ANNUAL REPORT 1997

Project PE-5 Sustainable Systems for Smallholders:

Integrating improved germplasm and resource management for enhanced crop and livestock production systems

Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture

Table of Contents

Annual Report

Project PE-5 Sustainable systems for smallholders: integrating improved germplasm and resource management for enhanced crop and livestock production systems

Project Overview

Objective
To reduce poverty by developing more productive combinations of crop and livestock technologies and sustainable management practices in smallholder farming systems of Latin America, Asia and Africa where beans, cassava, rice and livestock products are important commodities.

Outputs
Effective targeting for technology development and management of natural resources.
Technology components that produce productive and sustainable land use systems.
Strategy for diffusion of results from benchmark sites to other areas.
Indicators of environmental impact of new technologies evaluated at the farm level.

Gains
Integration of commodity and natural resource research. New approaches to the development of environmentally sound technologies. Increased productivity with sustainable land use and increased income of participating farmers. Effective partnerships for developing and implementing new technologies.

Strategy
To link natural resource management with improved germplasm options

i) Participate in existing research consortia in tropical hillsides and lowlands.
ii) Identify farmers' objectives using participatory diagnosis and collect secondary data.
iii) Analyze data to identify possible innovations attractive to farmers that optimize profitability and use of resources using farm and integrated resource models.
iv) Facilitate access to promising germplasm and technology options.
v) Use PR methodology for adapting and developing technology innovations with farmers.
vi) Evaluate and use indicators developed by other projects/organizations to measure socio-economic and environmental impact of new technologies.
vii) Develop strategy for diffusion of results from a reference site to other areas in an agroecosystem.
viii) Provide feedback to strategic research in germplasm improvement and natural resource management.

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

1999 Partners in study areas trained in methodology for integrating natural resource and commodity research; indicators for assessment of socio-economic and environmental impact evaluated at the farm level.

2000 New crop and livestock technologies for smallholder systems in Latin America, South- East Asia and Africa; use of legumes for soil improvement in cropping systems, forage alternatives for dry season feeding; increased bean production in low P soils; cassava varieties for mixed cropping system; demonstrated impact of technologies on increased welfare for rural families and on sustainable land use; methodology for more rapid dispersion of productive and sustainable technologies.

Users: The research will benefit low-income men and women 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; Systemwide Alternatives to Slash and Burn and Livestock Programs; linkages with national R&D organizations and specialized research organizations.

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

CIAT Project linkages: Linked with projects on 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; and in strengthening NARS through developing partnerships, participatory research and impact assessment.

Project PE-5. 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 crop and livestock technologies in smallholder farming systems of Latin America, Asia and Africa where beans, cassava, forages and rice are system components

Components

	Targeting Research	FPR Technology development	Dissemination	Impact
Outputs	Improved targeting for technology and management innovations	Integrated technology and management options for production systems	Enhanced ability to promote adoption of sustainable land use practices	Known impact and utility of new technologies and strategies
Activities	1. Characterize biophysical and socio-economic resources and resource use systems (PE-3, PE-4)* 2. Analyze this information through GIS or other databases (PE-4 3. Evaluate potential for new technologies, management and employment options and market opportunities (BP-1) 4. Develop new FPR approaches for targeting technology development (SN-3)	1. Develop collaborative research and development partnerships 2. Develop new crop and livestock technologies for production systems with farmer participation at benchmark sites (IP & PE projects) 3. Develop integrated soil, water and management practices with farmer participation (PE-2) 4. Investigate agro-industrial and non-agricultural alternatives that enhance sustainable natural resource use (SN-1)	1. Investigate methods for increasing adoption of technologies, developed by FPR, that are economic and environmentally sound (SN-3) 2. Develop integrated resource models to facilitate extension of results (PE-3) 3. Develop training approaches and materials on technology diffusion for use by farmers and technicians (SN-3) 4. Integrate farm level options for resource use with options at landscape and regional levels (PE-3, PE-4)	1. Determine economic impact (BP-1) 2. Assess social impact in collaboration with partners (SN-3) 3. Estimate environmental impact on soil, vegetation, water and atmosphere (PE-3, PE-3, PE-4) 4. Specific training (SN-2) 5. Communicate results through networks, workshops and journals

* collaboration with other projects within CIAT

Summary and main achievements

Summary

The purpose of the project 'Sustainable Systems for Smallholders' is to develop more productive and sustainable systems for smallholders. This involves targeting research, developing new technologies, facilitating their dissemination and measuring their impact. This involves both strategic and applied research even though there is a focus on adaptive research.

Thus an understanding of land use dynamics and effects on natural vegetation, soil, water and the atmosphere are basic to developing alternative land use systems that will be sustainable in the longer term. Likewise, a better understanding of factors that control soil erosion and development of parameters for models will facilitate developing new technologies to control soil erosion. Farmer Participatory Research itself can be regarded as strategic in the sense that we are investigating new methods of reducing poverty and providing new approaches for national institutions to work with resource poor farmers.

The 'Sustainable Systems for Smallholders' project began with a mixed bag of specially funded projects that were inherited from the germplasm program and systemwide programs. One was just beginning (Tropileche), some were well established (Forages for Smallholders and 'Improved Sustainability of Cassava-based Cropping Systems' in Asia and the Nestle project in Caqueta, Colombia), and another was phasing out (The University of Hohenheim/CIAT project 'Soil Degradation and Crop Productivity Research for Conservation Technology Development in Andean Hillsides'.

Some close collaboration has developed between some of these projects. There will be further collaboration as new resources are obtained and projects renewed. The desire of management that an African activity be incorporated within the project has not yet eventuated. Scientists are willing to foster closer collaboration. However, due to geographical limitations, research as far afield as Africa, as indeed it is in Asia, needs to be managed locally.

A major effort has gone into planning and preparing for adaptive systems sub-projects to be developed at the Ecoregional reference sites in Pucallpa, Peru, and Central America. The idea is that research teams would be formed at these sites linking and using outputs from strategic research by IARC scientists with national scientists through a technology development project driven by farmer needs. In this way Centers might demonstrate the impact of strategic and applied research at the farm level.

All the special projects that were transferred to Project PE-5 had a strong emphasis on technology development, and to a slightly lesser extent on targeting research. These two components continue to be the strongest in the Project. Increasing attention is being given to assessment of impact and this is evident in the section on site characterization in the Component 'Targeting Research'. Further attention will be given to impact assessment with the proposed appointment of a post-doctorate fellow in resource economics. Dissemination of results is usually considered the domain of extension rather than research. However, it is considered that attention needs to be given specifically to dissemination of results generated through participatory research if such methodology is to achieve widespread acceptance as an alternative method of technology development.

The main achievements have been grouped according to the four components in the project – Targeting Research, Technology Development, Dissemination and Impact.

It is considered that each adaptive systems or development-oriented project should include each of these components. While it may seem a little artificial breaking down the achievements and detailed results of each sub-project into these groupings, it is done with the hope that this will bring further cohesion with the 'Sustainable Systems for Smallholders' Project as a whole.

Main achievements

Component 1. Targeting Research

Latin America – Forest margins

- 151 farmer settlers in Pucallpa were interviewed, stratified into 4 client groups and research to improve each group identified.
- Farmer participatory research commenced in Pucallpa using these findings.
- Land use dynamics at 3 sites in Brazil and Peru were characterized and hypotheses . regarding causal factors in land use offered.

Latin America – Hillsides

- 44 livestock producers were interviewed in the hillsides of Esparza, Costa Rica to estimate the demand for alternative forages.
- Ex-ante analysis of new and improved grasses and legumes commenced in the forest margins of Pucallpa and in the hillsides of Costa Rica and Nicaragua.
- A strategy was developed for commencing an adaptive systems project in the reference sites in Central America.
- In soil erosion studies in Cauca, Colombia, relationships were established between soil parameters and both structural stability and soil management.

Asia

- Recommendations for improving FPR , in particular, initial data sets needed for the assessment of impact.
- Framework developed and agreement reached on minimum data set site characterization within the Forages for Smallholders (FSP) project.
- Collection and assembly of minimum data sets commenced within the FSP.
- Participatory diagnosis appraisals completed and summarized for 17 FPR sites in the Forages for Smallholders project.
- New Ideas developed for training others in participatory diagnosis and participatory farmer research .

Component 2. Technology Development

Latin America

- New collaborative research and development linkages established.
- Milk production increased with the inclusion of *Arachis* grown in association with *Brachiaria.*
- Feeding *Stylosanthes* calves increased output of milk from dual-purpose cows.
- A 25% increase in milk yield was obtained by feeding *Cratylia argentea* as a supplement when pasture availability was limiting.
- The effect of the *Cratylia* supplement was greatest with cows with a high genetic potential to produce milk.
- *Canavalia brasiliensis* and *Mucuna pruriens* were shown to be useful as green cover crops in Cauca, Colombia.

Asia

- The Forage for Smallholders project is developing forage technologies with farmers at 17 sites in South East Asia.
- Forage legumes are being adopted by farmers to improve soil fertility and subsequent crop yields.
- Commenced pilot seed production scheme for small farmers in Asia.
- Support given to development of leaf meal production in China.
- Critical levels for organic matter, extractable P and K established for cassava production in Asia.
- New management options to reduce soil erosion loss under cassava identified for South East Asia using grass barriers and inter-cropping.
- FPR established at 13 sites in Thailand and Vietnam to develop erosion control practices.
- Estimated that newly developed soil conservation practices will allow cassava production for over 90 years with only a minor yield depression. By comparison, production will decrease dramatically after 25 years with traditional practices, Cauca, Colombia.

Component 3. Dissemination

- Continued evolution and development of FPR methods for South East Asia.
- DSSAT simulation model being adapted for use in smallholder systems including phase of green manure.
- Farm-level simulation model to maximize profits using linear programming was calibrated and three scientists from CORPOICA were trained in its use and interpretation of results.
- Training module produced for 'Developing forage technologies with smallholder farmers'.

Component 4. Impact

- Reached agreement with national partners in the Forages for Smallholders project on methodology for impact assessment.
- National partners in Colombia trained in use of farm simulation model for impact assessment.
- Provided training for researchers and development workers in forages and cassava production.

- Communication established with partners in Tropileche through a newsletter and the Internet.
- Database on research in dual-cattle production established and made accessible through the Internet.
- Manual on soil conservation produced.
- Published SEAFRAD newsletter and Proceedings of the Regional Meeting through the Forages for Smallholders Project.
- Proceedings of the fifth regional Cassava Workshop edited and in press.
- See Publications Section for other communication activities.

Output 1. Improved targeting for technology and management innovations

Latin America - *Forest margins*

Detailed characterization of Pucallpa benchmark site

(1.1.1; S. Fujisaka)

Main achievements

- One-hundred and fifty-one settlers were interviewed.
- Respondents were stratified into four differing client groups.
- Research to improve each sub-system was identified.

Land use strategies in Pucallpa, Peru

Abstract. One hundred and fifty-one farmer-settlers were interviewed in a selected study area in Pucallpa, Peru, to understand current land use dynamics. Respondents were stratified according to broad differences determined by preliminary informal surveys. Settlers included: a) farmers practicing slash-and-burn agriculture in upper forested areas, b) slash-and-burn farmers living along rivers, c) small cattle ranchers with lands located largely along the road connecting Pucallpa to Lima, and d) a sub-set of forest slash-and-burn farmers who established oil palm as a cash crop. This working paper describes land use patterns and differences among these groups. Some of the problems and opportunities faced by each group are considered.

Introduction

Farmer-settlers in the western Amazon practice slash-and-burn agriculture to produce annual crops such as rice, maize, cassava, and beans. In so doing, colonists convert primary tropical forest lands to other uses--including pasture for cattle production, perennial crops, and fallows for future annual cropping. Slash-and-burn agriculture of this types has contributed to deforestation, emissions of atmospheric carbon, and losses of biodiversity (Brady, 1996; Fujisaka *et al*, 1997).

We examined land use in Pucallpa, Peru, as part of a global initiative coordinated by the International Centre for Research on Agroforestry (ICRAF) to develop "Alternatives to Slash-and-Burn" (ASB).

Pucallpa is characterized by humid tropical forest cover. The site is located in the Department of Ucayali (which borders Brazil to the east) and along an east-west gradient leading to the foothills of the Andes along which rainfall ranges from 1800 to 3000 mm (mean 2300 mm, with rainfall increasing to the west). Wet months are February-May and September-November; while dry months are June-August and December-January. Mean annual temperature is 25 C. Soils include more favorable alluvial, riverine systems where pH is approximately 7.7 and available P is 15 ppm; and higher, well drained forested areas of acidic (pH 4.4), low P (2 ppm) soils. Flatter areas near the city of Pucallpa (but out of our area of interest) are poorly drained (*aguajales*) and dominated by *Mauritia* spp palms. Although the Huanuco-Tingo Maria-Pucallpa highway was constructed in the 1940s, settlement became substantial in the 1970s with improvements to the highway (Riesco and Arroyo, 1997; Loker, 1993).

Methods

The Pucallpa study area (Figure 1) was selected by researchers representing Peru's Instituto Nacional de Investigacion Agraria (INIA), the Centro Internacional de Agricultura Tropical (CIAT), and ICRAF. The site was choosen as representative of the different types of slash-and-burn-based agricultural land uses in the broader region.

A multi-disciplinary team of researchers from INIA, CIAT, and ICRAF interviewed 151 settlers in Pucallpa in mid-1996. Interviews dealt with patterns of land use and resource management. Responses were coded and data tabulated and presented in simple descriptive frequencies. Farmers described land use allocations for 1995-96 and for 1996-97.

Preliminary fieldwork showed that the settlers were naturally grouped by location (e.g. forest, river, road) and by major enterprise (eg slash-and-burn, cattle, slash-and-burn plus oil palm). Groups included: a) farmers practicing slash-and-burn in upper forest areas, b) farmers living and practicing slash-and-burn along the rivers, c) small cattle ranchers located largely along the road connecting Pucallpa to Lima, and d) another sub-set of the forest slash-and-burn farmers who recently established oil palm as a cash crop.

A LandSat TM image from 1993 which showed part of the study site was obtained, classified, and analysed.

Results

Migration and settlement. Twenty-seven percent of the respondents were from Pucallpa. Of the others, 30% arrived in the period 1990-95. The remaining 70% of immigrants arrived from prior to the 1970s to 1989, with somewhat fewer arrivals in the decade 1975 through 1984. While, overall, the 73% of respondents who migrated to the area had been in Pucallpa for a mean 16 years, those raising cattle had arrived a mean 24 years ago (Table 1).

Table 1. Year of arrival of migrants (% of respondents, n=111) by main economic activity, Pucallpa, Peru

	Slash-and-Burn					
	Forest (N=32)	Riverine (n=54)	Sub-total (n=86)	Cattle (n=13)	Oil palm (n=12)	TOTAL
1990-95	34	31	33	15	25	30
1985-89	19	13	15	8	33	16
1980-84	9	7	8	8	0	7
1975-79	9	13	12	8	8	11
1970-74	16	17	16	23	17	17
< 1970	13	19	16	38	17	19
Mean years	14	17	16	24	15	16

Land use. Forest and riverine slash-and-burn farmers accounted for 76% of the respondents, had farms of a mean 29 ha of which the forest farmers had only 27% and of which the riverine farmers had 46% in forest in 1996. The forest farmers' 73% cleared area (in 1996) consisted of 39% in fallow or secondary growth, 16% in pasture, 10% in perennial crops and 8% in annual crops. The riverine farmers' cleared area was divided among 26% (again of the whole farm) in fallow, 12% in pasture, 7% in perennial crops, and 6% in annual crops. The 15% of respondents with cattle had significantly larger farms (67 ha) of which a high 80% was cleared--consisting of 54% in pasture, 21% in fallow, 3% in perennial crops, and 2% in annual crops. Finally, farmers who had planted oil palm had parcels of the same size (32 ha) as the other forest farmers, but had more land in perennial crops (17%) and less in fallow (24%). These farmers also had the lowest proportion of their farms in pasture (4%).

In terms of all respondents' land use changes from 1995 to 1996 and considering only lands held by the respondents (totalling 5249 ha), forest decreased from a total of 35% to 33% of the area; while area cleared increased from 65% to 67%. Pasture increased from 24% to 25% of the total; fallow decreased from 29% to 28%; annual crops increased from 5% to 6%; and perennial crops increased from 7% to 8% of total area. While all respondents had some cleared lands, only 67% still had some forest lands. In terms of cleared areas, 44% of all respondents had some pasture; 82% had fallowed land; 80% grew annual crops; and 84% grew at least some perennial crops (Table 2).

Table 2. Land use (% of area) by main agricultural system, Pucallpa, Peru, 1994-5 & 1995-6.

	Slash-and-Burn													
	Forest		Riverine		Total		Cattle		Oil Palm		TOTAL			
	95	96	95	96	95	96	95	96	95	96	95	96	Change	Resp (%)
Forest	30	27	48	46	40	38	20	20	52	51	35	33	-5	67
Cleared	70	73	52	54	60	62	80	80	48	49	65	67	+2	100
Pasture	16	16	12	12	13	14	54	54	2	4	24	25	+0.5	44
Fellow	43	39	25	26	33	31	22	21	25	24	29	28	-5	82
Annual crops	3	8	8	6	6	7	1	2	7	4	5	6	+15	80
Perennials	8	10	7	7	8	10	3	3	14	17	7	8	+14	84
Total area (ha)	1443		1846		3289		1538		422		5249			
Sample size	44		71		115		23		13		151			
Farm size (ha)	33		26		29		67		32		35			

Analysis of the LandSat TM image largely confirmed farmers' accounts: the image covered 109,100 ha of which 17,300 ha corresponded to colonists' parcels and 7,400 ha were held by large haciendas. Analysis indicated that 70% of the colonists' parcels were deforested in 1993 (comparing closely to the reported 67% in 1996 once a correction based on parcel sizes was made regarding the depth from the road of farmers' fields).

Most slash-and-burn farmers cleared new forest parcels every year (85% of forest, 57% of riverine, and 75% of oil palm farmers) or once every two years (10% of forest, 29% of riverine, and 25% of oil palm farmers). Two-thirds of the cattle ranchers, however, cleared forest lands once every three years and a third cleared lands every other year (Table 3). The slash-and-burn farmers (including those with oil palm) cleared means of 1.5 to 2.0 ha per year; while the cattle ranchers cleared a larger 2.6 ha per year (Table 4). Overall, comparing respondents having and not having cattle, the former cleared forest lands less often, but opened larger areas to grow crops such as rice and cassava for sale.

