume.

Contributors: Libardo Rivas (BP-1)and Federico Holmann CIAT-ILRI (PE-5)

2.4.4 Potential impact of new forage technologies in SE Asia assessed

Developing a framework for on-going impact analysis of forages-FPR in Asia

Highlights:

- A initial study has provided guidelines for developing tools for participating NARS researchers and farmers to monitor and analyze impacts of FPR in systems in which forages play important roles

Purpose: To develop straightforward tools for working with farmers, researchers, and technicians to monitor and assess forage-FPR in order to make appropriate modifications in the researchers' approaches and to develop methodologies and systems which can be adopted over wider areas.

Rationale: CIAT works in Asia with NARS researchers in farmer participatory research on forage systems. Most have no experience with impact monitoring and assessment; and many are new to FPR. Needed are tools and methods which can be comfortably adopted and effectively used by such NARS researchers.

Methods: There are a wealth of methods--both conventional and participatory--for measuring impacts. We have sought to introduce and test a simple selection of survey and participatory methods for NARS researchers and farmers to monitor and assess impacts as projects unfold; and are giving emphasis to farmer technology adaptation through their (farmers') own experiments and to the modification of what researchers have to "offer" farmers given such farmer technology adaptation.

Outputs: The Forage for Smallholders Project (FSP) is currently among projects at the forefront of participatory research in Asia. The project realized a need to measure and monitor impacts, including ex ante, ex post, and, importantly, changes occurring throughout the course of the project. Although the project's biological scientists had easily adopted participatory research methodologies, they had less experience with the sample survey research needed to monitor changes at the family level over time. The challenge is/was to develop straightforward useful tools for use by these national and international project scientists.

Sophisticated economic analyses are not needed, but simple financial, environmental and social analyses at individual household level are essential. These methods will focus on monitoring both the impact on farmers' perceived problems and on other outcomes, particularly in natural resource management, that may not readily emerge from discussions with farmers. It is not only the "average impact" of forages in an area that is important to the individual farmer as it is to a project to assess its impact or that might influence government policy and incentives. The specific needs of farmers vary greatly from individual to individual and so, impact of forage technologies is best monitored at the level of each individual farmer.

Our objective in M'drak, Vietnam, was to develop and test methods and instruments appropriate and useful to the FSP project at its various sites. We developed and tested a baseline survey, which included both farmer interview and farmer participatory diagnosis.

The survey instrument:

a) Elicits key descriptive data at the family level on farm size and land use allocations, present and one-year-ago animal numbers, and animal feeding systems;

b) Includes individual farmer participatory rankings, weightings, and matrix evaluations of different income sources, of production for household consumption, of different labor demands, and of problems associated with animal production; and

c) Asks farmers for information to be able to analyse individual forage/livestock budgets and simple costs and returns to different factors. Categories of information included labor use for cattle production, cash expenses for cattle production, and gross returns. Returns above variable costs and to factors such as labor and cash were calculated.

We also tested group-level farmer participatory calendars, rankings, and matrices to be used as monitoring tools over the project life.

The team had difficulties in conducting the interviews due to lack of experience. With additional practice, interviewers should be able to make the interviews "flow" as a conversation lasting no more than one and a half hours. Interviewers need a good understanding of the questions and an ability to note responses while discussing issues with farmer respondents.

The study at M'Drak also demonstrated that the impact assessment methods need further modification to make them sufficiently focused and straightforward to monitor impact of forages on smallholder farms. Local staff will need to be trained in the use of the methodology.

Impact: NARS researchers are becoming aware of the need for on-going impact measurements and how farmers' evaluations and results of their adaptive research can lead to a need for researchers to modify strategies or expectations. Further development for a monitoring and assessment framework is planned for the coming year through a joint CIAT/ACIAR initiative commencing in February 1999. The goal of this new project is to develop practical impact assessment methods at two FSP sites (Malitbog in Philippines and M'Drak in Vietnam) over a period of 18 months.

Contributors: Sam Fujisaka, Werner Stur, Peter Horne, CIAT; [PK can add others from Asia]

Output 3 Enhanced capacity to promote adoption of productive and sustainable land use practices

3.1 Methods for increasing adoption of technologies developed by FPR

3.1.1 Synthesis of participatory and systems research at CIAT

Results of the workshop at CIAT on participatory and systems research has been edited into book form and is being published by CIAT

Highlights:

- CIAT researchers have contributed to participatory and systems research in Latin America, Asia, and Africa and to the development and evolution of such approaches from on-site characterization through development of ways to facilitate new inter-institutional and cross-stakeholder relationships.

Purpose: The workshop served to analyse, present, and discuss experiences. The book serves to synthesize experiences, reflect upon trends in participatory and systems research, and share results with a wider audience.

Rationale: CIAT researchers in partnerships with farmers, NARS, and NGOs have been on the forefront of participatory and systems research in agriculture--currently both in germplasm improvement and natural resource management. There was a need to analyse individual projects, share results, to examine progress or evolution of concepts and approaches, and to discuss future directions.

Outputs: Scientists working for CIAT in Latin America, Asia, and Africa are increasingly conducting research which combines natural resource management and germplasm improvement. In so doing, scientists are working in inter-disciplinary teams, are helping to develop active research partnerships through networks and consortia in Latin America, Asia and Africa, and have been on the forefront in the continuing development and application of methods such as farmer participatory research (FPR) and geographic information systems (GIS). Researchers were invited to analyse, present, and discuss their work at a workshop held in late 1997 at CIAT headquarters in Cali, Colombia. The workshop and volume based on the workshop papers are intended to provide an opportunity for scientists to share their evolving approaches, findings, successes, failures, impacts, and lessons learned. The tentative book title is "Systems and Farmer Participatory Research: Developments in Natural Resource Management" with Chapters on:

Fujisaka, S. "Introduction: towards a new institutional model of farmer participation in research in natural resource management and germplasm improvement".

Baretto, H. "Targeting specific NRM technologies to agroenvironments: the mucuna-maize rotation on hillsides of northern Honduras"

Fujisaka, S. et al "Land use systems and dynamics in Pucallpa, Peru"

Friesen, D. et al, "Strategic systems research for the Latin American savannas"

Lascano, C. et al, "Developing improved pasture systems for the forest margins"

Ospina, B. et al, "Adaptation of farmer participatory research methods for developing integrated crop management in cassava-based systems in northeast Brazil"

Muller-Samann, K. et al, "Soil conservation strategies that take into account farmer perspectives"

Howeler, R. "Developing sustainable cassava production systems with farmers' involvement in Asia"

Stur, W. and P. Horne, "Towards farmer-participation: developing forage technologies with smallholder farmers in East Kalimantan, Indonesia".

Wortmann, C. et al, "Farmers' independent experimentation on green manure/cover crops: a component of participatory research for improving Ugandan farming systems"

David, S. and Kasozi, "Designing sustainable commercial farmer seed production systems in Africa: case studies from Uganda"

Ashby, J. "Institutional innovation as an entry point for system level technological change"

Fujisaka, S. "Conclusions: participatory & systems research: towards the future"

Impact: Centers such as CIAT started with basic crop improvement research, with new varieties developed largely by Center scientists. NARS scientists now conduct much of today's breeding efforts, although with contributions from the international centers. The chapters of this book span the last decade of further change as agricultural research was faced with the issue of sustainablity--initially the sustainability of production gains, but more recently the protection and sustainability of the agricultural and natural systems themselves. As research turned to more marginal environments such as the hillsides and forest margins and to the needs of resource-poor farmers, the benefits and beneficial forms of farmer participation have become more and more evident. What CIAT refers to as systems research features integration rather than coexistence of crop and NRM research, appropriate targeting of research on problems identified through participatory diagnosis, and new methods of systems characterization. These changes were logical and necessary as research has had to address issues from the local to global scales, for example, from increasing small farmer cassava production at location "x" to decreasing greenhouse gas emissions in the world's forest margins. Research support for international centers has decreased, NARS have strengthened, and power and responsibility are increasingly devolved to local levels. New forms of partnership research have developed and new institutional configurations are needed across levels to better represent the needs and potentials of a wide range of stakeholders.

Contributors: Sam Fujisaka and various authors, CIAT; Annie Jones, independent editing collaboration; CIAT publishing

3.2 Integrated resource and GIS models to better target extension of results

3.2.1 Integrated resource model for targeting research

This has been reported in Section 2.3.5

3.2.2 Cornell Rumen Model adapted for tropical feeds

Adapting a decision tool to overcome nutrition management constraints on dual-purpose cattle in tropical agrosilvopastoral systems

Highlights:

- An evaluation of the Cornell Net Carbohydrate and Protein System model suggests that it will be a useful tool for use in optimizing tropical feeds

Rationale: The Cornell Net Carbohydrate and Protein System (CNCPS) model was developed to better predict the nutrient requirements of cattle and feed utilization by different types of animals with diverse environmental and management conditions and feeds in the United States for temperate conditions. It is a structure that was designed to integrate and apply nutritional knowledge to:

(a) Solve feeding problems and reduce feed cost/unit of production,
(b) Set research priorities,
(c) Design sensitive experiments,
(d) Interpret experimental results,
(e) Teach application of biological principles through knowledge integration, and
(f) Minimize nutrient excretion into the environment per unit of product produced.

The CNCPS simulates the effects of nutrient intake, ruminal fermentation, intestinal digestion, absorption, and metabolism on nutrient utilization and cattle performance. Specific uses of the model are:

(1) To predict the effects of feed composition and quantity on cattle performance,
(2) To predict the effects of digestive and metabolic modifiers on cattle performance,
(3) To evaluate and balance rations for the host animal and rumen bacteria,
(4) To adjust cattle requirements and estimates of performance for environmental conditions, and
(5) To illustrate and predict the effects of gastrointestinal parameters on feed utilization.

Thus, this model is about nutrient requirements and nutrient pool sizes interacting with changing diet composition available to animals.

Ouputs: Federico Holmann visited Cornell University for training in the use of the CNCPS model and developed a collaborative project proposal with colleagues at Cornell for submission to the Systemwide Livestock Program to seek additional funding for the validation and calibration of the model for tropical grazing conditions. Analysis was also made of data from CIAT.

Results from the data obtained in feeding trials at Quilichao, Colombia

Data consisted in several grazing trials on *Brachiaria decumbens* at three stocking rates (2, 3, and 4 AU/ha) with crossbred cows being supplemented with sugarcane and varying levels of *Cratylia argentea.*

Chemical composition included NDF, CP, lignin, DIVMS, and DM for B. decumbens, sugarcane, and *Cratylia* for all trials. However, it was not possible to perform two important analysis that are also required by the model: solubility of protein (solP) and NPN (as % of the soluble protein). Thus, without these values it was not possible to calculate the protein and carbohydrate fractions. Therefore, I utilized values of *B. decumbens* generated by a PhD student at Cornell (Francisco Juarez) for the gulf coast of Mexico. In addition, I used solP and NPN data for *Gliricidia sepium* to emulate *Cratylia* and for sugarcane available in the feed library from Brazil in order to run the model.

Other data from Patricia Avila's thesis included environmental (mean temperature, wind velocity, and relative humidity), and management variables (stage of lactation, body weight, age, breed, milk yield, and level of supplementation).

Table 1 shows chemical data from Quilicaho and Tables 2 and 3 predicted dry matter intake from grazing and supplements consumed, and the actual milk yields (in kg milk/cow/day) vs the milk yields predicted by the CNCPS model.

The CNCPS predicts milk yield from three different sources: allowable milk from metabolizible energy (ME), from metabolizible protein (MP), and from amino acid availability (AA). However, I will discuss the results obtained from the first two sources since no information existed on the amino acid composition of the forages used at Quilichao.

Table 1. Feed Chemical composition for *Brachiaria decumbens*, sugarcane, and *Cratylia argentea* for the different trials at Quilichao

	Brachiara decumbens	**Sugarcane**	***Cratylia argentea***
Medium Stocking Rate (3 AU/ha)			
Dry matter (%)	35.0	30.5	33.5
Crude Protein (%)	4.4	2.1	22.4
Neutral Detergent Fiber (%)	70.4	43.1	66.4
Lignin (%)	3.4	5.3	17.4
TDN (%)	52.0	66.1	48.7
Low & High SR (2 & 4 AU/ha)			
Dry Matter (%)	39.0	27.1	35.5
Crude Protein (%)	3.7	2.1	20.4
Neutral Detergent Fiber (%)	69.0	43.1	63.4
Lignin (%)	3.2	5.3	16.1
TDN (%)	54.0	68.6	50.2

Table 2. Sugarcane and *Cratylia* consumed, and predicted intake of *Brachiaria decumbens* for the different trials at Quilichao.

	Measured Intake		Predicted Intake		
Treatments	**Sugar cane**	***Cratylia argentea***	***Brachiaria decumbens***	**Total**	**DMI (as %BW)**
MSR + Sugarcane	4.43	0	5.04	9.47	2.12
MSR + 75% SC + 25% leg	2.64	1.16	5.81	9.61	2.15
MSR + 50% SC + 50% leg	1.48	2.28	5.83	9.59	2.15
MSR + 25% SC + 75% leg	0.45	4.16	5.03	9.64	2.16
LSR + Sugarcane	2.00	0	7.48	9.48	2.30
LSR + Sugarcane + Legume	2.92	0.62	6.02	9.56	2.32
HSR + Sugarcane	2.00	0	6.96	8.96	2.17
HSR + Sugarcane + Legume	2.92	0.70	5.60	9.22	2.24

Table 3. Actual and predicted milk yield by the CNCPS model for the different trials at Quilichao

	Actual milk yield	**Predicted milk yield**	
Treatments		**ME**	**MP**
Med Stocking Rate + Sugarcane	6.0	4.9	1.4
Med Stocking Rate + 75% SC + 25% leg	6.5	6.5	7.4
Med Stocking Rate + 50% SC + 50% leg	6.4	4.5	5.1
Med Stocking Rate + 25% SC + 75% leg	6.6	1.9	3.1
Low Stocking Rate + Sugarcane	7.9	7.3	6.5
Low Stocking Rate + Sugar + Legume	8.2	8.1	8.1
High Stocking Rate + Sugarcane	6.1	6.4	6.3
High Stocking Rate + Sugar + Legume	7.0	7.5	8.0

As can be observed, the CNCPS model predicted the observed milk yields in both the low and high stocking rate trials, but failed to predict the observed milk yields for the medium stocking rate trials. This under prediction came from both the energy and protein portions, but the bias was larger in predicting the MP (metabolizable protein) allowable milk.