Farmers reported their criteria for selecting and clearing particular forest parcels. Overall reasons were fertile soil (43% of respondents), no flooding (29%), close to road and/or house (19%) and flatter topography (9%, Table 5).

Table 3. Percent of respondents (n=52) reporting given frequency (years) of forest clearing by main agricultural systems, Pucallpa, Peru, 1996

	Slash-and-Burn					
Frequency	Forest	Riverine	Total	Cattle	Oil Palm	TOTAL
1	85	57	71	0	75	69
2	10	29	19	33	25	19
3	0	9	5	67	0	8
>3	5	5	5	0	0	4
Mean	1.2	1.7	1.5	2.7	1.2	1.5

Table 4. Percent respondents (n=93) clearing given forest area (ha) by main agricultural systems, Pucallpa, Peru, 1996

	Slash-and-Burn					
Area	Forest	Riverine	Total	Cattle	Oil Palm	TOTAL
< 1.0	9	5	7	12	17	8
1.0-1.9	41	39	40	12	42	38
2.0-2.9	29	28	29	26	33	29
> = 3.0	21	28	24	50	8	25
Mean	1.8	2.0	1.9	2.6	1.5	1.9

Table 5. Percent of respondents (n=83) reporting criteria for choice of location of forest field to clear and crop by main agricultural system, Pucallpa, Peru

	Slash-and-Burn					
Area	Forest	Riverine	Total	Cattle	Oil Palm	TOTAL
Fertile soil	9	5	7	12	17	8
No flooding	41	39	40	12	42	38
Close to	29	28	29	26	33	29
road/house	21	28	24	50	8	25
Flatter areas						

Farmers reported needing 20 days/ha for slashing (prior to and after felling) and 27 days/ha for felling when clearing forest parcels; and 16 days/ha for slashing and 6 days/ha for felling fallowed parcels (Table 6).

Nearly all farmers grew rice in fields cleared from forest in the first year and cassava, maize, pasture, or other crops in the second year (if not fallowed). Farmers sowed rice, maize, cassava, and banana in fields cleared from fallows (Table 7). Although fluctuating by year, farmers overall maintained approximately equal areas sown to rice, maize, and cassava. For 1995, the sampled farmers sowed 64 ha of rice, 84 ha of maize, and 57 ha of cassava. For 1996, the same parcels sown to rice were fallowed (31%), planted to cassava (18%), maize (7%), banana (7%), pasture (4%), or a variety of other uses (32%) not including

Table 6. Reported labor (days/ha) for clearing forest and fallow by main agricultural system, Pucallpa, Peru

	Slash-and-Burn											
	Forest		Riverine		Total		Cattle		Palm		TOTAL	
	For	Fal	For	Fal	For	Fal	For	Fal	For	Fal	For	Fal
Slash	20	17	22	14	21	15	18	22	12	19	20	16
Fell	30	5	28	6	29	6	22	7	18	5	27	6
Total	50	22	50	20	50	21	40	29	30	24	47	22

Table 7. Percent respondents reporting main crop sown in fields cleared from forest (n=100) and from fallow (n=132), by main agricultural systems, Pucallpa, Peru

	Slash-and-Burn											
	Forest		Riverine		Total		Cattle		Palm		TOTAL	
	For	Fal	For	Fal	For	Fal	For	Fal	For	Fal	For	Fal
Rice	88	52	73	49	80	50	50	33	84	50	78	49
Maize	6	30	16	28	11	29	0	47	8	25	10	30
Cassava	3	10	0	2	1	5	25	0	0	17	3	5
Banana	3	3	11	9	8	7	25	7	8	0	9	6
Other	0	5	0	12	0	9	0	13	0	8	0	10

rice. For parcels sown to maize in 1995, the following year included 49% in fallow, 21% in maize, 9% in banana, and 5% in cassava (and 1% in rice). For the 1995 cassava area, 46% was fallowed, 29% was in cassava and 0% was in rice in 1996 (Table 8).

Table 8. Changes in land use for lands cropped to rice, maize, and cassava from 1995 to 1996, Pucallpa (% area planted in 1995)

	Planted in 1995		
Planted 1996	Rice (64 ha)	Maize (84 ha)	Cassava (57 ha)
Rice	0	1	0
Maize	7	21	0
Cassava	18	5	29
Banana	7	9	5
Pineapple	2	0	8
Pasture	4	3	4
Fallow	31	49	45
Other	32	11	1
Total	100	100	100

Farmers reported actual crop yields for 1995-96: the 1.4 t/h of rice, 1.7 t/h of maize, and 0.2 t/ha of beans were lower than their reported "normal" yields but higher than previous lowest yields of each respective crop (Table 9).

Table 9. Respondents' reported crop yields (t/ha), Pucallpa, 1995-96

	Reported range			
	Low	Normal	High	Actual 1995-96
Rice	0.9	1.9	2.6	1.4
Maize	1.1	2.2	2.9	1.7
Beans	0.1	0.8	0.9	0.2

Fields cleared from forest were cropped for a mean two years: 30% of the respondents cultivated for one year, 44% cultivated for two years, 16% for three years, and 10% for more than three years. Lands cultivated after fallow were cultivated a mean 1.3 years. Respondents discontinued cropping plots cleared from forest due to declining production (major reason cited by 75% of respondents) and weeds (46%).

Combining these interview-based results with more informal field observation and discussions with settlers, each of the sub-groups of respondents can be described.

Slash-and-burn farmers of the forest. Forest farmers had a high proportion of their lands cleared (73% in 1996), and the highest proportion (39%) of their farms in fallow or secondary re-growth. Rice was the major crop, and one which suffered from yield-reducing diseases. These farmers had 10% of their lands in perennial crops such as citrus, achiote, cacao, and various fruits. A substantial number grew coca, although demand declined since the end of the domination of the area by the terrorist Sendero Luminoso. To some extent it appeared that charcoal production has replaced coca production as an income generating alternative.

Riverine slash-and-burn farmers. These farmers had farms which were 54% cleared and 26% in fallow. Banana was established as a cash crop on the relatively richer soils (compared to upper-forest areas) after initial slash-and-burn rice production. Sikatoka was widespread as a problem in banana, and one that farmers reported may be exacerbated by the defoliants and herbicides sprayed from helicopters in the Peruvian army's efforts to eradicate coca fields. Flooding was a problem and solution (ie the deposits of richer river-borne silts). River farmers also earned incomes from fish and the softwood *Guazuma crinita* which grew in fallows.

Small cattle ranchers. These farmers had the largest parcels (67 ha), the least forest (20%), the lowest proportions of land in annual and perennial crops and in fallow (although they had the largest annual crop fields in absolute terms), and the highest proportion of land in pasture (54%). For the 20% of Pucallpa respondents having cattle, herd size was a mean 23 head. Pastures were reportedly 40% (of pasture area) *Brachiaria* spp and 28% *Brachiaria* spp plus *Pueraria phaseoloides*, although areas of native pasture (of *Axonopus compressus*, *Paspalum conjugatum*, and *Homolepis aturensis*) were clearly under-reported. Thirty-nine percent of the ranchers reported using fire for pasture regeneration at a mean interval of every two years; and 68% reported rotating animals to different pastures at a mean interval of one month. Pressure on pasture resources was low: 73% of these respondents maintained less than one head per ha, 24% had 1-2 head, and only 3% had more than 2 head of cattle per ha of pasture. It was widely reported that the period of terrorism by the *Sendero* led to substantial declines in cattle numbers and reduced maintenance of fences and pastures.

Oil palm farmers. These slash-and-burn farmers have accessible upper-area parcels, have taken advantage of local development projects promoting oil palm (*Eleais guineensis*), and, therefore, have the largest proportion of their farms in perennial crops (17%) and the lowest in pasture (4%). Success of oil palm will depend on the development of processing infrastructure and demand sufficient to maintain prices at profitable levels.

Conclusions: towards an appropriate research agenda

Overall, Pucallpa farmers relied on rice as a major crop for both sale and consumption. Research to help solve upland rice disease problems and the problems of soil nutrient depletion and increases of weeds would benefit many farmers in the area. Pucallpa farmers had a high proportion of their lands in fallow or secondary re-growth. Working with farmers on improved fallows using trees and legumes would appear to be reasonable.

Upper-area farmers who had earned incomes from coca production (from sales and/or from wages for weeding and harvesting) were seeking new alternatives. Charcoal production--given use of selected suitable forest species such as *Dipterix odorata*--cannot be expected to be sustainable. Efforts to develop and promote new crops (such as camu camu *Myciaria dubia*) and agroindustries (eg palm oil) would appear to be reasonable; and research is needed to carefully determine *ex ante* demand for new alternatives. Farmers have had experience with the promotion of supposedly income-generating crops such as citrus and achiote--which unfortunately were market failures.

Riverine slash-and-burn farmers were most concerned about diseases affecting their banana plantations (and upland rice). Research to address the problem would be appropriate and needed.

Research in Pucallpa has long targeted the cattle ranchers in the introduction and testing of forage and feeding systems alternatives including legumes such as *Arachis pintoi, Centrosema* spp, *Desmodium ovalifolium, Cratylia argentea, Stylosanthes guianensis*, as well as forage grasses. These settlers, however, may have little interest in more productive forage systems as long as current pasture resources are more than sufficient given the area's reduced herd size. On the other hand, targeted work to increase systems productivity and sustainablity with the few ranchers maintaining more animals per area may be appropriate, as appears to be the case with the current work of the Instituto Veterinario de Investigaciones Tropicales y de Altura (IVITA) and the CG project, Improved Feeding Systems for Dual Purpose cattle (TROPILECHE).

References

Brady NC (1996) Alternatives to slash-and-burn: a global imperative. *Agriculture, Ecosystems and Environment* 58:3-11

Fujisaka S, Escobar G, and Veneklaas E (1997) Plant community diversity relative to human land uses in an Amazon forest colony. Forthcoming in *Biodiversity and Conservation*

Loker, WM (1993) Medio ambiente y agricultura en la Amazonia Peruana: un experimento metodologico. In: Loker WM and Vosti S (eds) *Desarrollo Rural en la Amazonia Peruana*. Centro Internacional de Agricultura Tropical (CIAT) and the International Food Policy Research Institute (IFPRI), Cali, Colombia

Riesco A and Arroyo M (1997) Perfil socio-economico de la region de Ucayali. Unpublished report, Consorcio para el Desarrollo Sostenible de Ucayali/Proyecto de Desarrollo de Agroempresas Rurales del CIAT

Additional characterization in Pucallpa in relation to livestock

(1.1.2. F. Holmann)

The objective of this activity is to characterize the existing animal production systems in the benchmark sites at Pucallpa with emphasis on the characterization of existing resources, technologies, constrainsts, and opportunities.

In mid-1996, 151 farmers were interviewed in a selected study area in Pucallpa, Perú, to understand current land use dynamics (see section above). About 20% of respondents had cattle with a mean herd size of 23 head. These farmers had the largest parcels (67 ha), the least forest (20%), the lowest proportions of land in annual or perennial crops, and the highest proportion of land in pasture (54%). About 68% of pasture area was established with Brachiaria spp in different stages of degradation.

Pressure on pasture resources was low since 73% of the respondents maintained less than one head per ha, 24% had 1-2 head, and only 3% had more than 2 head of cattle per ha of pasture. It was widely reported that the period of terrorism by the Sendero Luminoso (Shining Path) led to substantial declines in cattle numbers and reduced maintenance of fences and pastures.

Research in Pucallpa has long targeted the smallholder cattle producers through the introduction and testing of new forage species including legumes and pasture grasses. These farmers, however, may have little interest in more productive forage systems as long as current pasture resources are more than sufficient given the reduced herd size. Thus, work at this stage should attempt to increase productivity and sustainability in farms with large numbers of cattle per unit area.

An additional survey on livestock in Pucallpa has been carried out and is currently being analyzed.

Integration and analysis of Forest Margins site data
(1.2.1; S. Fujisaka)

Main achievements

- Land use dynamics at three sites in Brazil and Peru were characterized.
- Land uses by site after initial slash-and-burn cultivation were described.
- Six hypotheses regarding causal factors in land use are offered.

Pasture or permanent crops after slash-&-burn cultivation? Land use choice in three amazon colonies

Abstract. Settlers in the Amazon practice slash-and-burn agriculture in forest lands to produce annual crops. After cropping, lands are converted to pasture, planted to perennial crops, or fallowed in anticipation of future annual crop production. Land use was examined in three settlements--Pedro Peixoto in Acre and Theobroma in Rondonia, Brazil, and Pucallpa, Peru. Land use after slash-and-burn cultivation in forest lands differed among the colonies. Colonists in Pedro Peixoto converted lands to pasture for cattle production; Theobroma settlers adopted a strategy encompassing both dual purpose cattle and perennial crop production; while the more heterogeneous settlers in Pucallpa included small cattle ranchers and riverine and forest slash-and-burn farmers for whom perennial crops were important. Land uses are described; hypotheses regarding differences are offered; and implications for the adoption of agroforestry are discussed.

Introduction

Farmer-settlers in the western Amazon have traditionally practiced slash-and-burn agriculture to produce annual crops such as rice, maize, cassava, and beans. In so doing, colonists convert primary tropical forest lands to other uses which include pasture for beef or dual purpose (milk and meat) production, perennial crops, and fallows for future annual cropping. We examined land use in the colonies of Pedro Peixoto, Acre, and Theobroma, Rondonia, in Brazil and in Pucallpa, Peru, where settlement has taken place largely since the late 1960s when road access was improved to each area.

Continued slash-and-burn agriculture has contributed to deforestation, carbon emissions into the atmosphere, and losses of biodiversity (Brady, 1996; Fujisaka *et al*, 1997). Areas converted to pasture--of either native or introduced species--in the Amazon have suffered degradation: many pastures in Acre and Rondonia are infested with *Vernonia ferruginea* and *Imperata brasiliensis* (ASB, 1994a); while a third of the pasture area in the cattle zone along the Pucallpa-Lima highway in the Department of Ucayali was considered to be degraded (Riesco *et al*, 1982). Colonists' establishment of perennial crops, on the other hand, has been viewed as positive in terms of diversification of household incomes, and as a relatively sustainable land use option with fewer environmental costs compared to pasture or continued slash-and-burn cropping (Sanchez, 1995; Harwood, 1996).

Overall, settlers in Pedro Peixoto converted lands to pasture for beef cattle production, showed little interest in perennial crops, and exploited forest products such as Brazil nut, timber, and game. Colonists in Theobroma employed a mixed strategy encompassing dual purpose cattle, perennial crops, and some use of forest products. Pucallpa was more heterogeneous, with some settlers forming small cattle ranches and others practicing slash-and-burn agriculture with perennial crop establishment and susbstantial proportions of land left in fallows.

This paper describes the different land uses after initial forest clearing, burning, and cropping in each of the colonies. Hypotheses are offered and discussed regarding the observed diffrences.

The sites

Pedro Peixoto in Acre and Theobroma in Rondonia, Brazil, are government sponsored colonies in the semideciduous forest zone. Pedro Peixoto was officially established in 1972, covers 370,000 ha divided into 3700 parcels distributed to 3200 families. Lots are located from 50 to 100 km from the state capital of Rio Branco. Theobroma was officially estabished in 1979 (both colonies were earlier settled by "spontaneous" arrivals), covers 300,000 ha distributed to 3000 families, and is located about 350 km southeast of the state capital of Porto Velho. The highway BR364 passes through both colonies. Climate is warm and humid tropical with a rainy season from November to June and a dry season from July to October in Acre and June to August in Rondonia. Annual rainfall is 2000 mm and mean temperatures are 22-26°C. Soils in Pedro Peixoto are largely Oxisols and in Theobroma are Oxisols, Ultisols, and Alfisols (Fujisaka *et al*, 1996).

The Pucallpa site (in the Department of Ucayali which borders the state of Acre to the east) features humid tropical forest and is located on an east-to-west gradient leading to the foothills of the Andes along which rainfall ranges from 1800 to 3000 mm (mean 2300 mm, with rainfall increasing to the west). Wet months are February-May and September-November; while dry months are June-August and December-January. Mean annual temperature is 25°C. Soils include more favorable alluvial, riverine systems where pH is approximately 7.7 and available P is 15 ppm; and higher, well drained forested areas of acidic (pH 4.4), low P (2 ppm) soils. Flatter areas near the city of Pucallpa (but out of our area of interest) are poorly drained (*aguajales*) and dominated by *Mauritia* spp palms (Riesco and Arroyo, 1997; Loker, 1993).

Methods

A team of researchers representing the Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA), the Centro Internacional de Agricultura Tropical (CIAT), the International Centre for Research in Agroforestry (ICRAF), and the International Food Policy Research Institute (IFPRI) interviewed 81 settlers in Pedro Peixoto and 74 in Theobroma in late 1994. A similar team representing Peru's Instituto Nacional de Investigacion Agraria (INIA), CIAT, and ICRAF interviewed 118 settlers in Pucallpa, Peru, in mid-1996.

Interviews were conducted as a part of characterization activities for the ICRAF-coordinated global project "Alternatives to Slash-and-Burn". Interviews dealt with patterns of land use and resource management. Responses were coded and data tabulated and presented in simple descriptive frequencies.

Results

Settlement. Twenty-seven percent of Pedro Peixoto respondents were born in Acre; only 1% of Theobroma respondents were from Rondonia; and 27% of the Pucallpa respondents were from Ucayali. Respondents immigrating to the study areas arrived a mean 16 years ago in the state of Acre and 9 years ago in the colony of Pedro Peixoto; 13 years ago in Rondonia and 10 years ago in Theobroma, and 17 years ago in both Ucayali and the Pucallpa study area. The studied areas in Brazil have been settled since the 1960s when the highway BR364 was opened and subsequently improved; while settlement in Pucallpa started in the 1940s after the construction of the highway linking the city of Pucallpa and Lima on the coast and was facilitated by road improvements in the late 1960s. The low proportion of "native" Theobroma settlers seems to indicate the arrival of a second generation of settlers from other parts of Brazil.