The probable cause of the low MP allowable for milk from the medium stocking rate runs is the indigestible dry matter which is causing low microbial growth due to high levels of NDF from both *Brachiaria decumbens* (69-70%) and *Cratylia argentea* (63-66%). Based on Dr. Alice Pell's comments, the high lignin content found in *Cratylia* could be the reason why the CNCPS model underpredicted observed milk yield. Based on her experience, lignin content of *Cratylia* leaves and stems should have been around 7-8% but not the 16-17% reported in the lab analysis. Thus, she argues that secondary compounds may be confounded with lignin, masking the overall effect of diet.

Based on the runs from the Quilichao data, several hypotheses can be drawn:

a. Cows were eating (selecting) *B. decumbens* with a higher CP content than actual lab results
b. Digestion rates for carbhodydrate and protein fractions used were wrong, or
c. Information about the pool sizes is inadequate

Table 5 contains the level of urea nitrogen found in milk (MUN) as well as the level predicted by the model. The reason for such a difference could be due to the soluble protein level in the diet, which was higher than the CNCPS prediction.

At present, because of the slow digestion rates associated with the B_3 protein fraction, the CNCPS predicts that the NDIP makes little contribution to the rumen N pool. However, Juarez et al. (1998) reported that tropical grasses' NDIP contribution to rumen N balance may be higher than the CNCPS predicts. Thus, hypotheses (b) and (c) are probably valid.

Increasing the crude protein content in the diet does not increase the MP allowable for milk in the same proportion because the diet is deficient in energy from high levels of NDF (in both *B. decumbens* and *Cratylia*). However, the model was very sensitive when the degradation rate of fiber (B2 carbohydrate fraction) was changed.

Table 5. Level of urea nitrogen found in milk (MUN) and predicted MUN levels by the CNCPS model for the various trials.

Treatments	Observed MUN	Predicted MUN
Med Stocking Rate + Sugarcane	10	3
Med Stocking Rate + 75% SC + 25% leg	11	3
Med Stocking Rate + 50% SC + 50% leg	14	7
Med Stocking Rate + 25% SC + 75% leg	17	11
Low Stocking Rate + Sugarcane	8.0	0
Low Stocking Rate + Sugar + Legume	12.0	0
High Stocking Rate + Sugarcane	6.4	0
High Stocking Rate + Sugar + Legume	12.3	1

To better understand the reason why the model is not adequately predicting the medium stocking rate trials at Quilichao, we would need the following additional information:

i. Chemical analysis of feed refused (i.e. sugarcane + *Cratylia*) during trials to better predict nutrient pool sizes consumed

ii. Body weights at weekly intervals for all trials and treatments to adjust for average tissue mobilized or repleted, especially for Experiment 5 where cows apparently did not gain weight (it could be that T-1 and T-2 trials cows lost weight but during T-3 and T-4 trials cows gained weight, yielding average weight change of zero across the experiment)

iii. Biomass availability of *B. decumbens* after grazing (it was only measured at the beginning of grazing) to get estimate of amount consumption.

iv. It is important to take samples from forage during grazing time simulating what the cow is eating by observing the cow to get estimates of composition of consumption every 2 weeks.

v. Weekly milk yield throughout the various trials

vi. Composite milk composition every two weeks

vii. Body condition score every two weeks

Impact: Tropileche can benefit from a close collaboration with Cornell by developing a tropical feed library and calibrating the model for tropical grazing conditions. Potential benefits of the CNCPS for Tropileche include:

i. This tool may help our efforts to identify feeding alternatives with potential to increase productivity by identifying limiting nutritional factors (i.e.dietary and farm level "best bets")

ii. It could be the basis for systemwide evaluation of whole farm nutrient management and farm-level "best bet" portfolios of practices,

iii. It compliments the CIAT farm-level model developed by Ruben Dario Estrada for ex-ante and ex-post analysis at the farm and watershed levels,

iv. It increases Tropileche's menu of options to support and complement the activities of NARS partners and producer's organizations which could finance forage research, and

v. Give a high return on investment because Tropileche will invest marginally to complement more than one decade of research to develop the CNCPS at its current state.

Collaborative Project Proposal: An important objective was to develop with colleagues at Cornell a concept note to establish a collaborative research agenda to complement the efforts of Tropileche and Cornell in LAC. This concept note is being submitted to the SLP for consideration.

Contributors: Federico Holmann (CIAT-ILRI, Colombia) and Robert Blake, Cornell University)

3.2.3 Adaptation of forages integrated with GIS

a) Targeting of forage germplasm through a Geographical Information Systems

Highlights

- Established an interdisciplinary working group to develop an integrated database of forage adaptation linked to the CIAT GIS database.

Purpose: To develop a GIS based system for the targeting of forage germplasm for multiple uses through integration of agro-ecological, economic and social information.

Rationale: The approach is based on the following assumptions:

i. A wealth of information on the agro-ecological adaptation of forage germplasm is available in CIAT-held databases. However, the access to and hence utilisation of this information could be improved.

ii. In previous evaluations and documentation of forage germplasm adaptation, the agro-ecological information is separated from the socio-economic factors influencing forage germplasm adaptation.

Based on these assumptions, the targeting of germplasm intends to enhance utilization of existing information and, in future, to integrate environmental and socio-economic adaptation of forage germplasm for multiple uses. It is anticipated, that this approach will allow a more accurate and client-oriented prediction of possible entry points of forage germplasm.

Methods: The working group agreed to follow step-wise procedure for system development:

i. Inclusion of the existing RIEPT (Red International de Evaluación de Pastos Tropicales) database – to start with the regional trials A+B – into the GIS –system to describe agro-ecological adaptation of forage germplasm in Latin America
ii. Inclusion of supplementary information agro-ecological adaptation as existing in CIAT-held databases
iii. Inclusion of experiences of (former) CIAT Scientists and collaborators
iv. Incorporation of socio-economic information based on existing results, from adoption studies and from on-going work, first on a regional level, Central America. It is assumed that in the design of future regional experiments enhanced attention will be given to the socio-economic adaptation of forage germplasm including the utilization of farmer-participatory technologies in on-farm evaluation of forage germplasm

The GIS-program to be utilized is currently being identified, but discussions center around the use of MAPINFO or PLANTGRO.