Overall land use. Pedro Peixoto settlers had parcels of a mean 88 ha, of which 34% was cleared (and 66% was still forested). Of the cleared lands and as a proportion of the total farm, 25% of the area was in pasture, 2% in fallow, 7% in annual crops, and less than 1% in perennial crops. Theobroma farmers had 76 ha parcels, of which 50% was cleared by 1995. The cleared area included 29% of the parcel in pasture, 4% in fallow, 9% in annual crops, and 8% in perennial crops. Pucallpa settlers had cleared 68% of their mean 35 ha parcels by 1996, with cleared areas including 25% of the land holding in pasture, 29% in fallow, 6% in annual crops, and 8% in perennial crops (Table 1; these land uses were confirmed by analysis of satellite images, Fujisaka *et al*, 1996).

Table 1. Land use (% area), Pedro Peixoto & Theobroma, Brazil, 1994-95, and Pucallpa, Peru, 1995-96

	Pedro Peixoto		Theobroma		Pucallpa	
	1964	1995	1994	1995	1995	1996
Forest	69	66	54	50	35	32
Cleared	31	34	46	50	65	68
Pasture	20	25	26	29	25	25
Fallow	6	2	8	4	29	29
Annual crops	4	7	7	9	5	6
Perennial crops	1	<1	5	8	6	8
Mean farm size (ha)	88		76		35	

Further analysis of the Pucallpa data shows that its more heterogeneous landscape and population features: a) riverine and b) forest slash-and-burn agriculturalists with about a half to three-fourths of their lands cleared, up to third of their lands in fallow, 10% of lands in perennial crops, and only 14% of their lands in pasture; c) cattle ranchers with larger farms which were 80% cleared, 54% in pasture, and 21% in fallow; and a special group of slash-and-burn farmers who established oil palm (*Eleais guineensis*) to the extent that they had 17% of their lands in perennial crops (Table 2).

Table 2. Land use (% area) by main agricultural system, Pucallpa, Peru, 1996

	Slash-and-Burn					
	Forest (n=44)	Riverine (n=71)	Sub-Total (n=115)	Cattle (n=23)	Oil Palm (n=13)	Total (n=15)
Forest	27	46	38	20	51	33
Cleared	73	54	62	80	49	67
Pasture	16	12	14	54	4	25
Fallow	39	26	31	21	24	28
Annuals	8	6	7	2	4	6
Perennials	10	7	10	3	17	8
Mean farm size (ha)	33	26	29	67	32	35

Slash-and-burn agriculture. Farmers had cleared a mean 1.5 to about 3.0 ha for annual cropping for the season in which interviews were conducted. Farmers cleared forest lands every two to three years, cropped the parcels from two to 2.5 years, and then fallowed lands for 2.5-3.5 years. Labor required for forest clearing was substantially lower in Brazil than in Pucallpa given the greater use of chainsaws in Brazil. Labor for clearing fallowed fields for re-cultivation usually did not require chainsaws and was substantially lower than that required for forest clearing (Table 3).

Table 3. Slash-and-burn agriculture, Pedro Peixoto, Rondonia & Theobroma, Acre, Brazil, and Pucallpa, Peru, 1996

	Pedro Peixoto	Theobroma	Pucallpa
Use of forest lands			
Frequency of forest clearing (yrs)	2.1	2.8	1.5
Mean area cleared per year* (ha)	1.8	2.8	1.9
Mean years cultivation	2.1	2.5	2.1
Mean years fallowed	2.4	2.4	3.2
Land clearing			
Forest; labor (days/ha)			
Fallow; labor (days/ha)	23	14	47
Use of chainsaw (% respondents)	16	14	22
	90	89	15

* actual area cleared in year of interview

Upland rice was the main crop sown in the first year after clearing. In the second year, Pedro Peixoto farmers sowed maize, cassava, and pastures; Theobroma farmers sowed maize and pastures; and Pucallpa settlers sowed cassava, maize, or fallowed their lands. After fallowing, colonists largely planted upland rice and maize in the first year of re-cultivation (Table 4).

Table 4. Farmers' (% respondents) dominant crop/land use choice for forest (first & second years after clearing) & fallow parcels (first year after re-clearing)

	Pedro Peixoto			Theobroma			Pucallpa		
	Forest		Fallow	Forest		Fallow	Forest		Fallow
	1st	2nd	1st	1st	2nd	1st	1st	2nd	1st
Rice	92	0	62	70	0	72	78	1	49
Maize	0	42	23	0	44	13	10	12	30
Cassava	0	26	3	0	0	0	3	36	5
Pasture	1	17	0	13	25	2	0	5	0
Fallow	-	8	-	-	8	-	29	-	-
Other	7	7	12	17	23	13	9	17	16
Total	100	100	100	100	100	100	100	100	100

Farmers reported harvesting from 1.3-1.5 t/ha of rice from their forest fields (in the harvest preceeding the interviews). These amounts were slightly lower than farmers' expected "normal" yields, but higher than their reported lowest yields of a mean 0.7-0.9 t/ha and lower than reported highs of 2.0-2.6 t/ha (Table 5).

Table 5. Farmer-reported rice yields (ha)

	Pedro Peixoto	Theobroma	Pucallpa
Low*	0.7	0.9	0.9
Normal	1.5	1.6	1.9
High	2.2	2.0	2.6
Actual**	1.3	1.5	1.4

* Farmers estimated "low", "normal", and "high yields

** Reported 1993 yields for Pedro Peixoto & Theobroma; 1996 for Pucallpa

Land use after annual cropping. Sixty-four percent of Pedro Peixoto farmers, 44% of Theobroma farmers, but only 6% of Pucallpa farmers reported that they converted lands to pasture as their major land use after cropping. Similarly, 91% of the Pedro Peixoto respondents, 81% of Theobroma settlers, and only 20% of Pucallpa farmers raised cattle. For those having cattle, settlers in Pedro Peixoto and Pucallpa had a mean 23 head, while Theobroma farmers had a mean 30 head. For farmers with cattle, pasture represented 22% of farm area in the Brazilian colonies and 36% of the Pucallpa ranches. Overall, pastures accounted for 25-29% of the total farm areas in the three colonies (Table 6).

Table 6. Land use after annual cropping forest lands

Land use	Pedro Peixoto	Theobroma	Pucallpa
Pasture & cattle			
Pasture = main land use after S & B	64	44	6
Respondents having livestock (%)	91	81	20
Mean head of cattle	23	30	23
Mean pasture area (ha)*	22	22	36
Pasture area (% of all farms)	25	29	25
Perennial crops			
Perennials = main land use after S & B	0	20	0
Have perennials (% respondents)	31	69	87
Land in perennial crops (%)	<1	8	8
Fallow			
Fallow = main land use after S & B	36	36	95
Land in fallow (% area)	2	4	29

* For those respondents having cattle

Pastures in Pedro Peixoto were, as reported by area, 57% *Brachiaria brizantha*, 24% *B decumbens*, and 10% *Brachiaria* spp plus *Pueraria phaseoloides*. Theobroma pastures were largely *B brizantha* (51%), and *B decumbens* (13%). Pastures in Pucallpa were similarly of *B brizantha* (40%) and *Brachiaria* spp and *P phaseoloides* (28%). Respondents tended to under-report areas of native pasture, which in Pucallpa included degraded areas dominated by *Axonopus compressus, Homolepis aturensis,* and *Paspalum conjugatum.*

Twenty percent of Theobroma farmers and none of the Pedro Peixoto and Pucallpa farmers reported that their main use of lands after slash-and-burn agriculture was for perennial crops. Eighty-seven percent of Pucallpa and 69% of Theobroma farmers had perennial crops, accounting for 8% of their lands; while only 31% of Pedro Peixoto settlers had perennial crops on less than one percent of their land (Table 6). Major perennial crops in Pucallpa were banana, citrus, miscellaneous fruit, and oil palm. Theobroma farmers produced coffee, cacao, and miscellaneous fruit (Table 7).

Table 7. Perennial crops (% respondents having named crop)

Perennial Crops	Pedro Peixoto	Theobroma	Pucallpa
Coffee	12	46	0
Cacao	2	34	3
Banana	15	1	37
Oil Palm	0	0	11
Ctrus	9	3	17
Other fruits	14	19	15
Softwoods	0	0	9
Other	1	0	5

Ninety-five percent of Pucallpa farmers reported fallows as their major land use after initial slash-and-burn cultivation in forest parcels; and fallows represented 29% of their lands. Although 36% of Theobroma and Pedro Peixoto settlers reported fallows as their major land use after cultivation, these covered only 2-4% of the farm areas in the two Brazilian colonies (Table 6).

Forest products. Almost all Pedro Peixoto farmers gathered Brazil nuts (*Bertholletia excelsa*); and substantial numbers harvested timber (in small quantities), rubber, fish, and game. Theobroma settlers exploited timber, Brazil nuts, palm heart and fruit (*Bactris gassipaes*), and fish and game. Only a quarter of Pucallpa farmers--and mainly those settled along the rivers--reported harvesting timber, mainly the softwood *Guazuma crinita*, locally *bolaina blanca* (Table 8). Field interactions revealed that a substantial number of Pucallpa farmers in areas farther from the roads produced coca for the illicit drug trade. Decline in demand due to control of terrorism and a return of state control has meant that some of these producers have turned to charcoal production, exploiting selected forest tree species such as *Dipterix odorata*.

Table 8. Respondent's (%) use of forest products

Forest product	Pedro Peixoto	Theobroma	Pucallpa
Brazil nut	90	36	0
Wood	33	50	25
Hunting	18	29	?
Palmito	5	17	2
Fish	6	13	?
Rubber	11	0	0
Medicinal plants	5	6	0
Other	11	16	3

Cash income sources. Farmers sold surpluses of rice, maize, beans (in Pedro Peixoto), and cassava (in Pucallpa). A fourth to a third of Theobroma farmers earned cash from sales of coffee and cacao; while similar proportions received imcomes from banana and citrus in Pucallpa. Pedro Peixoto settlers sold cattle (26% of respondents), milk (7%), and poultry and pigs (9%). Theobroma settlers had dual purpose operations, earning incomes from meat (22%) and milk (30%). Nineteen percent of Pucallpa settlers sold cattle and 27% earned cash from occasional sales of pigs and/or chickens. Almost half of Pedro Peixoto settlers sold Brazil nuts; and 17% of Pucallpa settlers earned cash from sales of timber. At least half of the respondents in the three colonies reported incomes from off-farm and non-farm labor and from pensions or other off-farm cash remissions (Table 9).

Table 9. Respondent's reported major income sources (% respondents)

Income source	Pedro Peixoto	Theobroma	Pucallpa
Annual crop sales			
Rice	50	57	39
Maize	47	16	37
Beans	41	9	2
Cassava	4	0	19
Perennial crop sales			
Coffee	3	36	0
Cacao	0	25	2
Banana	0	0	29
Citrus	0	0	25
Livestock/livestock products			
Cattle	26	22	19
Milk	7	30	0
Poultry/pigs	9	0	27
Forest products			
Rubber	7	0	0
Brazil nuts	44	6	0
Wood	0	9	17
Labor & pensions	63	53	50

Land evaluation. Almost all settlers at each site reported that the values of their lands had risen over their time period of occupation. Perceived values (calculated in terms of head of cattle) increased from 74% per year in Pedro Peixoto to 157% per year in Theobroma. Reasons given for the increases included more pasture, fencing, and watering ponds for cattle in Pedro Peixoto; more pasture, fencing, perennial crops, and more area cleared in Theobroma; and perennial crops, pastures, fencing, and more area cleared in Pucallpa (Table 10).

Discussion and hypotheses

Descriptive results showed that although slash-and-burn forest clearing and annual cropping in the three study areas were similar, subsequent land use differed. Pedro Peixoto settlers followed annual cropping with conversion to pasture for beef cattle production, kept little land in fallow, placed little importance on perennial crops, and exploited available forest products.

Table 10. Reported change in land values

	Pedro Peixoto	Theobroma	Pucallpa
Respondents (%) reporting > value	93	97	95
Mean reported annual increase (%)	74	157	97
Reasons for increased value			
More pasture	60	50	30
Fencing	56	36	12
Watering pond	30	13	2
Corral	12	16	0
More area opened	12	26	15
Perennial crops	12	35	46
House	26	16	28
Roads	25	27	39

Theobroma farmers also placed little land in fallow, but had a more mixed economy, balanced among dual purpose cattle production and perennial crops.

Pucallpa farmers--who included forest and riverine slash-and-burn farmers, cattle ranchers, and oil palm producers--had a substantially higher proportion of their lands in fallow relative to the Brazilian colonists, had a much lower proportion of families with cattle; and--except for the cattle ranchers--relied upon perennial crops to an extent similar to Theobroma.

These findings give rise to several hypotheses for further research (hypotheses which our current characterization data were not able to address with sufficient certainty). Four related hypotheses are of a general nature:

1. The more "pioneer" conditions of larger land holdings, greater proportions of forest, and greater isolation from urban markets favor the combination of cattle ranching and forest products exploitation.

Pedro Peixoto is located nearly at the end of the highway BR364 far from populated center-south region of Brazil. Settlers with their larger parcels, extensive pastures, cattle and abundant forest lands had little interest in and had had little success with perennial crops due to a lack of markets. There would appear to be few alternatives to the extensive exploitation of land and forest resources of interest to these settlers.

2. Conversely, diminishing pioneer conditions--eg less area in primary forest, greater ties to markets, decreasing farm size--favor more mixed economies which include perennial crops and dual purpose cattle production.

Theobroma and Pucallpa settlers have more limited land and forest resources, are closer to urban markets (the center-south region of Brazil and Lima, respectively), and appear to be making a transition from more exploitative land use to more diversified economies. Cheese factories in Theobroma and nascent agroindustries in Pucallpa are associated with such diversification in these areas.

3. Land speculation has been a farm-level factor leading to more land clearing and conversion of forest lands to other uses.

In each colony settlers perceived that the values of their land assets had substantially increased because of their efforts in establishing more pasture, clearing land, building fences, and planting perennial crops. Related to the first two hypotheses, Pedro Peixoto settlers saw greater returns from pasture and fence development, while Theobroma and Pucallpa farmers also placed value on their perennial crops.

4. Perennial crop establishment promoted by development projects risk failure where market projections are overly optimistic.

In spite of an emerging wealth of publications dealing with potential new market opportunities for exotic Amazonian fruit and forest products (Toledo,1994; Clay and Clement, 1993), citrus and achiote (*Bixa orellana*) in Pucallpa and achiote Pedro Peixoto and Theobroma were commercial failures (although farmers still harvest and sell citrus at low prices in the city of Pucallpa). More recently, oil palm and camu camu (*Myrciaria dubia*) have been promoted in Pucallpa. Theobroma farmers continue planting coffee and cacao, and are now faced with the promotion of acerola (*Malpighia punicifolia*) and cupuacu (*Theobroma grandiflorum*). Whether or not camu camu, oil palm, acerola, and the forest products palmito and uña de gato (*Uncaria tomentosa*) will represent marketing opportunities or disasters for small farmers remains to be seen.

Two additional hypotheses relate to Pucallpa

5. Cattle numbers in Pucallpa and the number of settlers maintaining cattle were negatively affected by the period of terrorism associated with the *Sendero Luminoso* (Shining Path) guerrillas.

Respondents in Pucallpa indicated that they had decreased their cattle holdings and had failed to maintain fences during the period of terrorism which ended during the present (Fujimori) government administration. The relatively greater proportion of lands fallowed and the relatively fewer respondents with cattle may reflect such a trend (Figure 1).

6. "Alternatives" to coca production were not economically attractive when coca demand was high; and that high demand was facilitated by the presence of the guerrillas and absence of government control.

Informal interviews with small coca leaf farmers in Pucallpa indicated that: a) coca supplied relatively high cash incomes from both sales of leaves by producers and wages for weeding and harvesting; b) demand was high during the *Sendero* period when the guerrilla protected coca commerce; but c) demand dropped when the central government regained control of the area and has actively worked to eradicate coca.

Conclusions

Slash-and-burn agriculture in forest lands has been followed by pasture establishment and cattle, fallows and secondary forest re-growth, and perennial cropping, as well as by pasture degradation, soil degradation, and loss of biodiversity (ASB, 1994b; Borit, 1997). The promotion of more diverse and potentially sustainable land uses such as agroforestry or agrosilvopastoral systems should consider and, to the extent possible, build on farmers' existing experiences with annual and perennial crops, pastures and livestock, and forest products.

On the one hand, there appears to be little current potential for the promotion of more intensive, permanent, and diversified (and sustainable) land use in areas such as Pedro Peixoto where abundant land and forest resources combined with isolation from urban markets tend to support the current exploitative pattern of resources use.

On the other, decreasing farm sizes (due to inter-generational land fragmentation?) combined with access to new market opportunities appear to be associated with intensification and diversification. The establishment of perennials and the settlers' associated perceptions of the high value in such establishment in Theobroma (where coffee, cacao, and dual purpose cattle have been successful) and Pucallpa (where banana, oil palm, and exploitation of bolaina have been successful) should be seen as locally developed precursors to more sustainable agroforestry schemes.

The reported high proportion of improved pastures at the three sites would indicate that the settlers already value and have a tradition of managing such a technical innovation, and that improved agrisilvopastoral systems may be a "logical" next step.

Of course, caution is needed in the promotion of new cultivars and products. Many farmers in the region with healthy, productive orchards of citrus or achiote have been more than disappointed by the lack of promised markets.

Finally, historically idiosyncratic local development paths must be considered: improved forrage systems are presently of little use to Pucallpa ranchers who have an overabundance of pasture resources as they now rebuild herds reduced during the *Sendero* period. The development of new Amazonian products was at a minimum during the same period when coca production was the most attractive alternative for the areas' small farmers. Once herd numbers are rebuilt, however, the Pucallpa area may see an increase in pasture and a decrease in fallow area to proportions of land use more similar to that encountered in Theobroma. If the proposed highway connection between Acre and Peru--and to Lima--is completed, land use in Pedro Peixoto may become more exploitative (eg more deforestation for soybean production) or may become more diversified (and hopefully sustainable) with increased access to new markets.

References

ASB (1994a) Report of research site selection in Acre and Rondonia states of the Amazon region, Brazil. International Centre for Research on Agroforestry (ICRAF) and the project Alternatives to Slash-and-Burn (ASB)

ASB (1994b) Alternatives to slash-and-burn: a global strategy. International Centre for Research on Agroforestry (ICRAF) and the project Alternatives to Slash-and-Burn (ASB)

Borit HP (1997) Situacion y perspectivas de la seguridad alimentaria en la Amazonia en un marco de produccion agropecuaria y de cooperacion intra-regional, estudio de Peru. Working document, Proyecto GCP/RLA/128/NET, Tratado de Cooperacion Amazonica-Food and Agriculture Organization of the United Nations

Brady NC (1996) Alternatives to slash-and-burn: a global imperative. *Agriculture, Ecosystems and Environment* 58:3-11

Clay JW and Clement CR (1993) Selected species and strategies to enhance income generation from Amazonian forests. FO:Misc/93/6 Working Paper: Food and Agriculture Organization of the United Nations

Fujisaka S, Bell W, Thomas N, Hurtado L, and Crawford E (1996) Slash-and-burn agriculture, conversion to pasture, and deforestation in two Brazilian Amazon colonies. *Agriculture, Ecosystems and Environment* 59:115-130

Fujisaka S, Escobar G, and Veneklaas E (1997) Plant community diversity relative to human land uses in an Amazon forest colony. Forthcoming in *Biodiversity and Conservation*

Harwood RR (1996) Development pathways towards sustainable systems following slash-and-burn. *Agriculture, Ecosystems and Environment* 58:75-86

Loker, WM (1993) Medio ambiente y agricultura en la Amazonia Peruana: un experimento metodologico. In: Loker WM and Vosti S (eds) *Desarrollo Rural en la Amazonia Peruana.* Centro Internacional de Agricultura Tropical (CIAT) and the International Food Policy Research Institute (IFPRI), Cali, Colombia

Riesco A, Meini M, de la Torre M, Huaman H, Reyes C, and Garcia M (1982) Analisis exploratorio de los sistemas de fundo de pequenos productores an la Amazonia, region de Pucallpa. IVITA-CIID. Lima, Peru

Riesco A and Arroyo M (1997) Perfil socio-economico de la region de Ucayali. Unpublished report, Consorcio para el Desarrollo Sostenible de Ucayali/Proyecto de Desarrollo de Agroempresas Rurales del CIAT.

Sanchez, PA (1995) Science in agroforestry. *Agroforestry Systems* 30:5-55

Toledo, JM, ed (1994) *Biodiversidad y Desarrollo Sostenible de la Amazonia en una Economia de Mercado.* Stansa, SA, Lima, Peru

Latin America - *Hillsides*

Characterization of site for livestock research in Costa Rica - Tropileche

(1.1.2, S. Fujisaka, F. Holmann, G. Escobar (CIAT); L. Badilla, Nils Solorzano, Leticia Badilla, Luis Umaña, Vidal Acuña and Marco Lobo (MAG).

The objective of this activity was to characterize the existing animal production systems in the Tropileche benchmark sites in the Central Pacific region of Costa Rica, with emphasis on the characterization of existing resources, technologies, constrainsts, and opportunities.

Main achievements

- 44 livestock producers were interviewed
- There is demand for new and improved forage alternatives
- Research should be conducted with farmer participation

Dual purpose cattle in the pacific coast region of costa rica: land use systems & demand for forage alternatives

Abstract. Farmer-ranchers of the Pacific Coast Region of Costa Rica were interviewed. Holdings were small (4-20 ha), medium (21-60 ha), large (61-100 ha), and "hacienda" (above 100 ha). About half of those interviewed had dual (milk and meat) purpose operations. Other production systems were mixed crop and livestock, cattle fattening, calf production and sale, and dairy. Respondents reported few problems with their pastures and livestock. A major farmer concern was providing sufficient feed in the pronounced dry season. Strategies included renting pastures and providing animals with cane and chicken manure supplements. That nearly two-thirds had established some improved pasture (largely *Cynodon nlefluensis* or *Digitaria decumbens*) and a similar proportion had more recently sown *Brachiaria* spp. would argue for continued work on improved pasture systems. Problems associated with *Brachiaria* included high seed costs, low germination, and poor and costly establishment. Experience with forage legumes and trees was negligible. Further adaptive and farmer-participatory research is needed.

A small team of researchers from Costa Rica's Ministerio de Agricultura y Ganaderia (MAG) and the Centro Internacional de Agricultura Tropical (CIAT) conducted a *sondeo* to better understand resource use and production systems in the Pacific Coast region--where livestock systems dominate land use (Table 1)--and to

Table 1. Land use, Pacific Coast Region of Costa Rica, 1996*

Land use	Area (ha)	% of total
Livestock	188,533	85
Oil palm	11,130	5
Rice	6,500	3
Sugar cane	5,435	2
Mango	4,474	2
Others**	5,040	3

* Source: MAG, unpublished

** Coffee, beans, papaya, melon, watermelon, maize, tizquizque, vanilla, achiote, tomato, chili analyze findings in terms of present and future demand (and constraints) for pasture/forage innovations. The work represented an effort by and for TROPILECHE and the (CG) system-wide livestock initiative. Results are intended to assist in research planning in the region.

Methods

The *sondeo* was conducted 14-22 October 1996 by three to five researchers from MAG and three from CIAT. The group kept a set of guide questions in mind in order to converse with farmer-ranchers in the regions surrounding Orotina, San Mateo, Esparza, and Miramar. A formal or written questionnaire was not used. The team spent five days visiting farms and fields, and interviewing 44 opportunistically sampled respondents. Interviewers worked singly or in pairs. Interviews were conducted in the mornings and group discussions to review findings were held each afternoon. A final day was spent compiling data, discussing implications and conclusions, and brainstorming about future project activities.

Findings

Land use. Size of holdings ranged from four to 450 ha. We classified farms as small (4-20 ha), medium (21-60 ha), large (61-100 ha), and "hacienda" (100+ ha). Forty-one percent of holdings were small, 34% were medium, 16% were large, and 9% represented haciendas (Table 2).

Larger proportions of small (72%) and medium (53%) compared to the larger land holders (43-50%) produced annual crops such as beans and maize. Mean areas of annual crops for the small and medium holders having annual crops were 1.4-1.9 ha. At least half of those interviewed raised perennial (largely mango, citrus, cashew) or tree (ie *Tectona grandis, Gmelina arborea*) crops with the small and medium holders having means of 2.9 and 3.5 ha respectively. The proportion of respondents and areas held in forest or forest fallow increased from 22% of small holders with a mean 1.8 ha to 75% of the hacenderos having a mean 64 ha (Table 2).

Mean areas of pasture were 8 (small), 35 (medium), 54 (large), and 171 (hacienda) ha. Most pasture was native *jaragua* (largely *Hyparrhenia rufa*): 78% of small holders and all of the medium to hacienda holders had native pasture, with mean areas ranging from 7 to 159 ha. A minimum of two-thirds of respondents in each farm-size category had improved pastures of largely *Cynodon nlemfluensis* or *Digitaria decumbens* (and of smaller areas of more recently established *Brachiaria* spp). As a proportion of pasture holdings, small holders had 45% of total pasture lands in improved species, medium had 15%, large had 23% and haciendas had 7% (Table 2). *D decumbens* was produced by some for baling and sale. Other improved grasses in the area were estrella mejorada (*Digitaria swazilandensis*), jaragua mejorada (*Andropogon gayanus*), king grass (*Pennisetum purpureum*), and pasto Honduras (*Ixophorus unisetus*).

Livestock. Small holders had a mean 13 head of cattle, medium had 50, large had 66, and haciendas had 131. These included means of 11, 34, 37, and 70 adult animals respectively, such that adults per ha of pasture decreased as farm size increased--from 1.6 on small holdings to 0.5 on the haciendas. Mean numbers of cows giving milk ranged from 5 (small holders) to 14 (haciendas), with production largely in the 6-7 bottles/head/day range. Operations having 10 or more milk cows accounted for 12% of small, 47% of medium, 71% of large, and 50% of hacienda holders. Forty-four percent of small holders, 53% of medium, 71% of large, and 50% of hacienda could be classified as dual-purpose (milk and meat) producers. The others included cattle fattening operations, calf producers, and (two cases) dairies. Many of the small-holders (50%) but few of the larger operations (0-14%) relied on non-livestock and off-farm activities such as fruit (eg mango) and crop (eg rice, maize, beans, coffee) production or carpentry or hired labor (Table 2).

Table 2. Land use, interviewed farmer-ranchers, Pacific Coast Region, Costa Rica, 1996 (n=44)

	Small 4-20 ha (n=18)	Medium 21-60 ha (n=15)	Large 61-100 ha (n=7)	Hacienda 100 + ha (n=4)
Mean farm size	11	41	76	235
% w/annual crops	72	53	43	50
Mean area (ha)*	1.4	1.3	1.5	13.0
% w/perennial crops**	56	53	43	75
Mean area	2.9	3.5	1.4	13.3
% w/forest/fallow	22	53	71	75
Mean area	1.8	6.3	20.0	63.7
% w/sugar cane	39	40	43	50
Mean area	0.3	0.3	0.9	0.4
Total pasture area	8	35	54	171
% w/improved pasture	72	67	86	100
Mean area	3.6	5.4	12.2	11.4
% tot pasture improved	45	15	23	7
% w/native pasture	78	100	100	100
Mean area	7	32	46	159
Mean total head cattle	13	50	66	131
% w/milk cows	85	80	100	100
Mean milk cows	5	11	12	14
Mean bottles/day/cows	6.1	7.7	7.0	4.4
% tot w/10+ milk cows	12	47	71	50
Mean head adults	11	34	37	70
Mean adults/ha pasture	1.6	1.2	0.8	0.5
% dual purpose	44	53	71	50
% w/non livestock income	50	7	14	0

* Mean area for those respondents having the given item

** Includes afforestation w/commercial timber species

Pasture management. All farmers reported manual weeding of their pastures (by machete); and 79% applied herbicides (2, 4-D, Tordon, Combo) as needed. Thirty percent reported applying inorganic fertilizers, largely to their *Brachiaria* spp plots at establishment. A third (32%) of all respondents distributed evenly across classes rented pasture lands for part of the year--either in the rainy season to allow pastures to recover for the dry season or during the dry season when owned pasture resources were depleted (Table 3).

Worst weeds appeared to be *Sida* sp (locally Escobilla), what was tentatively identified as *Ischaemum indica* (locally Ratana), *Mimosa pudica* (Dormilon), *Paspalum virgatum* (Zacate Burro), *Rottboellia* sp (Zacate de Fuego), *Cyperus* sp (Piepaloma), and the unidentified Maton and Espino. Other weeds mentioned (but not

Table 3. Pasture management: use of herbicides, fertilizers and rented land *

	% all respondents
Herbicides	79
Fertilizers	30
Rented land	32

* Only one reported burning; the group thought that more used fire

identified) were Casa Gente, Chiguiza, Escobilla Morada, Quiebra Plato, Florecilla, Churrisata, Oreja de Chancho, Paira, Horguctillo, Muneco, Una de gato, Chaperno, Chan, Bledo, Canilla de Venado, Guizarro, Quebracha, Santa Maria, Achotillo, Vainilla, Ajillo, and Papa Miel. *Calapogonium mucunoides* (locally Taranta) was considered both a weed and pasture component by many respondents who recognized the benefits of the legume while controlling its domination over other pasture species.

Animal feed supplements. Considering all respondents, almost all provided animals with salt and mineral supplements; 72% provided molasses (largely in the dry season; and 44% provided chicken manure. Other purchased supplements included soybean husks, concentrates, and bone meal. Thirty-five percent provided sugar cane and 9% gave crop residues produced on-farm (Table 4).

Table 4. Use of feed supplements

	% of respondents
Purchased	
Salt	93
Minerals	84
Molasses	72
Chicken manure	44
Soybean husks	16
Concentrates	12
Bone meal	5
Palote	5
On-farm produced	
Sugar cane	35
Crop residues	9

Reported problems. Farmers reported relatively few problems associated with pastures, livestock, or life in general: 60% had no livestock problems; 70% had no pasture problems; and 70% had no general problems. The few livestock related problems included vampire bats (23%) and lack of water (9%). Pasture problems included weeds (19%, see above) and pests affecting *C nlemfluensis*. General problems were high input costs (19%) and low output prices (12%, Table 5). Livestock problems--which farmers reported having solutions--included ticks and fleas, carbon sintomatico, septicima, and mastitis.

Exposure to pasture and forrage alternatives or innovations. As mentioned, 62% of the respondents had experience sowing improved pastures other than *Brachiaria* spp; and the same proportion had experience (albeit more recent and on small areas) with *Brachiaria* spp. Few had experience with forage trees or *hala,*

Table 5. Reported problems

Problem	% respondents
Cattle	
None	60
Vampire bats	23
Lack of water	9
Snakes	5
Diseases	5
Pasture	
None	70
Weeds	19
Pests (in *C nlemfluensis*)	9
Winds/drying	5
General	
None	70
High input costs	19
Low output prices	12
Lack of roads	5
Lack of lands	5
Taxes	5

legumes (Table 6). Farmers commonly recognized that cattle ate the fruit of the tree *Guazima ulmifolia*. Projects in the area have worked to introduce *Gliricidia sepium, Cratylia argentea, Leucaena luecocephala,*

Table 6. Use of forage technical alternatives

Alternatives	% respondents
Improved pasture *	62
Brachiaria spp pasture	62
Legume forages	5
Forage trees	5

* Improved pastures other than *Brachiaria*; legume forages and forage trees were recently established on two farms each by projects

Erithryna spp, and *Morus* sp as multi-purpose species. The use of live fences was universal in the area. A few farmers had recently established *Arachis pintoi* as a part of other projects and mainly to control weeds and soil erosion under coffee.

Based on the interviews and on even more informal follow-up discussions, the following factors were identified as constraints to the adoption of improved pastures:

a) the high price (and unavailability) of seed,
b) low germination rates of the seed,

c) difficulties in establishment,
d) the need to prepare land/cost of mechanization,
e) availability of land to rent as an alternative,
f) the slow process of seed releases by the government, and
g) some lack of exposure to innovations.

On the other hand, other factors were identified as supporting the adoption of pasture and forage innovations:

a) lack of feed resources in the dry season,
b) possibly increasing prices for supplements such as chicken manure,
c) existing substantial adoption of improved pastures,
d) practice of establishing improved pasture following intensively managed high-valued annual crops such as watermelon,
e) the intensive management systems of the small-holders, and
f) the assumed higher yields associated with the alternatives.

Conclusions

For this draft, the group concluded that:

1. There is, especially with the small-holders, experience with and demand for improved pastures.

2. There would be high demand for innovations which would increase feed resources in the dry season.

3. There was negligible experience with forage legumes.

4. Almost all of those interviewed were familiar with the constraints to the adoption of improved pastures.

5. We need to know the results and experiences of the various other projects (eg ODA) which have worked in the area on reforestation, improved pastures, multi-purpose trees, soil erosion control, and green manures.

6. Research on the limiting factors mentioned above has already been conducted.

7. Further adaptive research is desirable on fodder and animal yields comparing existing and improved systems.

8. Participatory adaptive research on management of new alternatives and technology transfer (eg farmer-to-farmer) is needed.

9. Among other constraints, researchers now have overly large areas of responsibility (both in terms of geographical areas covered and in fields of expected expertise); and that local MAG technicians lack needed capacity.

The main constraint facing livestock operations was the lack of dry season feed resources. Farmers rented lands in the wet season so that pastures would be healthy for the dry or rented in the dry season once owned pastures were depleted. Farmers also purchased supplements such as chicken manure, concentrates, and molasses for their animals, but were worried about high and increasing costs of such inputs. Research needs to address the issue of dry season feed scarcity; and resulting innovations would be of high local demand.

Ex-ante analysis of improved forage alternatives

(1.3; F. Holmann)

Main achievements

- Demonstrated 35% of hillsides in dual-purpose farms could be protected for reforestation if forage production was intensified on lower slopes and still maintain same net income.
- New and improved forage alternatives are more profitable than current feeding systems but require matching genetic potential of cows.

The objective of this activity was to evaluate alternative feeding systems in dual purpose animal production systems in the benchmark sites by means of: (a) bio-economic optimization models to simulate different management and macroeconomic scenarios, and (b) identification of alternatives with potential for improving existing systems.

During the first half of 1997 visits were made to benchmark sites in Perú, Costa Rica, and Nicaragua to collect the information needed to do the ex-ante analysis of collaborating farms in order to determine their current situation in terms of management, use of resources, animal productivity and profitability. This information will be used to analyse alternative scenarios in terms of animal production, capital investment, and profitability from improved alternative feeding systems being implemented in the benchmark sites. It is expected that the ex-ante analysis will be completed by January 31, 1998.

The main conlcusions from a preliminary analysis for Costa Rica are the following:

A linear programming model developed to analyze agricultural production systems at the farm level was used. Under average productivities and input-output prices, the most profitable option is to grow sugarcane. However, this activity requires a topography which allows mechanization and soils with good fertility. The second and third best options are growing cashew and producing milk under specialized dairy systems. The dual-purpose activity was a viable option only when the price of milk was between US$0.19/kg to $0.13/kg or when the price relationship between beef and milk ranged between 4.5 and 8.

Beef production was a viable option only in situations where the price relationship between beef and milk was greater than 8.5:1, which has never existed in Costa Rica. However, it is an attractive activity in places where there is no infraestructure (ie., roads, electricity) and where the opportunity cost of labor is greater outside the farm since this activity requires little labor which in many cases, can be performed by children or adults excluded from the job market.

With respect to the forage alternatives evaluated, the marginal profitability of improved grasses and legumes is a function of labor wage rate, output price, and productivity. Thus, in dual purpose systems, the legume *Cratylia argentea* is 47% more profitable than the most common forage alternative (ie., jaragua) when the milk price is US$0.30/kg. However, when the price of milk is US$0.20/kg, the marginal profit of Cratylia es practically nil due to the fact that it utilizes 54% more labor than the Brachiaria+Arachis mix and 233% more labor than Jaragua.