Outputs: In 1998 the workgroup agreed on the step-wise procedure as described above. Indicators of forage germplasm adaptation retrieved from RIEPT regional trials A+B have been identified and the data is currently organized and supplied to statistical analysis for inclusion into the GIS system. During several consultations, it was agreed that the current system of ecosystem classification utilized in the RIEPT, is not suitable for the development of the GIS system and work has been initiated for a different description of the ecosystems based on existing data base information.

Impact: The systems being developed will increase availability of information on the agro-ecological and socio-economic adaptation of forage germplasm for multiple uses, improve targeting of forage germplasm to farmer's needs, and enhance dissemination and adoption.

Contributors (to be amplified according to progress): Glen Graham Hyman, Luz Amira Clavijo, Alexander Gladkov (PE-4), Luis-Horacio Franco (PE-5), Manuel Arturo Franco, Gerardo Ramirez, Bellisario Hincapié, Carlos Lascano, Michael Peters (IP-5)

b) A GIS database of livestock in Latin America

Highlights

- Linkage of livestock inventory data from LAC to the CIAT GIS database

Rationale: Information on the livestock inventory in LAC may facilitate the selection of new sites with potential for adoption of improved germplasm.

Methods: Locate the herd inventory for each country in LAC at the state level (~375 states in LAC), and then sub-divide them by animal production system (beef, dairy, and dual-purpose). The breakdown of the cattle population figure into production system for each state will be estimated based on contacts with LAC cattle systems experts. Since this relies somewhat on the good will of outside experts, we can only guarantee that we will attempt to make a complete inventory.

The GIS laboratory has some data from agricultural census and annual reports for some countries, but not all the available data. Detailed activities to collect information to construct the GIS map for livestock population are:

i. Conduct Web or library search for the information needed
ii. Find census volumes and other information on the spatial distribution of animal production systems in Latin America (FAO, CIAT, etc)
iii. Error checking
iv. Positioning of data with respect to land cover. This will involve using the GRID land cover data sets (based on AVHRR) to locate cattle populations within administrative units.

Output: The development of this map has commenced. A draft is expected to be completed by the end of 1998.

Impact: This database will be useful for many purposes in planning livestock-related issues in addition to linking it with the forage database.

Collaborators: Glenn Hyman (PE-4); Federico Holmann (PE-5)

3.3 Persons trained and materials developed on participatory technology development and diffusion

3.3.1 Manuals on participatory research

Highlights

- a training manual for in-country courses on "Developing forage technologies with smallholder farmers" was produced in English, Indonesian, Lao and Vietnamese

Purpose: To provide a basis for in-country courses on participatory development of technologies.

Rationale: Participatory technology development is a decentralized approach conducted by local development workers. It is these development workers who need training in participatory approaches as well as in the technical aspects of relevant technologies. Also, in-country training courses in Southeast Asia have to be conducted in local languages. Sustained impact of training can only be achieved when countries have developed a capacity to train a large number of their own staff. This manual was designed as a basis for such in-country training courses.

Outputs: The FSP held a workshop with key partners from national organizations to decide on the form and content of the training manual. A draft was produced in English and tested in an in-country course in the Philippines. It was then revised and translated into Indonesia, Lao and Vietnamese. Several training courses have since been held using the manual as the basis for the course.

Impact: The manual has been used by other projects in addition to the FSP.

Contributors: Werner Stür and Francisco Gabunada (CIAT, FSP Philippines), Peter Horne and Phonepaseuth Phengsavanh (CSIRO, FSP Laos), Maimunah Tuhulele (DGLS, Indonesia), Ed Magboo (PCARRD, Philippines), Viengsavanh Phimphachanhvongsod (DLF, Laos), Le Hoa Binh (NIAH, Vietnam), Chaisang Phaikaew (DLD, Thailand), Liu Guodao (PR China), and Wong Choi Chee (MARDI, Malaysia).

3.3.2 Increased capacity in FPR

Development and conduct of courses on farmer participatory research in Southeast Asia

Highlights:

- Courses on farmer participatory research have been adapted for researchers working in Asia on forages and forage systems and on cassava germplasm, management, and natural resource management systems.
- Five in-country training courses on "Developing forage technologies with farmers" were held in Vietnam, Laos, and Indonesia (two courses); a further two courses are planned for the Philippines before the end of 1998
- Provided practical training for three development workers from the Philippines, Laos and Indonesia at FSP sites in Indonesia
- 31 and 27 researchers and extension staff associated with cassava R & D were trained in FPR methodologies in Indonesia and China, respectively.

Purpose: To train researchers and extension staff in FPR approaches and increase their sensitivity to the needs and perspectives of farmers through courses aimed to provide both tools and enthusiasm.

Rationale: CIAT has adopted a farmer participatory approach to extending germplasm and developing new technologies for cassava and forages in Asia. As FPR approaches are new to most of the national partners with whom we work, it is essential to train researchers and extension staff in FPR methodologies so that they feel confident in the use of a participatory approach. In addition, institute administrators should be informed about this new approach, so that in the future they will understand and support the activities of the project, and may eventually use a more participatory approach in their own institutions. The 'training of trainers' courses addresses the concerns of the supervisors through inviting them to the first day of a course. The courses aim to provide equal doses of: a) basic and useful tools for working with farmers and b) enthusiasm on the part of course participants' resulting from successful and real application of tools in the field. The enthusiasm, in turn, is meant to spark researchers and institutions to get started on FPR.

Methods:

Forage for Smallholders Project. An initial course was held for participants from 7 countries and an output was the development of a training manual for in-country courses (Section 3.3.1). The approach and manual were modified as experience was obtained with in-country courses.

Improved Management for Cassava-based Systems. A similar procedure was followed with an introduction to FPR to all country coordinators. Since then a series of in-country courses have been held. From these experiences we can now offer a short 8-10 day course, which combines talks on concepts, presentations of participatory research projects, classroom participatory exercises, and field exercises with farmers. The manual developed by the FSP group is used as a resource material in the local language.

The course provides tools and exercises for participatory diagnosis, rapid rural appraisal, participatory evaluation, participatory planning, and participatory technology development. Tools included mapping, calendars, weightings and rankings, and matrix evaluations. Participants worked as teams with each tool presented in a novel or fun fashion in the classroom; and then in the field with project farmers. Analysis of results and feedback on processes followed each session (including through use of cartoons made after field visits and depicting course participants and farmers). Additional sessions cover farmer participatory experimental techniques and agronomy trials. Participants finish the course with the development--by teams--of concept notes for future FPR projects or project components.

Outputs:

Forage for Smallholders Project

Training courses on 'Developing Forage Technologies with Farmers' were held at Hue, Vietnam from 16-22 February (20 participants), Nam Suang, Lao PDR from 1-12 April (21 participants), Samarinda, Indonesia from 1-10 May 1998 (15 participants) and Aceh, Indonesia (20 participants). These courses were organised and taught by FSP partners who were trained in a regional TOT course in 1996, and are actively working with farmers in the FSP. Twelve development workers from Luang Phabang and Xieng Khouang provinces, Lao PDR participated in a course on 'Evaluating Forages with Farmers' in Luang Phabang from 26-28 January 1998. The hands-on course was designed for local collaborators such as district livestock officers and extension personnel to help them work more effectively with farmers and to obtain feedback from farmers about their experiences. The course clearly achieved its objective and we are planning to hold further courses in other areas.