Likewise, in dual purpose systems with a productivity of 1,000 kg milk/l and labor wage rate valued at US$10/day, the *Arachis+Brachiaria* mixture and *Cratylia* generates 45% higher net income than the alternative with jaragua alone. However, as labor wage rate increases >$13/day, the alternative with jaragua alone starts to be the best option under these low productivities. If milk productivity increases from 1,000 kg milk/l to 1,500 kg/l, the improved grasses and legumes are more profitable than jaragua under all labor wage rates evaluated in this study.

In addition, the trade-offs of intensification were estimated for the three animal production systems (ie., specialized dairy, dual purpose, and specialized beef, Tables 1 thru 3). Given current animal productivities, intensification liberates signifficant areas now under livestock use (ie., from 9% for specialized beef up to 35% for dual purpose systems). However, intensification increases the production costs in all cases (from 3% for specialized beef to 8% for dual purpose systems). Thus, to obtain the same net income per farm without increasing production costs per unit of product, the new and improved forage alternatives evaluated in this study need not only to increase stocking rate, but also to increase productivity per cow by at least 10%.

Table 1. Trade-offs of the intensification process in specialized dairy systems to obtain the same annual farm net income with different forage alternatives at two milk productivities.

	Jaragua @ 2,000 kg/l	B + A & *Cratylia* @ 2,000 kg/l	B + A & *Cratylia* @ 2,200 kg/l	Change[1] (%)
Area (ha)				
* Pastures	30	21.7	16.1	-28 (-46)
* Conservation	0	8.3	13.9	+28 (+46)
Net Income				
* Farm/yr	3613	3687	3,614	0 (0)
* ha/yr	120	170	224	+42 (+87)
Productivity (kg/ha)				
* Milk	971	1,648	1,842	+70 (+90)
* Beef	105	178	178	+69 (+69)
* Stocking Rate (AU/ha)	0.96	1.63	1.63	+70 (+70)
Cost of Production				
* Milk ($/kg)	0.187	0.203	0.186	+8 (0)
* Beef ($/kg)	0.59	0.63	0.58	+7 (0)
Use of Resources				
* Labor (# days/yr)	261	358	266	+37 (+2)
* Cows (#)	24.5	30	22.3	+22 (-9)
* Capital ($)	14,974	21,662	15,228	+45 (+2)

[1] Values in parenthesis show the porcentual change for the productivity level of 2,200 kg/l with respect to Jaragua.

Table 2. Trade-offs of the intensification process in dual purpose systems to obtain the same annual farm net income with different forage alternatives at two milk productivities.

	Jaragua @ 1,200 kg/l	B + A & *Cratylia* @ 1,200 kg/l	B + A & *Cratylia* @ 1,300 kg/l	Change[1] (%)
Area (ha)				
* Pastures	30	19.4	16.5	-35 (-45)
* Conservation	0	10.6	13.5	+35 (+45)
Net Income				
* Farm/yr	2,693	2687	2694	0 (0)
* ha/yr	90	138	163	+53 (+81)
Productivity (kg/ha)				
* Milk	487	812	899	+67 (+85)
* Beef	140	233	233	+66 (+66)
* Stocking Rate (AU/ha)	0.91	1.52	1.52	+67 (+67)
Cost of Production				
* Milk ($/kg)	0.197	0.203	0.193	+3 (-2)
* Beef ($/kg)	0.83	0.86	0.82	+4 (-1)
Use of Resources				
* Labor (# days/yr)	206	260	221	+26 (+7)
* Cows (#)	23.2	25	21.2	+8 (-9)
* Capital ($)	13,446	17574	14487	+31 (+8)

[1] Values in parenthesis show the porcentual change for the productivity level of 1,300 kg milk/l with respect to Jaragua.

Table 3. Trade-offs of the intensification process in specialized beef production systems to obtain the same annual farm net income with different forage alternatives at two beef productivities.

	Jaragua @ 200 kg/calf	B + A & *Cratylia* @ 200 kg/calf	B + A & *Cratylia* @ 230 kg/calf	Change[1] (%)
Area (ha)				
* Pastures	30	27.3	15.9	-9 (-47)
* Conservation	0	2.7	14.1	+9 (+47)
Net Income				
* Farm/yr	1292	1,292	1,294	0 (0)
* ha/yr	43	47	81	+9 (+88)
Productivity (kg/ha)				
* Milk	NA	NA	NA	NA
* Beef	157	263	280	+67 (+78)
* Stocking rate (AU/ha)	0.87	1.45	1.41	+67 (+62)
Cost of Production				
* Milk ($/kg)	NA	NA	NA	NA
* Beef ($/kg)	1.06	1.15	1.07	+8 (0)
Use of Resources				
* Labor (# days/yr)	134	258	149	+93 (+11)
* Cows (#)	22	33.5	19	+52 (-14)
* Capital ($)	14660	26,691	15,187	+82 (+4)

[1] Values in parenthesis show the porcentual change for the productivity level of 230 kg per weaned calf

Sites for production systems research in Central America

(1.1.4; S. Fujisaka and P.C. Kerridge)

Main achievements

- Hillsides sites and farmers in Nicaragua and Honduras were visited.
- Contacts were made with project researchers, government officials, others.
- A suggested research approach and funding possibilities are discussed.

Visit. We visited the hillsides "reference" sites in Nicaragua (San Dionisio, sub-cuenca del rio Calico, Matagalpa) and Honduras (Yorito, Yoro) to explore the need for and possibilities of conducting farmer participatory research to improve agricultural and natural resource use systems.

CIAT's work in the two hillside sites in Nicaragua and Honduras have featured collaborative efforts structured largely around characterization of the watershed sites using GIS analysis, the organization of CIALs (with the Programa Campesino a Campesino in Nicaragua and IDRC-Guelph's Investigacion Participativa en Centro America in Honduras), and data gathering to develop indicators of well-being. Funding has come from SDC, IDRC, BID, and Holland.

CIAT researchers working in Central America agreed that additional specific (agronomic, varietal, soils, resource management) research was needed in Central America; and that PE5 efforts might be an appropriate addition to the collaborative teams working in the region. Ronnie Vernooy in Nicaragua and Hector Baretto in Honduras each expressed the same view, ie that additional focused, farmer participatory agricultural problem solving within the respective sites would be appropriate and desirable.

We also discussed future collaborative research possibilities with MAG-Nicaragua. They were emphatic that research on specific, problem-solving agricultural innovations was needed. The MAG thought that such research should be conducted in a (so far not identified) site in the dryer region around Esteli as well as San Dionisio. Although in agreement that farmer-participatory research was needed, they were less supportive of community organization efforts per se. Eduardo Marin Castillo, Asesor de Planificacion del Uso de la Tierra, was identified as CIAT's contact person within the MAG.

Trip findings. Nicaragua. The local population of San Dionisio appears to be somewhat equally divided between small dual-purpose cattle ranchers and maize-bean farmers. The ranchers make extensive use of live fences, but have little in the way of improved animal feeding resources. Research similar to that conducted by Tropileche would be appropriate for the small ranchers.

Farmers plant maize followed by beans on large, sloping fields. For the observed bean crop, farmers planted along the contour and and used herbicides and low levels of tillage at crop establishment and for weed control. Use of moderate amounts of inorganic fertilizer in the maize crop probably benefitted the beans. Farmers' bean fields looked vigorous, with good plant density and few signs of pest or disease problems (other than an unidentified yellowing or requema in lower, possibly waterlogged areas).

Various projects in the area--apparently reacting to the cropping on steep slopes--have worked on the introduction of contour hedgerows as a means of soil erosion control. Soil loss rates were not available. Although some shallow soils and eroded fields were in evidence, many cropped fields appeared to have relatively deep soils; most fields displayed few signs of serious soil erosion; and in most cases the standing bean crop appeared healthy. We would recommend against our involvement in soil erosion control research. Given an apparent opportunity and need to introduce and test improved bean and maize germplasm, Dr Vernooy is coordinating farmer participatory varietal testing through the CIALs. The three trials visited were well designed and established. Farmers were enthusiastic; although they mentioned that interest had been insuffcient to involve more community members in conducting trails. Future work could involve many more farmers as interest grows, however.

Greater particpation was demonstrated by a women's CIAL working with vegetables. Nurseries had been established, but these had been placed in open fields far enough from water sources to make the necessary hand irrigation a task requiring substantial coordination among CIAL members. Rabbits, a local pest of beans, would probably become a problem as vegetables emerged. A suggestion was made to establish vegetable nurseries close to farmers' houses--albeit protection from chickens would then be required.

Overall, wider farmer participatory testing of improved forages (legumes including trees and grasses) and of annual crops (beans, maize) would appear appropriate to the area.

Honduras. Similar to San Dionisio, Yorito farmers grew maize (May-Sep) followed by beans (Oct-Dec). The area spans from 500 to 1400 masl and includes steep slopes, small areas of river-bottom lands, and wider, flat valley floors. Pine forests on shallow soils are interspersed with agricultural areas at higher elevations. Most farmers had few animals--at most a pair of oxen or a mule or horse for draft and transport. There are, however, substantial numbers of cattle ranchers and cattle in areas adjacent to the research area.

As in Nicaragua, although there was ample evidence of projects working on soil erosion control, we would make a preliminary guess that such work is largely unnecessary (or not serious enough as a problem that farmers would more widely invest in such innovations) given low tillage levels on sloping fields, low total rainfall, substantial vegetative cover other than at crop establishment.

CIALs in the area were testing new bean germplasm and integration of legume cover crops (mucuna) in the maize-bean system. The Program Regional de Maiz was testing maize cultivars on farmers' fields. CIAT has been testing the suitability of different mucuna and canavalia germplasm to different altitudes (given differences in flowering and flowering times by altitude).

In coordination with these efforts, we would propose: a) further rapid diagnosis focusing on land use histories of cultivated parcels, systems productivity, crop management practices, crop problems, farmers' problem solving practices, and related farmers' knowledge; and b) farmer participatory testing of a limited number of new maize, bean, cover crop legume, and forage cultivars. Research would be conducted at three to five sites along a transect including lower, middle, and higher altitude areas. Larger numbers of farmers interested in testing new cultivars and systems would be sought. Simple trials of sound experimental design would be necessary. Work could begin in both Nicaragua and Honduras at the start of the wet season in May-June, 1998.

Farmers in Nicaragua and Honduras make extensive use of live fences—largely but not limited to Gliricidia sepium. We are looking for ways to introduce more use of live fences in Pucallpa, Peru. Investigation of the extension programs--if any--needed to get such widespread adoption would be useful.

Conclusions

There appears to be a need for additional work by the systems project in Central America. Collaboration and coordination will be essential to the success of CIATs work in Central America. The ideas and suggestions presented here can be discussed by CIAT researchers (PE2, PE4, PE5, SN1, SN3, IP1, IP5, PROFRIJOL, TROPILECHE) working in Central America during the week of the ICR.

Norway has indicated that they will discuss details of a proposal MAG-Nicaragua submitted to Norway on CIAT's behalf. DICTA (Honduras) is interested in developing a joint project with CIAT in the area of production system research.

Improved predictability and prevention of erosion

(1.1.6; Karl Mueller Samann, Jesús A. Castillo, Kai Sonder, Ana María Patiño: Collaborators: Edgard Amézquita, Raúl Madriñán, Cesareo Gallego, Luis E. Mina, José Luis Adarve, Disnardo Peña, Universidad de Hohenheim, Germany; National University of Colombia, Palmira.)

University of Hohenheim – BMZ Project – Soil Degradation and Crop Productivity Research for Conservation Technology Development in Andean Hillsides Farming)

Main achievements

- Over 100 rainfall events were recorded over the last year for analysis of intensity –energy relationships in the tropical Andes.
- Soil parameters like turbimetry, the pattern of aggregate size distribution and hot water extractable carbohydrates (HWEC) could be identified as sensitive descriptors of changes in structural stability properties of tropical inceptisols.
- Parameters like turbimetry, content of HWECs and aggregate size distribution were also closely related with differences in soil management.

Report. Research on basic processes and the characterization of the physical parameters involved in soil degradation and erosion lead to a better understanding of soil loss and form the basis for sound decisions and decision supporting models in the areas of applied research and in conservation politics. They thus provide the foundation for targeting the problems in the field.

Since 1987 basic research related to soil and water management improvement is carried out on two sites in the Cauca department of southern Colombia. The Universal Soil Loss Equation (USLE), a widely used amount of data on climate, soils, soil dynamics, soil losses and cropping systems performance from over 40 runoff plots were systematically collected.

In the last year basic research concentrated on three mayor areas:

- Characterization of rainfall and rainfall intensity / energy relationships on a tropical Andean site (rainfall factor R).
- Research on soil inherent parameters and on soil water balance related with observed management induced changes in soil's susceptibility to erosion (erodibility factor K).
- The qualitative and quantitative relationships between erosion induced soil degradation and crop productivity and the economic and ecological appraisal of the costs of soil erosion.

a) Drop-size energy load-rainfall intensity relationship

Aggressiveness of rainfall, the agent inducing erosion processes at the soil surface varies a lot with intensity. Higher rainfall intensities like those occurring in tropical rainstorms are related with bigger drop size, higher velocities of raindrops and hence higher kinetic energy.

The relationships existing between rainfall intensity, drop-size distribution and the kinetic energy hitting the soil surface are well documented for temperate climates and the mathematical descriptors developed in North America are used in models pertinent to water erosion. Nevertheless its accurateness has never been tested or verified under conditions of the tropical Andes.

Complementary to the registering rain gauges used since 1987 to determine the amount and intensity of rainfall, in 1993/94 an electronic raindrop sensor – computer system (Distrometer) was used to describe rainfall intensity / energy relationships at the Santander de Quilichao site.

Preliminary results from 35 measurements done at that time suggested no mayor differences with regard to drop size distribution and intensity, between the tropical Andean site and temperate climates. However observations of only 35 rainfall events is too small a sample to draw conclusions and therefore additional measurements had to be carried out to examine this hypothesis and base R-factor calculations on a solid and sufficiently representative set of data.

New measurements of rainfall events were started in September of 1996 continued throughout 1997 with a high record density especially in the rainy season that lasted from March until June and during the second rainy period which started in October. During the dry season from June to September 1997 only one rainfall event was recorded and it didn't produce soil loss. In total 100 rainfall events were recorded from September '96 until October '97. Due to the climate during this time period most rainfalls were rather moderate ones with maximum intensities never exceeding 80 mm per hour.

It is hoped that the phenomenon "El Niño" will not interfere severely with the rainfall characteristics and - amounts in the remaining time available for this research activity. The raw data collected so far was imported into data sheets (Excel) to facilitate further evaluation, especially to calculate rainfall intensity, the erosivity factor R of the Universal Soil Loss Equation (USLE) and other rainfall characteristics like erosivity indices and to permit easier importation into the mega database on project results and of available figures accumulated in the project over the last ten years.

b) Search for data on the R-factor and mapping of erosivity

During the recent soil conservation workshop held in CIAT in October 1997, several contacts were made with visitors from different Andean countries on the acquisition of rainfall intensity data. The best possibilities are offered by IDEAM, the Colombian institute that manages hydrological and climatic information bases and related matters and the coffee-growers federation FEDECAFE. Other possibilities but probably with less amount of data exist in Ecuador and Venezuela.

Though data about rainfall intensity is rather scarce, as most meteorological stations are not equipped with a pluviograph it is expected that it will be possible to compile a set of stations for a better assessment of rainfall erosivity in the Andean region.

After the present rainy season a data gathering trip is planned in early 1998 with priority given to data available in Colombia and if resources will allow it also in Venezuela and Ecuador.

c) Validation of indicators for soil health with respect to soil erodibility

Research on erosion plots over the last years clearly showed that erodibility, a soil's susceptibility to be dispersed and carried away by the action of rainfall is a very dynamic soil characteristic. It tends to increase during prolonged soil exposure and in response to intensive tillage operations.

Soil loss measurements carried out in previous years in different cropping and management sequences also could show, that mayor changes in soil erodibility can occur over short periods of time. These changes are not sufficiently detected and differentiated by the prediction model which takes into consideration soil organic matter (SOM), aggregation degree classification, soil texture and infiltration properties.

A Ph.D. research program was therefore started in 1996 to investigate the impact that tillage, cropping practices and rotation sequences have on soil aggregation, microbial activity and other, biologically influenced parameters of structural stability or soil health with respect to erodibility.

The research effort aims at the identification of parameters that can be used as indicators for the monitoring and diagnosis of management impact on short- and long term changes in structural strength. The objective is to provide tools for the formulation of precise recommendations for land management in tropical hillsides, where soil erosion is the single most important factor of soil degradation.

Reproducible indicators, with some of them being simple and accurate enough to be used by local scientists and extension services to monitor the efficiency of regenerative techniques, can help to make better use of the high potential to reduce degradation through cropping and management practices.

At the same time they can issue an early warning signal if indicators show that current land use is conductive to an enhancement of erodibility rather than stability.

During the last year the influence of several long term management patterns, applied to the runoff plots on two research sites were evaluated as to its influence on the changeable erodibility of tropical inceptisols. The following parameters were tested for its applicability as quantitative descriptors for erodibility changes:

1. Determination of stable aggregates
2. Aggregate size distribution of stable soil aggregates
3. Quantification of the content of hot water extractable carbohydrates (HWCH)
4. Physical rupture and measurement of soil in suspension by turbimetry
5. Microbial activity
6. Abundance and diversity of soil fungi
7. Presence and composition of soil mesofauna

The numeric values of the above mentioned descriptors which are a function of the contrasting management history of the plots will be related with other, well understood soil attributes measured in the laboratory. Moreover and – very rarely found – figures will also be related with values of real soil loss and surface runoff under the influence of naturally occurring rainfall in the field and should lead to proven indicators for soils resistance to erosion.

The following six out of eight treatments were selected for evaluation in this experiments:

1. bare fallow after pasture (grass removed in March 1996) – check –
2. crop rotation + chicken manure + tillage
3. crop rotation including cycles of sown grassland + fertilizer + minimum tillage
4. crop rotation including weed fallow + fertilizer + tillage
5. crop rotation always with a legume associated + fertilizer + tillage
6. crop rotation including cycles of sown grassland + fertilizer + tillage

In a first phase methods and parameters were tested and adjusted for further use as descriptors and preliminary results have been obtained that still require verification in the field during the 1997/ 1998 cropping season.