On-site training in Indonesia was provided for Mr. Willie Nacalaban (Philippines), Mr. Soulivanh Novaha (Lao PDR) and Mr. Ghozali (Indonesia) from 22 March to 8 April 1998. The trainees were attached to FSP sites in Makroman and Sepaku (East Kalimantan), and Marenu and Pulau Gambar (North Sumatra) where they worked with local partners at these sites. They assisted with participatory diagnoses, farm visits and farmer evaluations. Visiting and working at other sites provides a good opportunity for our partners to learn from each other and to share experiences and ideas.

Improved Management for Cassava-based Systems

During 1997, 28 Thai and 27 Vietnamese researchers and extentionists were trained in FPR methodologies, while in 1998 another 31 Indonesians and 27 Chinese were similarly trained. While many of these people had no previous knowledge of, or experience with, the FPR approach, and many were initially doubtful of its usefulness, most people participated in the course with great enthusiasm and left with a better understanding of the approach and with greater sensitivity for farmers' needs and perspectives. Many also expressed their desire to use this approach in their future work.

Impact: Increased capacity of researchers and extension staff to apply FPR approaches. External reviews of both the forage and cassava projects applauded the FPR approach. In the case of forages, there has been a breakthrough in the introduction of new germplasm to farmers in the region. In the case of cassava, improved varieties were an attraction for farmers to adapt new methods of soil management. Both reviews pointed out the need to reinforce the FPR approach both for key individuals and in the national organizations.

Contributors:

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3.4 Results communicated

3.4.1 Network and newsletters and databases

a) Tropileche

Highlights

- A readily accessible database on research on dual-purpose cattle systems is available through the internet in addition to publishing two newsletters

Outputs:

Newsletter

A newsletter is produced in March and October to inform colleagues in Latin America about the activities of the Tropileche Consortium. Items include on-going research trials, research results being produced at the different benchmark sites, and any other news items offered by our partners. These newsletters are freely available on the Tropileche HomePage on the Internet.

Database on research on dual-purpose cattle systems

The database includes results generated since 1960 in tropical Latin America on dual-purpose cattle. Themes include nutrition and feeding, forages (grasses and legumes), genetic improvement and reproduction, animal health, economics, and extension, transfer, and adoption of technology.

There are more than 1,900 references and about 100 additional ones are added each month. All references include basic descriptors and 71% of them include an abstract. This database was developed in micro CD/ISIS and follows the normative of the information system AGRIS-CARIS from FAO. This database is available through the Tropileche HomePage on the Internet or can be supplied on diskette. The average number of users consulting the database is about 3.8 per day.

Tropileche on Internet

The Tropileche Consortia has developed its own HomePage on the Web, which contains the newsletters that have been produced as well as the database containing research results generated in tropical Latin America. This HomePage can be accesed through the CIAT HomePage (http://www.ciat.cgiar.org/tropileche/start.htm) either through the "Soil and System" icon or through the "Information and Documentation Unit". The HomePage contains a list of researchers and contact addresses from LAC with interests in research on dual-purpose cattle in LAC. Thus, researchers can access Tropileche from anywhere in the world and consult the database, solicit information, and communicate and interact with other colleagues.

Impact: Outputs and activities of the Tropileche project are well documented.

Contributors: Federico Holmann and Anderson Medina, CIAT-ILRI, Colombia

b) Forage for Smallholders Project

Highlights

- published two issues of the SEAFRAD newsletter

Outputs: SEAFRAD, the Southeast Asian Forages and Feed Resources Research and Development Network is a network of researchers and development workers who are working with forages. The secretariat of SEAFRAD and editorship of the SEAFRAD newsletter rotate between member countries on an annual basis. In 1997, it was based in the Livestock Research Center, MARDI, Malaysia; and it moved to the Directorate General of Livestock Services, Indonesia in 1998. In 1998, two issues of the SEAFRAD newsletter were produced and distributed in January and September. A further issue is in preparation by the current editor, Mrs. Maimunah Tuhulele, for distribution in December 1998.

Impact: SEAFRAD Newsletters published as planned

3.4 Publications

See following section of the report

Publications 1998

Journal papers

Argel, P. J. and Lascano, C.. 1998. Cratylia argentea: Una nueva leguminosa arbustiva para suelos ácidos en zonas subhúmedas tropicales. Pasturas Tropicales 20:37-43

Chee, Y.K., Chong, D.T., Ahmad Faiz, Tajuddin Ismail, Stür, W.W. and Shelton, H.M. (1998). Forage resources in rubber plantations in Central Malaysia. Malaysian Journal of Animal Science 3, 28-36.

Duarte, Oscar., Pulido, José., Silva, Jorge and Holmann, Federico. 1998. Analysis of the current situation and technological alternatives of agricultural production systems in the Ceasar's Valley Watershed of Colombia". Revista de Corpoica (In press)

Fujisaka, S. 1997. Sense and nonsense: contour hedgerows for soil erosion control. Agroforestry Forum 8:4:8-11.

Fujisaka, S. and D. White. (1998) Pasture or permanent crops after slash and burn cultivation? Land use choice in three Amazon forest colonist. Agroforestry Systems (In press)

Fujisaka, S., Escobar and Veneklaas. 1998. Plant community diversity relative to human land use in an Amazon forest colony. Biodiversity and Conservation 7:41-57.

Fujisaka, S, C. Castilla, G. Escobar, V. Rodrigues, E. Veneklaas, R. Thomas and M. Fisher. 1998. The effects of forest conversion to annual crops and pastures: estimates of carbon emissions and plant species loss in a Brazilian Amazon colony. Agriculture, Ecosystem and Environment 69:17-26.

Gijsman A.J. and Sanz J.I. 1998 Soil Organic Matter Protection in a Volcanic-Ash Soil under Fallowing or Cultivation with Applied Chicken Manure. European Journal of Soil Science *49:427-436.*

Giraldo L.M., Lizcano L.J., Gijsman A.J., Rivera B., Franco L.H. 1998 Adaptación del modelo DSSAT para simular la producción del *Brachiaria decumbens.* (translated: Adaptation of the DSSAT model for simulating the production of *Brachiaria decumbens*). *Pasturas Tropicales (in print).*

Guodao, L., Phaikaew, C and Stür, W.W. 1997. Status of *Stylosanthes* development in other countries. II. *Stylosanthes* development and utilisation in China and south-east Asia. Tropical Grasslands 31, Tropical Grasslands 31:460-466.

Hacker, J.B., Phimphachanhvongsod, V., Novaha, S., Kordnavong, P., Veldkamp, J. and Simon, B. K. 1997. A guide to the grasses of Xieng Khouang province, Lao PDR, and some notes on ecology of grazing lands in the province. Genetic Resources Communication (translated into Lao)

Hess H.D. y Lascano C.E. 1997. Comportamiento del consumo de forraje por novillos en pasturas de gramínea sola y asociada con una leguminosa. Pasturas Tropicales 19(No.2): 12-20

Holmann, F. 1998. Ex-ante analysis of new forage alternatives in dual-purpose farms in Peru and Nicaragua. Pasturas Tropicales. (In press)

Horne P.M. and Stür, W.W. 1997. Current and future opportunities for improved forages in south-east Asia. Tropical Grasslands, Special Issue 2, 117-121 (in press).

Müller-Sämann, K. M. 1997 y Castillo, J. A. 1997. Labranza mínima, una tecnología para las laderas de Colombia? CONSERVANDO, Vol. 1(1): 4p. – Continuado en Vol. 1(2):3p.

Ng, K.F., Stür, W.W. and Shelton, H.M. 1997. New forage species for integration of sheep in rubber plantations. J. Agric. Sci. (Camb.) 128, 347-356.

Pachico, D, J Ashby, A Farrow, S Fujisaka, N Johnson, and M Winograd. 1998. Case study and empirical evidence for assessing natural resource management research: the experience of CIAT. Paper, Workshop on Assessing Impacts in natural Resource Managment Research, 27-29 April 1998, ICRAF House, Nairobi, Kenya.

Pezo, Danilo. Holmann, Federico and Arze José. 1998. Bioeconomic evaluation of a dairy production system based on the intensive use of fertilizd grasses in the humid tropics of Costa Rica. Agronomía Costarricense.(In press)

Putthacharoen, S., R.H. Howeler, S. Jantawat and V. Vichukit. 1998. Nutrient uptake and soil Erosion losses in cassava and six other crops in Psamment in eastern Thailand. Field Crops Research 56: 113-126.

Rivas, Libardo and Holmann, Federico. 1998. In press. Early adoption of Arachis pintoi in the Humid Tropics: The case of Dual Purpose Production Systems in Caqueta, Colombia. Pasturas Tropicales. (In press)

Workshop and conference papers

Abdullah, A., Wong, C.C. and Mohd Yusof, C.E. 1998. Experiences with on-farm forage evaluation on the east coast of Peninsular Malaysia. In: W.W. Stur, J.A. Owen, P.C.Kerridge, P.M. Horne and J.B. Hacker (eds). Proceedings of the Second Regional Meeting of the Forages for Smallholders Project. Hainan, P.R. China, 19-24 January 1997. CIAT Working Document No 173, Los BañosPhilippines, 81-86

Binh, L.H. 1998. The FSP in Vietnam-Proceedings and plans. In: W.W. Stur, J.A. Owen, P.C. Kerridge, P.M. Horne and J.B. Hacker (eds). Proceedings of the Second Regional Meeting of the Forages for Smallholders Project. Hainan, P.R. China, 19-24 January 1997. CIAT Working Document No 173, Los Baños, Philippines, 9-14

Dorji, S. 1998. Mechanisms of fodder seed supply systems in Buthan. Australia's experience with tropical forage seed supply systems. In: Horne, P.M., Phaikaew, C. and Stur W.W. (eds). Forage Seed Supply Systems: Preceedings of an International Workshop. Khon Kaen, Thailand 31 October to 1 November 1996. CIAT Working Document No 175, Los Baños, Philippines. (in print)

Evangelio, F.A. and J.C. Ladera. 1998. Recent progress in cassava agronomy research in the Philippines. In: R.H. Howeler (Ed.). Cassava Breeding, Agronomy and Farmer Participatory Research in Asia. Proc. 5th Regional Workshop, held in Danzhou, Hinan, China. Nov 3-8, 1996. pp. 331-339.

Ferguson, J.E. (1998). Experiences of forages seed systems in Latin America. In: Horne, P.M., Phaikaew, C. and Stur, W.W. (eds). Forage Seed Supply Systems: Proceedings of an Internatioal Workshop. Khon Kaen, Thailand, 31 October to 1 November 1996. CIAT Working Document No 175, Los Baños, Philippines. (in print)

Fujisaka, Sam. 1998. Challenges facing soil science: a view from the outside. Opening Session of the 16Th World Congres of Soil Science ("The Aims of Soil Science, Challenges to be Met by Soil Science, and the Services Soil Science Can Render"). 20 August 1998, Montepellier, France.

Gabunada, F., Balbarino, E. and Obusa, A. 1998. Farmer participatory research in forage in Matalom, Leyte. In: W.W. Stur, J.A. Owen, P.C. Kerridge, P.M. Horne and J.B. Hacker (eds). Proceedings of the Second Regional Meeting of the Forages for Smallholders Project. Hainan, P.R. China, 19-24 January 1997. CIAT Working Document No 173, Los Baños, Philippines, 59-79.

Gabunada, F. and Stur W.W. Agronomic evaluation of the leucaen foundation collection on a fertile soil in the humid tropics in the Philippines. In: Proceedings of an international workshop 'leucaena-Adaptation, Quality and Farming Systems' Hanoi, Vietnam, 9-14 February 1998. (In press).

Gundaya, E. and F.A. Evangelio. 1998. Farmer's participation in cassava technology transfer in the Philippines. In: R.H. Howeler (Ed.). Cassava Breeding, Agronomy and Farmer Participatory Research in Asia. Proc. 5th Regional Workshop, held in Danzhou, Hainan, China, No 3-8, 1996. pp. 482-496.

Guodao, L., Changjun, B. and Huang Huide. 1998. Forage seed supply systems in Hainan, P.R. China. In: Horne, P.M., Phaikaew, C. and Stur, W.W. (eds). Forage Seed Supply Systems: Proceedings of an international workshop. Khon Kaen, Thailand, 31 October to 1 November 1996. CIAT Working Document 175, Los Baños, Philippines. (in print)

Guodao, L., Changjun, B., Changjun J. and Jiashao W. (1998). The FSP activities in China. In: W.W. Stur, J.A. Owen, P.C. Kerridge, P.M. Horne and J.B. Hacker (eds). Proceedings of the Second Regional Meeting of the Forages for Smallholders Project. Hainan, P.R. China, 19-24 January 1997 CIAT Working Document No 173, Los Baños, Philippines, 3-8.

Hopkinson, J.M. (1998). Australia's experience with tropical forage seed supply systems. In: Horne, P.M., Phaikaew, C. and Stür, W.W. (eds.). Forage Seed Supply Systems: Proceedings of an International Workshop held in Khon Kaen, Thailand, 31 October to 1 November 1996. CIAT Working Document Number 175, Los Banos, Philippines. (in print).

Horne, P.M., Phaikaew, C. and Stur W.W. (eds) 1998. Forage Seed Supply Systems: Proceedings of an International Workshop. Khon Kaen, Thailand, 31 October to 1 November 1996. CIAT Working Document No 175, Los Baños, Philippines.

Howeler, R.H. 1998a. Cassava Agronomy Research in Asia. - An Overview 1993-1996. In: R.H. Howeler (Ed.). Cassava Breeding, Agronomy and Farmer Participatory Research in Asia. Proc. 5th Regional Workshop, held in Danzhou, Hainan, China. Nov.3-8, 1996 pp. 335-375.