The stability and size distribution of aggregates at the soil surface, two parameters that govern soil erosion to a large extent in most soils, were highly influenced by contrasting management patterns. In figure 1 the distribution curves of stable aggregates of a " virgin" soil after a) more than 10 years of improved pasture

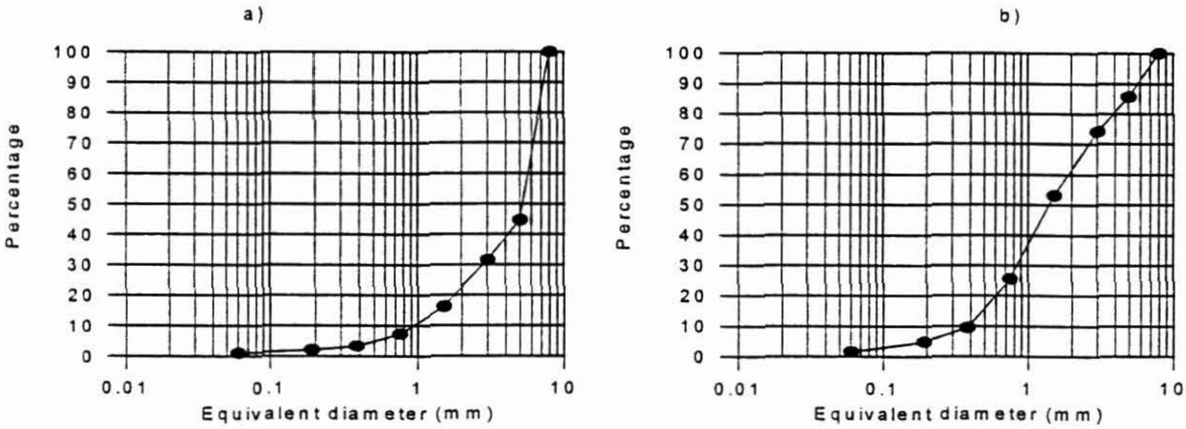


Figure 1 . Distribution of stable aggregate sizes at the soil surface on the Mondomo site in an a) "virgin" soil after more than 10 years of improved pastures and b) after 10 years of an intensive crop rotation including legume components, tillage and mineral fertilization.

and the distribution curve after b) 10 years of cultivation and tillage, show marked differences in shape. In the soil after grassland about 50% of the aggregates at the surface have a diameter of more than 5.5 mm, whereas after 10 years of cultivation less than 15 % have a diameter of more than 5.5 mm and more than 50% have a diameter of less than 1.5 mm.

The method of comparing the shape of the curve of the aggregate size distribution at the soil surface seems to have potential for being used as an indicator to describe the direction of changes, away from or towards more sustainability. Intensive monitoring of characteristics of aggregation at the soil surface in function of previous management is therefore undertaken in uniformly tilled and standardized plots of all treatments and will be compared against the "virgin" soil check.

Another parameter studied on the basis of different management patterns is the content of hot water extractable carbohydrates (HWEC). About 10 % of the organic matter of a soil may occur as carbohydrates and the majority of them as polysaccharides. From the point of view of the stability of soil aggregates they constitute an important component , because they act as binding agent for soil particles. In previous studies reported last year and in the present studies only the fraction of HWECs is evaluated.

Preliminary results from studies at the Mondomo site are shown in figure 2. Highest levels of hot water extractable carbohydrates could be observed in the "virgin" soil after recent removal of the improved pasture followed by the soil from a crop rotation with minimum tillage, a conventional rotation with tillage and lowest levels after several years of a bare fallow treatment.

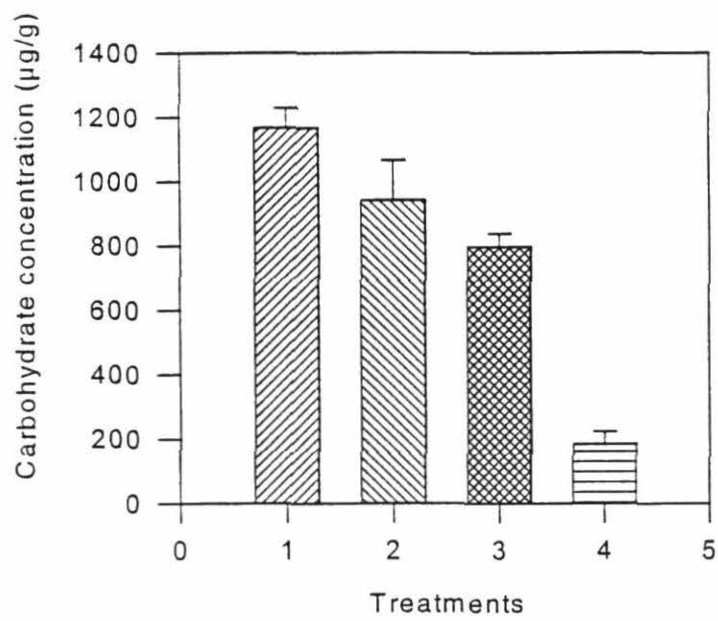


Figure 2. Concentration of hot water extractable carbohydrates (HWEC) equivalent to µ g glucose per g of soil in aggregates >0.25 mm in an oxic Humitropept of the Mondomo site. 1 = "virgin" soil after removal of grassland, 2 = crop rotation with minimum tillage 3 = conventional rotation with tillage 4 = bare fallow for more than 5 years.

Similar results have been obtained with the method of monitoring structural stability by turbimetry (results not shown) but the method is still in the process of refinement for evaluating the soil type under investigation.

Starting in October 1997 the response values of the selected variables will be related to values of real soil loss from tilled bare fallow plots from "virgin" plots after grassland (best bet reference value) and from plots with variable soil-crop management history. Correlations with other standard parameters of structural stability in the laboratory will also be established. The overall objective of this procedures is to prove their aptitude as indicators of changeable erodibility of a given soil. It is assumed, that as a result of this verification process a set of parameters can be selected for the diagnosis of a soil's erodibility status. As already mentioned changes in the erodibility of a soil are often attributed to biological agents and their influence on the stabilization of macro aggregates or even the reconstitution of soil structure. However, in spite of their high potential as indicators for soil health and their influence on structural soil dynamics, the extent and the nature of biological reconstruction agents is still poorly understood.

First results from research started in this area a few months ago suggest, that Penicillium, Trichoderma and Rhizopus exert a very positive effect on soil structure in the inceptisols evaluated but both the role of fungi and the role of soil mesofauna (e.g. mites) is not yet clear and needs further evaluation. A M. sc. thesis research project has therefore been started in collaboration with the National University of Colombia in Palmira (Ana Maria Patiño). Samples will be taken from the same treatments of the erosion plots as those used in the Ph. D. thesis of Jesus A. Castillo and will allow to establish relationships between management, soil physical properties and the presence and function of the biological agents under evaluation.

d) Relation between indicators and soil-crop management

As it is shown with the examples presented in figure 1 and figure 2 most of the parameters used in this study not only showed high correlation values with soils susceptibility to erosion but could at the same be related to variation in management practices. The parameters therefore fulfill an important requisite for its use as indicators, because gains in structural sustainability can be related to soil-crop management practices and hence to recommendations for better land husbandry.

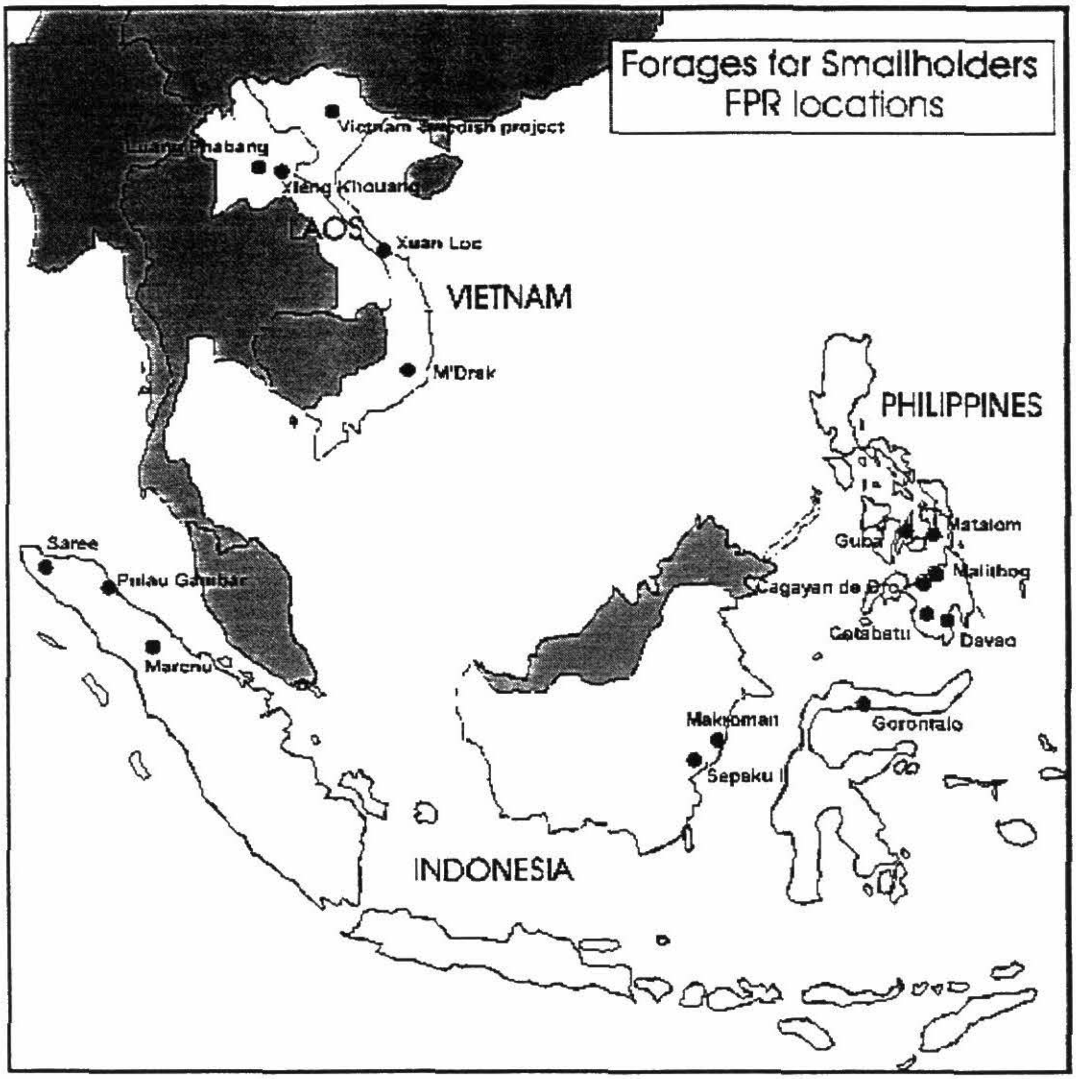
References

Haynes, R.J. and Francis G.S. 1994. Influence of crop species on microbial biomass and soil aggregation. Transactions 15th world congress of Soil Science. Vol. 4B. Acapulco, Mexico, July 1994

Molope, M.D., Page, E.R. and Grieve, I.C. 1985. A comparison of soil aggregate stability tests using soils with contrasting cultivation histories. Communications in Soil Science an Plant Analysis 16: 315-322

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

Wischmeier, W.H. and Smith, D.D.1978. Predicting rainfall erosion losses - a guide to conservation planning. US. Dept. of Agriculture. Agricultural Handbook No. 537, Washington D.C.



Asia - *Forages for smallholders*

The forages for Smallholders Project (FSP) is a Southeast Asian regional project that began in 1995, funded by AusAID and managed by CIAT (Centro Internacional de Agricultura Tropical) and CSIRO Tropical Agriculture (the Commonwealth Scientific and Industrial Research Organisation). Its focus is to develop forage technologies in partnership with smallholder farmers in upland areas, where they are needed for livestock feeding or resource management (including erosion control, soil fertility improvement, weed control and reducing labour requirements).

The FSP is a network of smallholders farmers, development workers and researchers. It is coordinated by national organisations in Indonesia, Laos, Malaysia, Philippines, Thailand, Vietnam and southern China. In 1997, the FSP worked at seventeen on-farm sites in Indonesia, Laos, Philippines and Vietnam (Figure 1). Additional sites will become operational in Laos and Vietnam in 1998.

Minimum data for site characterization in on-farm studies in S.E. Asia

A visit was made to Asia by Sam Fujisaka to review the farmer participatory activities within the Forages for Smallholders and the Improved Sustainability of Cassava-based Systems Projects. Particular attention was given to initial site characterization with respect to assessing future impact. We present both this report and framework that has been adopted by the FSP.

CIAT's farmer participatory research in asia: towards improving trials and assessing impacts

(1.1.3; S. Fujisaka)

Main achievements

- Farmer participatory research sites in Asia were visited.
- Recommendations are provided for improving FPR in soil conservation and use of forages and legumes for animal feeding systems and improved fallows.
- Recommendations are provided for improving impact analysis.

Abstract. The International Center for Tropical Agriculture collaborates with national agricultural research systems in Southeast Asia on farmer participatory research to improve forage and cassava systems. Research includes work on a range of systems in which forages can play different problem-solving roles and on soil erosion control in cassava systems. Several sites were visited and farmers interviewed. Suggestions are provided for the possible improvement of the farmer particpatory research and the measurement of project and research impacts. Suggestions concerned improved targeting by working with individuals and community sub-groups in the diagnostic process, improved trial lay-out to facilitate data recovery and demonstration effects, on-farm monitoring of both both technical performance and farmer feedback, facilitating farmer discovery and innovation in participatory research, and impact and adoption assessment.

Introduction

Field sites where the International Center for Tropical Agriculture (CIAT) collaborates with the national agricultural research systems (NARS) of Thailand, Laos, Indonesia, and the Philippines on farmer participatory research (FPR) were visited in February 1996 to consider the issues of site characterization, farmer-participatory technology evaluation, and impact assessment.

Research to improve agricultural systems through use of improved forages is conducted at three sites in Xieng Khouang Province, Laos, at two sites in East Kalimantan, Indonesia, and on Leyte in the Philippines. These sites are among 30 located in Indonesia, Laos, the Philippines, Vietnam, Malaysia, Thailand, and China where the "Forages for Smallholders Project" (FSP) is managed by CIAT and the Commonwealth Scientific and Industrial Research Organization (CSIRO), with funding from the Australian Agency for International Development (AusAID).

Additional research is being conducted at one site in Thailand and two in East Java, Indonesia, to improve cassava-based systems through soil erosion control, improved cassava germplasm, and soil nutrient management. These sites are among 13 located in Thailand, Indonesia, Vietnam, China, and the Philippines; and linked via a research network funded by the Nippon Foundation of Japan.

Researchers at most of the sites used participatory rural appraisal (PRA) techniques to characterize sites, diagnose problems, and prioritize participatory (and other) research. In terms of FPR implementation, sites ranged from initial start-up efforts to fairly well-established farmer trials. FPR trials included measurement of soil run-off under different erosion control alternatives, screening of "best bet" forages, and farmer-designed forage trials by "spontaneous" collaborators.

Site visits

For the FSP forage research sites, Peter Horne (CSIRO/CIAT), Sam Fujisaka, and Phonepaseuth Phengsavanh (FSP) visited several sites (Ban Ta, Ban Sang, and Ban Phousi) in Xieng Khouang Province in Laos; Horne, Fujisaka, Nathan Russell (CIAT) Maimunah Tuhulele (Directorate General of Livestock Services, Jakarta),and Ibrahim (East Kalimantan Livestock Service) visited Sepaku and Makroman in East Kalimantan; and Werner Stur (CIAT), Francisco Gabunada (CIAT), and Dolores Alcober (Farm and Resource Management Institute, FARMI, at the Visayas State College of Agriculture, ViSCA) visited the Matalom site(s) in Leyte, Philippines.

For the Nippon Foundatation supported network of cassava research sites, Reinhardt Howeler (CIAT) and Fujisaka visited Soeng Saang in Thailand; and Howeler, Fujisaka, Russell, and staff from the Research Institute for Grain Legumes and Tuber Crops and Brawijaya University, both in Malang, East Java, visited the Blitar and Dampit sites in East Java.

CIAT, FSP (in the case of the forage FPR sites), and NARS researchers visited the sites, farmers' fields, and research trials--both FPR and researcher-managed. Farmers were informally interviewed at each site. NARS staff (and staff of a Lao-German project in Laos) and local farmer leaders provided additional information at each site. Impressions gained and suggestions offered reflect short field visits: inaccuracies and misperceptions are hopefully not extensive.

The sites

Forage research sites. Forages research in Laos, East Kalimantan, and the Philippines consists of small farmer testing of improved grasses and legumes--including leguminous trees--for livestock feed, improved soil nutrient cycling, fallow improvement, and conversion of areas dominated by *Imperata cylindrica*.

FPR on forages is conducted in collaboration with the Lao-German (GTZ) Nam Ngum Watershed Management and Conservation Project (NAWACOP). NAWACOP works at several sites--including Ban Ta, Ban Sang, and Ban Phousi--in Xieng Khouang Province.

Farmers at Ban Ta managed small lowland rice paddies and larger fenced fields for shifting cultivation of upland rice, opium poppy (*Papaver somniferum*), and other upland crops. Cattle were pastured in common access grazing lands located some 5 km from the village. Farmers were starting to test forages, with objectives of improved and more accessible animal feed, fallow improvement and improved soil nutrient recycling and weed control. Trees for use as live fences will be tested in the future.

Farmers were testing forages for livestock feed at Ban Sang on the Plain of Jars. Farmers grazed animals on local grasses (*Themeda* sp, others). Extremely low available phosphorous (3-5 ppm) was a factor leading to severe animal health problems and to difficulties in producing forages without fertilizer P applications (Gibson 1996). One interviewed farmer lost a cow in the past year. He described symptoms of P deficiency, but had treated the animal with antibiotics which cost more than the triplesuperphosphate (TSP) needed to have cured the animal.

Farmers in Ban Phousi had sufficient rainfed lowland rice (and opium poppy) that shifting cultivation on their sloping lands was reportedly declining. Forages for carabao (water buffalo) strengthening prior to land preparation, for pregnant and lactating females, and for cattle fattening may be among needed and desired innovations. Carabao in the area appeared healthy and fairly well nourished.