Howeler, R.H. 1998b. Cassava production practices - Can they maintain soil productivity? In: Proc. Intern. Sympj. on Cassava, Strch and Starch Derivatives, held in Nanning, Guangxi, China. Nov 11-15, 1996. (in press)

Howeler, R.H. 1998c. Developing sustainable cassava production systems with farmer's involvement in Asia. In: Proc. CIAT's Internal Workshop on "CIAT's Experience with Systems Research and its Future Direction", held at CIAT, Cali, Colombia, Dec 1-2, 1997. (in press)

Howeler R.H. and G. Henry. 1998. Farmer Participatory research for cassava technology transfer in Asia.- Constraints and opportunities. In: R.H. Howeler (Ed.). Cassava Breeding, Agronomy and Farmer Participatory Research in Asia. Proc. 5th Regional Workshop, held in Danzhou, Hainan, China. Nov 3-8, 1996, pp. 497-514.

Howeler, R.H., Horne P.M. and Stur, W.W. 1998. CIAT projects on Natural Resources Management in Asia with special reference to the Red River Basin of Vietnam. 1998. Proceedings of a workshop for the Red River Basis . Hanoi, Vietnam, 6-9 October 1997. IRRI Los Baños, Philippines.(In press).

Howeler, R.H., Nguyen The Dang and W. Vongkasem. 1998b. Farmer participatory selection of Vetiver grass as the most effective way to control erosion in cassava-based cropping systems in Vietnam and Thailand. In: Proc. International Conference on Vetiver, held in Chiang Rai, Thailand. Feb 4-8, 1996. (in press)

Howeler, R.H, Nguyen The Dang and W. Vongkasem. 1997. Farmer participatory selection of vetiver grass as the most effective way to control erosion in cassava-based cropping systems in Vietnam and Thailand. *In*: Proc. Intern. Conference on Vetiver, held Feb 4-8, 1996 in Chiang Rai, Thailand (in press).

Ibrahim, T. (1998). Participatory research on forages with smallholder farmers in North Sumatra, Indonesia. In: W.W. Stür, J.A. Owen, P.C. Kerridge, P.M. Horne and J.B. Hacker (eds). Proceedings of the Second Regional Meeting of the Forages for Smallholders Project, held at the Chinese Academy of Tropical Agricultural Science, Danzhou, Hainan, P.R. China, 19-24 January 1997. CIAT Working Document No. 173, Los Baños, Philippines, 27-33.

Khanh, Truong Tan and Truong Hung Tien Adaptation of Leucaena to the central highlands of Vietnam. In: Proceedings of an international workshop ' Leucaena – Adaptation, Quality and Farming Systems' held in Hanoi, Vietnam, 9-14 February 1998. ACIAR Proceedings, Canberra, Australia. (In press).

Krishnan, K. (1998). The Kerala experience with forage seed production and supply system. In: Horne, P.M., Phaikaew, C. and Stür, W.W. (eds.). Forage Seed Supply Systems: Proceedings of an International Workshop held in Khon Kaen, Thailand, 31 October to 1 November 1996. CIAT Working Document Number 175, Los Banos, Philippines. (in print).

Lascano, C.E., W. Stur and P. Horne. 1998. Small farm production systems for rumiant animals in tropical regions. In: Proceedings of the 8Th World Conference on Animal Production. Symposium Series 1, Seoul, Korea, p. 377-391.

Magboo, E., Gabunada, F. and Faylon, P.S. (1998). Collaborative forage R & D program in the Philippines – the Forages for Smallholders Project. In: W.W. Stür, J.A. Owen, P.C. Kerridge, P.M. Horne and J.B. Hacker (eds). Proceedings of the Second Regional Meeting of the Forages for Smallholders Project, held at the Chinese Academy of Tropical Agricultural Science, Danzhou, Hainan, P.R. China, 19-24 January 1997. CIAT Working Document No. 173, Los Baños, Philippines, 35-45.

Müller-Sämann, K.M., J.Restrepo, D. Leihner and Rafael Posada 1998. CIAT–NGO partnership in soil and water conservation, - the case of the BMZ funded research project on soil degradation and crop productivity research and FIDAR, the Foundation for Research and Development in Agriculture. Paper presented at the International Workshop on Research Partnerships, IIRR, Silang, Philippines, Oct. 4-10, 1998.

Mullen, B.F., Gabunada, F., Napompeth, B., Shelton, H.M., Stür, W.W. and Ramirez, L. 1998. Psyllid resistance in Leucaena. Proceedings of an international workshop ' Leucaena – Adaptation, Quality and Farming Systems' held in Hanoi, Vietnam, 914 February 1998. ACIAR Proceedings, Canberra, Australia. (in press).

Nguyen Huu Hy, Pham Van Bien, Nguyen The Dang and Thai Phien. 1998. Recent progress in cassava agronomy research in Vietnam. In: R.H. Howeler (Ed.). Cassava Breeding, Agronomy and Farmer Participatory Research in Asia. Proc. 5th Regional Workshop, held in Danzhou, Hainan, China. Nov 3-8. 1996. pp. 235-256.

Nguyen Huu Hy, Pham Van Bien, Nguyen The Dang and Thai Phien. 1998. Recent progress in cassava agronomy research in Vietnam. In: R.H. Howeler (Ed.). Cassava Breeding, Agronomy and Farmer Participatory Research in Asia. Proc. 5th Regional Workshop, held in Danzhou, Hainan, China. Nov 3-8. 1996. pp. 235-256.

Phaikaew, C. and Hare, M. (1998). Thailand's experience with forage seed supply systems. In: Horne, P.M., Phaikaew, C. and Stür, W.W. (eds.). Forage Seed Supply Systems: Proceedings of an International Workshop held in Khon Kaen, Thailand, 31 October to 1 November 1996. CIAT Working Document Number 175, Los Banos, Philippines. (in print).

Phaikaew, C., Klum-em, K. and Nakamanee, G. (1998). Forages for Smallholders Project in Thailand. In: W.W. Stür, J.A. Owen, P.C. Kerridge, P.M. Horne and J.B. Hacker (eds). Proceedings of the Second Regional Meeting of the Forages for Smallholders Project, held at the Chinese Academy of Tropical Agricultural Science, Danzhou, Hainan, P.R. China, 19-24 January 1997. CIAT Working Document No. 173, Los Baños, Philippines, 53-57.

Phimphachanhvongsod, V. (1998). The FSP in Lao PDR – progress and plans. In: W.W. Stür, J.A. Owen, P.C. Kerridge, P.M. Horne and J.B. Hacker (eds). Proceedings of the Second Regional Meeting of the Forages for Smallholders Project, held at the Chinese Academy of Tropical Agricultural Science, Danzhou, Hainan, P.R. China, 19-24 January 1997. CIAT Working Document No. 173, Los Baños, Philippines, 47-52.

Stür, W.W. and Horne, P.M. 1998. Towards farmer participation – Developing forage technologies with smallholder farmers in East Kalimantan, Indonesia. Proceedings of a workshop 'CIAT's Experience with Systems Research and Future Directions' held at CIAT, 1-2 December 1997. CIAT, Cali, Colombia. (In press).