FPR on forages is being conducted in East Kalimantan as a collaborative effort by FSP, CIAT, the Directorate General of Livestock Services, Jakarta, and the East Kalimantan Livestock Service headquartered in Samarinda.

Sepaku farmers are transmigrants from Java. They have established small, relatively intensive tree- and crop gardens surrounding their homelots along the unpaved access roads. Most farmers had lowland rice paddies formed along natural watercourses and lower areas near the settlements. The surrounding uplands were dominated by *Imperata* grasslands. Wild pigs--which are neither hunted nor consumed by the Muslim population--made food cropping in the grasslands virtually impossible. Cattle were a main system component, with animals now grazed (both tethered and herded) in the grasslands and supplemented by cut-and-carry feeding of the more palatable native grasses. Farmers complained that such grasses were now found only at greater distances, making cut-and-carry more time consuming. Cattle appeared relatively well nourished.

Makroman farmers produced maize, cassava, and lowland rice. Although clearly not distributed evenly across farm families, Makroman's approximately 1100 families had some 1000 head of cattle, 1100 goats, 900 ha of lowland rice, and a total village area of 20,000 ha. The landscape included large lower areas were salinity was a problem and some upland areas dominated by *Imperata*. FSP works with two farmer groups: Maju farmers had both goats and cattle, while Sidodadi farmers raised only goats. The few cattle seen appeared to be well-managed and healthy. Use of oversown *Centrosema pubescens* and *Stylosanthes guianensis* as a green manure and live mulch in maize and cassava was being tested by at least one farmer.

Matalom, on the island of Leyte in the Philippines, consists of a lower area of acidic soils (from pH 4.5) and an upper area of calcareous soils (up to pH 8.4). Farmers in the lower Barangay San Salvador grew paddy rice, maize, sweet potato, and some upland rice. Most had a few cattle, either owned or managed under a local sharing system (*alima*). It appeared that cattle were sold to finance children's educations or to make needed home improvements, and that remittances from employed sons and daughters living outside of the community formed a substantial part of local incomes. Farmers complained of decreasing open- or common access grazing areas (where animals were tethered) due to increasing numbers of animals. Overgrazing, pasture dominance by *Axinopus compressus*, and under-nourished animals were common throughout the area.

Barring reductions in aggregate herd size as a response to declining forage resources (or to other economic or policy factors), farmers clearly needed additional and better forage resources. Farmers did not supplement animaldiets for periods of peak draft demand or for pregnant or lactating females.

Farmers in the upper area (Monte Alegre) of calcareous soils relied largely on cash incomes from production and preliminary processing of abaca (*Musa* sp) fiber. Some families mantained goats, which were both tethered and penned and fed (using cut-and-carry) leaves of the local *Leucaena leucocephala* and *Gliricidia sepium*. Farmers complained about a relatively recent and growing problem of infestation by *Chromolaena odorata*. Farmers had an insignificant number of cattle. Not observed, the community reportedly had a substantial number (40) of carabao, apparently in the lower areas.

Cassava research sites. Sites visited in Thailand and East Java feature FPR on soil erosion control and both FPR and researcher managed trials/demonstration plots on cassava varieties and soil nutient management.

Farmers from Ban Noen Sombuun (Soeng Saang District, Korat Province, Thailand) produced cassava for the commercial starch market on gently undulating slopes. The relatively large fields with long slopes were subject to soil erosion, although not as severe as in other more steeply cultivated areas in Thailand (and throughout the region). Farmers reported increasing cassava yields due to adoption of new varieties (Rayong 1 followed by Rayong 5 and Kasetsart 50). Farmers did not seem to be very concerned about soil erosion.

Farmers in Blitar, East Java, grew maize, soybean, upland rice, a variety of tree crops, and fast-growing trees for timber. The calcareous soils ranged from shallow with exposed sub-soil rocks to deeper soils in more level areas. Farmers had terraced much of their land, with construction reportedly following granting by the government of private land tenure only a few years ago. Farmers' terraces, live fences, and hedgerows appeared to control much of the potential in-field soil erosion in this area of sloping but intensive agriculture. Gully erosion by run-off between fields appeared to be a problem, however.

Farmers in Dampit, East Java, produced fewer crops and more cassava; and had terraced their lands less than Blitar farmers. Besides terracing, farmers' contour ridging within cassava fields would appear to reduce soil erosion. Farmers were most interested in the cassava varietal testing, secondly in the fertilizer trials, and lastly in the soil erosion control trials.

Farmer-participatory research

Site selection. Sites ideally should be selected as those in which given problems to be addressed exist, where problems are serious enough that farmers have sought solutions to the problems, where potential technical innovations function in the manner intended, and where the problem-solving superiority of the innovation(s) can be clearly demonstrated.

Forage research sites were selected to represent agroforestry, upland, plantation, grassland, and lowland farming systems (FSP 1995); and somewhat different forages and uses are being tested as appropriate to each site type. For example, Ban Ta represents fenced shifting cultivation plus extensive cattle grazing where improved fallows for improved soil nutrient cycling and eventual grazing are being tested. Nearby Ban Phousi represents a lowland system having both cattle and carabao feeding needs. Sepaku represents a grassland and cattle system in which increasingly scarce quality grazing may induce farmers to sow forages for cut-and-carry supplementation; while nearby Makroman represents a site with few large animals, but in which soil nutrient cycling and ground cover were among primary concerns. Both FPR and researcher-managed trials in these different systems are to eventually be tailored to local systems needs. Such site differentiation and research targeting should contribute strongly to the success of the FPR efforts and will facilitate *ex post* impact assessment.

Although the cassava research sites were not similarly classified, the three sites visited varied from large field cassava monocropping in Thailand, to a system in which cassava is one of several important crops produced on small farms (Blitar, Indonesia).

A possible concern is that the sites where cassava is a major cash crop did not feature the steep, more erosion-prone slopes found in, for example, northern Thailand and parts of Sumatra. The cassava farmers largely reported increasing yields and a lack of concern over their moderate rates of soil loss. Effective FPR on soil erosion control will likely be more difficult in areas where: a) farmers do not perceive productivity losses due to soil erosion and b) soil losses in the demonstration contour treatments may be only slightly less than farmers' current practices.

As an arguable idea based on comparing sites around the tropics, perhaps a minimum of about 80 t/ha/year of soil loss is necessary (but not necessarily sufficient) for farmers to be sufficiently concerned about soil erosion such that they would be willing to invest in new soil management practices.

Site Characterization. Site characterization at most of the sites relied upon PRA tools and interactions with farmer groups.

For the NAWACOP sites in Laos, project personnel conducted participatory "situation analyses" which examined natural resources, local social-institutional and economic structure, and site-specific factors. The project uses aerial photos for participatory land use planning. Results are available through the NAWACOP project.

PRA was conducted in the East Kalimantan sites as part of a training course in FPR conducted by FSP and the Directorate General of Livestock Services. Written results of these exercises--if they exist--were unavailable, although FSP-DGLS staff were very able to recall PRA results. PRA or "participatory diagnosis" (PD) was similarly conducted in Matalom by FSP and FARMI-ViSCA as part of a similar training course. Written results are available (Gabunada *et al* 1997).

PRAs were conducted by the cassava researchers at the FPR sites in Thailand and East Java. Written results were either not produced or were not made available. The cassava research, however, implicitly--and probably correctly--concluded that soil erosion was a problem at each site, that farmers needed and wanted new cassava varieties, and that N, P, and K trials were needed to assist farmers in their fertilizer-use decisions.

Overall, site characterization (and, as will be discussed, impact analysis) could benefit from interviews with individual farmers. Benefits for characterization would include a better understanding of different strategies encountered within sites--e.g. cattle fattening, calf production, single animal "bank accounts" or draft power in the case of livestock systems and forage needs.

Diagnosis. Initial characterization needs to be diagnostic as well as descriptive. Farmers and researchers need to jointly identify and prioritize problems, and to understand interacting problem causes and effects. Farmers' knowledge, perceptions, and problem solving approaches need to be understood.

The FSP researchers have done well in combining characterization, often a descriptive process, with adequate problem diagnosis, identification of current farmer problem solving practices, and identification and prioritization of needed further FPR (eg Gabunada *et al* 1997; Gibson 1995; NAWACOP, personal communication). Although the cassava researchers are clearly correct in their concerns regarding soil erosion control, FPR may turn out to be more successful in germplasm screening and selection and soil nutrient management than in soil erosion control due to the lack of farmer concern over the rates of soil being lost at the sites visited.

Farmer participant selection. Farmer participants might best be selected among those who: a) are faced with and are aware of a given problem that the proposed FPR and associated innovations are meant to address, and b) have attempted to solve the problem in the past. "Problem" in this case should be factors leading to reduced yields and/or income. Individuals wanting to join the participatory research after seeing initial field trials should be allowed and encouraged to participate, especially in the more farmer-designed "spontaneous" experiments. It is less desirable to work with farmers whose participation is based on their perceived or real benefits of project participation *per se.*

Charismatic, enthusiastic farmers had leading roles at several sites. In some cases, these early-adoptors appeared to be effective in increasing farmer participation. On the other hand, project staff may become overly comfortable working with these leaders at the expense of working towards more extensive participation and participation of the initially less enthusiastic.

FPR trial design: forages. At least in the Philippine site, farmers' trials were divided into those in which farmers volunteered to test at least four, usually "best bet" species, and more "spontaneous" trials in which farmers were free to test whatever they requested. Such a division of trials is sensible and useful. Some suggestions may be appropriate considering all forage sites visited:

a) Some of the more "formal" trials were fenced, others not. Unwanted grazing was a "problem" in some of the initial trials in Laos. These trials might all be fenced.
b) Where appropriate, live fence species trials can be incorporated with the forage FPR trials.
c) Line-sown forages might best be planted along the contour where slopes are more than 18 percent.
d) Clear and relatively permanent marking of treatments and signs briefly explaining each trial would be useful for data collection and in promoting demonstration effects of each trial.
e) Farmer-accessible locations would increase the demonstration potential of FPR trials.

FPR trial design: soil erosion control. Initial poor layouts supported the idea of increasing supervision on a fewer number of erosion run-off trials in order to increase effectivity of these trials both as trials and as demonstrations. At the same time, it would be desirable to increase the number of farmers (interested in) testing best-bet or desired contour vegetative strip alternatives. Some ideas for the run-off trials, either farmer or researcher managed:

a) All vegetative strips must be established along the contour. Simple instruments such as the A-frame or carpenter's level on a string can be used to establish contour lines.
b) The sides of the treatment plot must be perpendicular to the contour.
c) Contours should extend in-line across the various treatments so that natural terracing can take over the whole area.
d) Run-off trenches need to be placed along a single contour line.
e) Trees in hedgerows need to be established at closer distances for effective hedgerow formation.
f) To increase realism and demonstration effects, treatment lengths should be sufficient to incorporate at least three contour rows, each placed at distances corresponding to a one meter elevation drop.
g) Again, soil erosion trials may need something in the order of at least a 20-25% slope, 80 t/ha/year soil loss, and shallow soils to be effective as farmer demonstrations.
h) Farmer-treatment controls must be accurately replicated in trials. Using a treatment "worse" than actual farmer practice (eg not using contour ridges where farmers use such a measure) does not allow farmers to accurately compare their practices to tested innovations.

A caution, however: as run-off trials are better managed through more researcher supervision, there may be a tendancy for the same researchers to provide recommendations based on trial results. Such recommendations can work against farmer experimentation, learning, technology adaptation, and eventual adoption of individually or locally appropriate innovations.

Trial monitoring and data collection. Among data to be collected as FPR trials are conducted are: a) performance indicators for the forages or erosion control treatments, b) farmer evaluations and perceptions regarding treatments, and, to the extent possible, c) records or estimates of benefits derived from, and of direct and/or opportunity input costs (ie in terms land, labor, and capital) required by the innovations. Again, Gabunada *et al* (1997) provide good examples of "researcher observations" and "farmers' comments"--both "negative" and "positive". Although it may be too early at most of the sites to measure costs and benefits, the issue should be considered (and is discussed in the section on impact assessment).

The collection of farmers' appraisals and insights should be done in the field with individual farmers. Participating farmers should each be encouraged to discuss what they feel are possitive and negative factors associated with particular innovations. Farmers' individual observations can be aggregated and presented in simple descriptive, tabular form.

An important activity of the cassava FPR is the farmer field day in which experimental plots are harvested, yields (cassava and intercrop) measured, and results compiled and discussed by participating farmers. Farmers and researchers work with soil erosion, soil nutrient management, and varietal treatments. Farmers' initial evalautions have been used to select treatements for subsequent seasons of FPR.

Forms of FPR. Useful approaches to FPR include: a) relatively formal, replicated trials conducted by a few farmers with moderate trial design and organizational inputs provided by researcher-facilitators (eg Ashby 1993), b) more informal trials, often without replication, but with some researcher-inputs into "best-bet" treatments and trial lay-out (eg the FPR erosion trials and the more formal forage trials discussed in this paper), and c) informal farmer-developed testing of components and adaptations of components and combinations of components.

The formal trials produce replicable results and allow for statistical testing of hypotheses, but leave little room for farmer innovation and broad participation. Supervision and organization costs can be high. The simpler trials--as used at the sites visited--may provide findings suitable largely for the formulation of further hypotheses or may suggest trends, but often serve as demonstrations and learning tools for participating farmers.

The very informal testing of new combinations by interested farmers can result in greater numbers of participating farmers, locally appropriate problem solutions, and possible adoption of such innovations (Fujisaka 1993). Projects usually must encourage and enable such farmer experimentation through initial provision of seed or, for example, of farmer-to-farmer training.

The cassava and the forages FPR appear to have settled on the relatively more informal trials of best bets followed by more extensive, less "supervised" trials by interested farmers. This overall strategy appears to be quite appropriate to the (Asian) sites visited.

Towards impact assessment

***Ex ante* impact assessment.** Broad *ex ante* impacts are commonly assessed in the initial development of research projects in the definition of problems and statement of expected outputs.

Considerable work has been done to define forage needs and to target forages research in Southeast Asia. Assessments of then future needs made 10 years ago were accurate: the region's self-sufficiency in meat production was 94% in the period 1973-77, but was expected to drop to 62% by year 2000; and demand for forages--given increases in ruminant production--was expected to double by year 2000 (Remenyi and McWilliam 1986, cited in Stur 199x). Implicitly, future adoption of improved forages and increased self-sufficiency in meat production (although not necessarily causally linked) would be quantifiable and was to comprise the major desired impact.

In terms of soil erosion, the quantity of sediments eroding into rivers and then flowing into the world's oceans is greatest in southeast Asia (Milliman and Meade 1983). How much of the sediment load can be attributed to natural processes vs human activities, and how much of the erosion caused by human activities is due to agricultural practices are not known. Soil loss rates measured on upland agricultural fields in the region vary widely, as do soil losses in cassava growing areas. The FPR on reducing soil erosion in cassava systems would have benefited from initial quantification of soil losses in the different cassava growing areas and general targeting (eg areas where soil losses exceed given levels) in order to make some general *ex ante* estimates of expected impacts.

***Ex post* impact assessment.** Three levels of *ex post* impact analysis can be considered: the region (Southeast Asia), the targeted agroecosystem, and the project site. Impact assessment is most practical at the site level, however.

For the forages research at the regional, Southeast Asia, level, broad impacts in terms of increases in herd sizes, liveweight gain rates, adoption of introduced forages and meat self-sufficiency are among longer-term objectives. The FSP would not necessarily be concerned with *ex post* <u>measurement</u> of such impacts as these are expected after broader technology transfer and corresponding implementation of needed policy and institutional innovations. Such impacts, however, are long-term goals and are measurable, usually through use of national agricultural statistics.

Similarly, for research on soil erosion at the regional level, monitoring of sediment loads in the world's major river systems may provide one way to assess impacts of changing land management trends. Again, this would not be a project activity (albeit a key concern).

In targeting different farming systems the FSP forages research defined its more specific expected extrapolation domains. The systems were agroforestry, upland, plantations, grasslands, and lowland systems. Countries were Indonesia, Laos, Malaysia, Philippines, southern China, Thailand, and Vietnam. Given such targeting, it would have been ideal to have data on: a) area of each system by country, b) current herd size by system and country, c) current adoption of introduced forages by system and country, d) typical liveweight gains by system and country, and e) numbers of livestock producers per system and country. Impact analysis could then, at a minimum, assess changes in herd sizes, forage adoption, and liveweight gains. Unfortunately, data to clearly delineate the sub-systems are lacking, as are ways to disaggregate data on (among others) livestock numbers by subsystem. Data on current levels of adoption of introduced forages is similarly lacking.

For FPR on soil erosion in cassava systems, different cassava producing systems (eg cassava in shifting cultivation, commercial starch producers, cassava in mixed permanent cropping) in Asia were not initially defined and then characterized in terms of respective ranges of soil losses. Impact analysis by the project at the targeted agroecosystem level is, therefore, not possible.

Impact analysis at the local or site level, however, can be done using data is collected at the initiation, conduct, and termination of project activities.

For the forages research, useful community level data to be gathered initially would include:

a) "problem(s)" to be addressed by the research in the community and agroecosystem (ie what type of system does the communuty represent?), and proposed measures of success;
b) problems and opportunities defined in terms of different farmer strategies encountered in the community (eg, lowland rice producers with a draft buffalo vs cash crop producers with several head of beef cattle vs upland farmers needing improved nutrient cycling);

c) similarly, problems and opportunities defined in terms of different livestock strategies employed within the community (eg calf production, dual purpose, steer fattening, draft animal maintenance) and the proportions of persons engaged in each strategy;
d) number of families, number of families having livestock, total number of different types of livestock, and ranges of individual livestock holdings; and
e) livestock feed resources and different livestock feeding systems employed in the community (ie open access grazing, grazing on own fields plus cut and carry, types of pasture and fodder resources used, use of supplements, use of fodder trees); and rough proportions of persons engaged in each activity.

The above would allow researchers to further define problems and objectives, target individuals and groups within the community, and specify expected achievements.
Data gathered from individual farmers representing project-targeted sub-groups could then be obtained:

a) The above-mentioned numbers of livestock and feeding systems employed per individual farmer participant;
b) Simple analyses of costs and returns of individuals' current livestock systems;
c) Use, if any, of innovations (ie introduced forages).