Thai Phien, Tran Minh Tien, Tran Quang Thong, Nguyen Tu Siem and Tran Duc Toan. 1998. Notes from the models of cassava cultivation on sloping land in Phuong Linh site, Thanh Ba, Phu Tho province. In: Thai Phien and Nguyen Tu Siem (Eds). Sustainable Farming on Sloping Lands in Vietnam (Research Results 1990-1997) pp. 140-148. (in Vietnamese)

Tongglum, A.,V. Pornprompprathan, K. Paisarncharoen, C. Wongwitchai, C. Sittibusaya, S. Jantawat, T. Nual-on and R.H. Howeler. 1998. Recent progress in cassava agronomy research in

Thailand. In: R.H. Howeler (Ed.). Cassava Breeding, Agronomy and Farmer Participatory Research in Asia. Proc. 5th Regional Workshop, held in Danzhou, Hainan, China. Nov 3-8, 1996. pp. 211-234

Tuhulele, M. (1998). Progress report on the FSP in Indonesia. In: W.W. Stür, J.A. Owen, P.C. Kerridge, P.M. Horne and J.B. Hacker (eds). Proceedings of the Second Regional Meeting of the Forages for Smallholders Project, held at the Chinese Academy of Tropical Agricultural Science, Danzhou, Hainan, P.R. China, 19-24 January 1997. CIAT Working Document No. 173, Los Baños, Philippines, 15-25.

Turton, C. and Baumann, P. (1998). Beyond the formal sector: Fodder seed networks in India. In: Horne, P.M., Phaikaew, C. and Stür, W.W. (eds.). Forage Seed Supply Systems: Proceedings of an International Workshop held in Khon Kaen, Thailand, 31 October to 1 November 1996. CIAT Working Document Number 175, Los Banos, Philippines. (in print).

Utomo, W.H., Suyamto, H. Santoso and A. Sinaga. 1998. Farmer participatory research in soil Management in Indonesia. In: R.H. Howeler (Ed.). Cassava Breeding, Agronomy and Farmer Participatory Research in Asia. Proc. 5th Regional Workshop, held in Danzhou, Hainan, China. Nov 3-8, 1996, pp 471-481.

Vongkasem, V., K. Klakhaeng, S. Hemvijit, A. Tongglum, S. Katong and D. Suparhan. 1998. Farmer participatory research in soil management and varietal selection in Thailand. In: R.H. Howeler (Ed.). Cassava Breeding Agronomy and Farmer Participatory Research in Asia. Proc. 5th Regional Workshop, held in Danzhou, Hainan, China. Nov 3-8, 1996, pp. 412-437.

Wargiono, J., Kushartoyo, Suyamto H. and B Guritno. 1998. Recent progress in cassava agronomy research in Indonesia. In: R.H. Howeler (Ed.). Cassava Breeding, Agronomy and Farmer Participatory Research in Asia. Proc. 5th Regional Workshop, held in Danzhou, Hainan, China. Nov 3-8, 1996. pp. 307-330.

Xiaoliang, L. (1998). The use of improved grasses and legumes in Guandong. In: W.W. Stür, J.A. Owen, P.C. Kerridge, P.M. Horne and J.B. Hacker (eds). Proceedings of the Second Regional Meeting of the Forages for Smallholders Project, held at the Chinese Academy of Tropical Agricultural Science, Danzhou, Hainan, P.R. China, 19-24 January 1997. CIAT Working Document No. 173, Los Baños, Philippines, 91.

Zhang Weite, Lin Xiong, Li Kaimian and Huang Jie. 1998. Farmer participatory research in cassava soil management and varietal dissemination in China. In: R.H. Howeler (Ed.). Cassava Breeding, Agronomy and Farmer Participatory Research in Asia. Proc. 5th Regional Workshop, held in Danzhou, Hainan, China. Nov 3-8, 1996. pp. 389-411.

Zhiping, Q, Sumei, T and Caixang, H. (1998). Phosphorus application increases the yield of *Stylosanthes guianensis* in Hainan. In: W.W. Stür, J.A. Owen, P.C. Kerridge, P.M. Horne and J.B. Hacker (eds). Proceedings of the Second Regional Meeting of the Forages for Smallholders Project, held at the Chinese Academy of Tropical Agricultural Science, Danzhou, Hainan, P.R. China, 19-24 January 1997. CIAT Working Document No. 173, Los Baños, Philippines, 87-90.

Book/Book chapter

Fujisaka, Sam. (Ed.) Forthcoming. Systems and Participatory Research: Developments in Natural Resource Management. Cali, Colombia: CIAT.

Howeler, R.H. (Ed.). 1998. Cassava Breeding, Agronomy and Farmer Participatory Research in Asia. Proc. 5th Regional Workshop, held in Danzhou, Hainan, China. Nov 3-8, 1996. 539 p.

Prain, Gordon and Sam Fujisaka, eds. In press. Biological and Cultural Diversity. London: Intermediate Technology Publications.

Stür, W.W. and Horne, P.M. (eds.). (1998). Developing Forage Technologies with Farmers – A Training Manual. Forages for Smallholders Project, Los Baños, Philippines.

Stur, W.W., J.A. Owen, P.C. Kerridge, P.M. Horne and J.B. Hacker (eds). Proceedings of the Second Regional Meeting of the Forages for Smallholders Project. Hainan, P.R. China, 19-24 January 1997. CIAT Working Document No 173

Other publications:

Centro Internacional de Agricultura Tropical (CIAT). 1998. Nippon Foundation Project on Improving Agricultural Sustainability in Asia. End-of Project Report, 1994-1998.

Hacker, J.B., Phimphachanhvongsod, V., Novaha, S., Kordnavong, P., Veldkamp, J. and Simon, B. K. (1997). A guide to the grasses of Xieng Khouang province, Lao PDR, and some notes on ecology of grazing lands in the province. Genetic Resources Communication (in press) (Australian Tropical Forages Genetic Resources Centre, CSIRO Tropical Agriculture, Brisbane). (in Lao)

Horne, P.M. and Stür, W.W. (1997). The Changing Face of Agricultural Development. FOCUS, Australian Agency for International Development, Canberra, Australia, December 1997, 16-25.

Lynam, J.K. and K.T. Ingram. 1998. The Nippon Foundation Project on Improving the Sustainability of Cassava-based Production Systems. A Project Evaluation Report. July 1998.

Staples, R. and B. Roder. 1998. The Forage for Smallholders Project. – A Project Evaluation Report. April 1998.

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Funding: Legume-based forage systems for dual-purpose cattle farm
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Funding: Improved legumes and grasses for small milk producers in Caquetá
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Funding:	Providing supplementary funds to FSP for added emphasis on tree legumes with funds from DFID (Philippins and Central America)
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Funding :	Legume-based forage systems for dual-purpose cattle
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Funding:	Improving agricultural sustainability in Asia
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Funding:	Supporting *Leucaena* evaluations as part of ACIAR PN 9433 ("New Leucaenas for Southeast Asian, Pacific and Australian Agriculture
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