Simple costs and returns can be obtained by gathering data from a sample of farmers representative of the larger target group (and of any smaller sub-set of participating farmer researchers). Data would include material, cash, and labor costs and yields and gross returns. Data should reflect annual costs and returns, and should reflect both costs and returns per annimal unit and per farm. Given difficulties of obtaining liveweight gains, increase in price of animal at time of sale vs at the time of purchase can be used to tabulate gross returns. Calculations can then include returns to variable costs and to factors (labor, farm resources, material costs, cash).

Ex post impact can then be assessed at the end of the project by examining:

a) changes in numbers and types of livestock (by both participating and non-participating farmers);
b) adoption of innovations: changes in livestock numbers, adoption of new livestock feeding systems, and adoption of introduced forages--expressed in terms of numbers of individuals and areas;
c) simple analyses of costs and returns of adoptors' systems; and estimation of differences in income (returns above variable costs) from livestock enterprises, comparing adoptors and non-adoptors or pre-and post-adoption.

Adoption (and non-adoption) of innovations should be assessed over the course of the project via experimental plot monitoring and farmer interviews. Plot monitoring was discussed above and reflects the need to measure the performance of innovations and to accurately compare that performance with the performance of existing farmers' systems and practices. Field visits should also serve to assess adoption of innovations by project non-participants.

Farmer interviews are necessary to obtain farmer feedback on the innovations tested. Farmers who participate in the project and who adopt innovations, non-participants who adopt, participants who do not adopt innovations beyond the experimental plot, and non-participants who do not adopt tested innovations should be interviewed. Simple interviews should include questions regarding:

a) farmers' open-ended assessments of the innovation(s);
b) adoptors' reasons for adoption;

c) non-adoptors' reasons for non-adoption (including non-participants' non-familiarity with the innovation);
d) adoptors' costs (material, labor, cash) and returns; and
e) adoptor's modifications or adaptations of the basic innovations tested and reasons underlying such adaptations.

While the projects visited may choose not to consider all off-farm and non-farm activities in their simple economic analyses, some idea of the opportunity costs of cash, labor, and land needs to be obtained in evaluating adoption of innovations. Farmers will, of course, invest their resources where gains are highest and/or risks lowest.

Finally, some idea is needed of larger national and regional trends in assessing local impacts. For example, to what extent have farmers adopted soil erosion control innovations due to increasing population and a closing of the land frontier vs due to project efforts?

Environmental impacts. Differences in soil erosion comparing treatments and using the plastic lined soil collector trenches developed by Howler provide a direct idea of environmental benefits possible if adoption of the respective soil erosion control measures were to take place. Again, measurement of soil erosion in different cassava production systems would be needed to estimate potential environmental benefits. Further thinking about levels of erosion on different types and depths of soils "needed" to induce farmers to want to adopt erosion control measures is needed.

For forage innovations, plot level studies can indicate changes in soil nutrient status and organic matter levels; and, at a higher scale, researchrs can measure such benefits as decreases in degraded natural pasture areas, reduction in annual grassland burning, and increases in tree cover and use of trees for forages and live fencing. Assessing potential environmental impacts of introduced forages, however, would need to consider whole systems; just as more productive agricultural systems in the forest margins can contribute to increases in deforestation rates, more productive livestock systems could contribute to either systems degradation or improvement.

Conclusions

Collaborative farmer participatory research now underway in Southeast Asia seeks to enhance local adaptation and adoption of innovations in animal feeding, soil nutrient management, weed control, fallow improvement, Imperata grassland "reclamation" for more productive use, intensive livestock systems, soil erosion control, and varietal (cassava and forage) improvement.

Farmer participation is important to the extent that several innovations are "knowledge intensive" rather than the simpler introduction of new varieties or specific management practices. Systems to control soil erosion, new livestock feeding systems combining legumes (including trees) and grasses and cut-and-carry with grazing, the very idea of sowing and managing forages (in systems where forages have never been sown or directly managed), systems to improve fallows and provide fodder resources, fodder banks, and use of rainfed lowland rice fields in the dry season are all examples in which farmers must gain new forms of knowledge and make systems-level adaptations and adjustments.
Participation has been manifested in participatory rural appraisals, in the development and management of on-farm trials, and in the assessment of results.

This paper discussed the need to better understand intra-community diversity. Site characterization and diagnosis can be expanded from largely PRA group activities to work with individuals and targeted sub-groups within communities. Farmer participants perhaps need to be those: a) aware of, b) suffering from given problems being addressed by the research, and c) who have tried to solve the given problem in the past. Care might be taken such that work with charismatic farmer leaders results in broader participation.

Several recommendations were provided regarding design, execution, and monitoring of the FPR trials. Continual monitoring of the performance of the innovations and of farmers' (open-ended) insights remains the ideal. In the case of the soil erosion control research, care will be needed to maintain a balance between well-supervised demonstration trials and an associated tendency to then provide recommendations to farmers and the heart of farmer participatory research--that of farmer experimentation, discovery, adaptation, and, eventually, adoption.

Finally, the measurement of impacts, both estimating *ex ante* and measuring *ex post* must be a key part of FPR. Definition and delineation of targeted systems (both regional and agroecosystem levels), measures of their current performance (eg in terms of current soil losses or livestock productivity) and levels of desired performance changes brought about by project efforts are essential for the development of *ex ante* estimates.

Site-level success can be estimated more directly using simple rates of adoption of innovations and the costs and benefits associated with such adoption. Such specific *ex post* analysis shows what is possible and allows for further *ex ante* extrapolation, again given addressing of larger institutional and policy needs.

References

Ashby, J. 1993. Insitutionalizing farmers' participation in agricultural research. Annual report of the Farmer Participation Special Project. Cali: CIAT

Fujisaka, S. 1993. A case of farmer adaptation and adoption of contour hedgerows for soil conservation. *Experimental Agriculture* 29:97-105

Gabunada, FA, EA Balbarino, and AP Obusa. 1997. Farmer participatory research on forages in Matalom, Leyte. Unpublished.

Gibson, Trevor. 1997. The Plain of Jars: an example of phosphorus deficiency for forages and livestock. *SEAFRAD News* 4:2

Milliman, JD and RH Meade. 1983. World-wide delivery of river sediment to the oceans. *Journal of Geology* 91:1-21

Remenyi, JV and JR McWilliam. 1986. Ruminent production trends in Southeast Asia and South Pacific, and the need for forages. In: GJ Blair, DA Ivory, and TR Evens, eds. *Forages in Southeast Asian and South Pacific Agriculture*. Canberra: Australian Centre for International Agricultural Research

Stur, Werner. 199x. Research and development for forage production and supply in South-east Asia.

Minimum data set for site characterization in on-farm studies in Southeast Asia

(1.1.5; W. Stür, CIAT, P. Horne, CSIRO)

Main achievements

- Development of a framework for characterization of FSP sites
- Agreement reached on a minimum information set for site characterization at community and surrounding area levels
- Collection/assembly of minimum information has been initiated for all sites

Report. Sites were selected to cover a range of environments and farming systems, commonly found in upland agriculture in Southeast Asia. Within systems, sites selection was based on the following criteria:

1) Are farmers facing a serious problem that can be addressed by introducing forage technologies and does it affect many farmers?
2) Are there many farmers who perceive it as a serious problem and are they looking for ways to overcome it?
3) Are farmers interested and willing to work with the project?
4) Are our national partners able to support work at these sites?
5) Are local development workers (and support from their office) available to join the project?
6) The existence of effective farmer groups is an advantage in many but not all situations.

Site characterization is carried out for different purposes (or phases) of the project (Figure 2). These are

1. To identify potential sites for farmer participatory forage technology development,
2. To select sites and obtain commitment of farmers and development workers to work together,
3. To plan and work with farmers,
4. To assess of the impact of forage technologies.

The methodology of characterization for these different purposes varies. It includes secondary information, participatory diagnosis, participatory planning, interviews with individual farmers, participatory evaluation, surveys and direct measurements. The framework for characterization including target communities, methodology and outputs is described in Figure 1.

Following are summaries of site descriptions for identification and selection of potential FPR sites. Results of problem diagnosis during participatory diagnosis are discussed in Output 1.2.2, details of activities at sites in Output 2.2, and assessment of impact of forage technologies in Output 4.

Site descriptions for identifying and selecting FPR sites

By September 1997, seventeen on-farm sites were operational. Several of the sites in Indonesia and the Philippines started work in 1996, while most of the sites in Vietnam and Laos were established only recently. Site descriptions for identifying and selecting FPR sites are available for all sites. However, comparisons across sites are difficult since descriptions have not been based on a common information set. Recently, the FSP has established a minimum information set for this purpose and this information is in the process of being assembled for all sites by national partners (Table 1).

The required information includes sources such as

1. data and maps (often available in district or provincial offices)

Figure 1. Framework for characterization of FSP sites

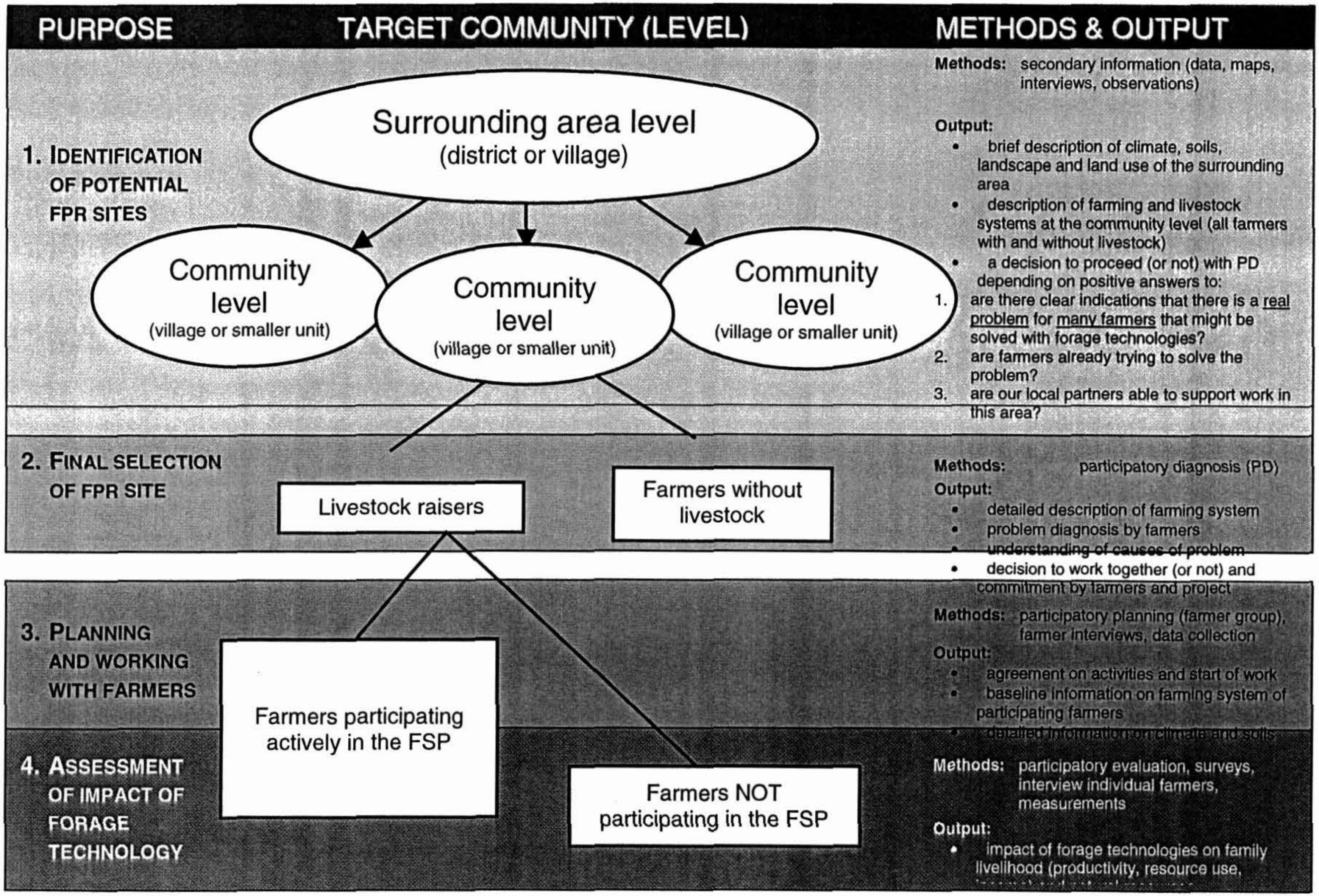


Table 1. Minimum information set for FPR site selection.

a) Brief description of the farming systems and physical features of the area surrounding the on-farm site (district or province level)	**Info. Source**[1]
1. **Location** (e.g. latitude, nearest towns, road access)	d
2. **General description** (e.g. *human population*, history of settlement, sources of income)	d, i
3. **Landscape** (topography, altitude range, vegetation)	d, i
4. **Land use systems**	d, i
4. **Climate** – long term (at least 10 years) data for	
• monthly rainfall, and number of rain days/month	d
• mean and extreme monthly max and min temperatures	d
• incidence of catastrophes (such as typhoons and flooding)	d, i
5. **Soils**	
• pH, texture and drainage	d, i
• broad fertility status, known fertility deficiencies	d, i
b) Description of the farming system at the FPR site (including all farmers at the site – with and without livestock)	
1. ***Brief description*** of the area focussing on key issues affecting development	i, PD
2. **Description of topography, soils, local climate if different from general area**	d, i, PD
3. **Land use systems**	
• relative land area for each use (%)	d, i, PD
• topographic location of each land-use	PD
• *what are the main land use systems* and their benefits/constraints?	PD
• what inputs are used in agriculture?	PD
• how is non-cropped land used?	PD
• what is the land-ownership system?	PD
4. **Livestock farming systems**	
• *types, number*, distribution	d, i, PD
• why are livestock kept? (e.g. production systems)	PD
• what proportion of farmers keep livestock?	d, i, PD
• ownership (e.g. is shared ownership of livestock common?)	PD
• are inputs used in raising livestock? (e.g. supplementary feeding, veterinary chemicals?)	PD
• how are livestock managed? (e.g. feeding systems – are animals grazed throughout the year, are they fed cut feed, who in the family is involved and how)	PD
• how are livestock marketed?	
• what/when are the main constrains and opportunities?	PD
• how have farmers been dealing with these constraints until now?	PD
• how do they want to deal with them in future?	PD
5. **Trends in the farming system**	PD
• what changes are happening within the farming system?	
• what changes are happening within the livestock raising system?	PD
6. **What are the main sources of income of farm families?**	PD
7. **What other rural development programs have been and are currently working in this area?**	i, PD
	i, PD

[1] d = data and maps i = key information/observations PD = participatory diagnosis

2. key information from discussions with government officers, village heads and key farmers, and personal observations;
3. participatory diagnosis.

A summary description of sites showing the range of agro-ecosystems and environments included in the FSP is provided in Table 2.

Full site descriptions will be available at the time of the 3rd Regional Meeting of the FSP in March 1998.

Table 2. Summary of site descriptions

SITES	LOCATION			AGRO-ECOSYSTEMS						CLIMATE		SOILS	
	Latitude	Altitude (m ASL)	Market access[1]	Grassland	Intensive upland	Extensive upland	Slash and burn	Rainfed lowland	Plantations	Annual rainfall (mm)	Length of dry season (months with <50mm)	Soil fertility[2]	Soil acidity (pH)
Indonesia													
Sepaku II, East Kalimantan	1°S	<100	D-M	✔		✔				2,200	<3	L	4.5-5.0
Makroman, East Kalimantan	0.5°S	<100	M		✔	✔				2,000	<3	M	4.8-5.3
Gorontalo, North Sulawesi	0.5°N	<100	M						✔	1,300	3-5	M	6-7
Marenu, South Tapanuli	1°N	<200	D		✔	✔				<2,000	3-5	L	4.5-5.5
Pulau Gambar, North Sumatra	4°N	<200	E					✔		2,000	0	M	6-7
Saree, Aceh	5°N	500	M	✔						1,600	2-4	L	4.5-5.5
Laos													
Luang Phabang	20°N	300-1000	D			✔	✔			1400	5	L-H	5-7
Xieng Khouang	19°N	1,300	D				✔			1400	5	L-H	4.5-6.5
Philippines													
Cagayan de Oro, Mindanao	8°N	<100	D-M			✔				2,000	2-4	L-M	5.5-6.5
Cotabato, Mindanao	9°N	<300	D			✔		✔		>2000	<3	M	6.5-7.5
Davao, Mindanao	9°N	<100	E						✔	2,500	<3	M	6
Guba, Cebu	10°N	500	E		✔					>2,000	<3	M-H	6-7
Malitbog, Bukidnon	8°N	<300	D			✔				<2,000	2-4	L-M	5.9-6.0
Matalom, Leyte	10°N	<300	M		✔	✔				2,000	3-5	L-M	4.5-8.5
Vietnam													
Xuan Loc	16°N	100	M			✔	✔	✔		3,200	2-4	L-M	5-6
M'Drak, Daklak	12°N	500	M	✔						1400	4	M	4.5-5.5
Vietnam-Swedish Project (northern provinces)	21°N	300	E		✔	✔				1700	5	M	5-6

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

Summaries of rapid PD appraisals

(1.2.2; W. Stur, CIAT and P. Horne, CSIRO)

Main achievements

- participatory diagnoses (PD) have been conducted at all 17 on-farm sites of the FSP during 1996 and 1997
- reports on PDs are available in local languages; English summaries are available for most sites and the remaining English language summaries are being prepared by national partners

Participatory diagnosis

Participatory diagnoses have been found particularly effective in

1. Identifying if there are problems which can be addressed with the introduction of forage technologies;
2. Determining if farmers perceive these problems as sufficiently serious to be willing to allocate input (labour and capital) towards trying to solve them;
3. Learning how farmers cope with these problems and what approaches they have tried to overcome them;
4. Understanding problem–cause relationships faced by farmers
5. Sensitising our local technical counterparts to how well farmers understand their farming systems and how able they are in analyzing problems and potential solutions;
6. Establishing a good working relationship with farmers.

A summary of major problems identified by farmers during PDs is presented in Table 1.

An important part of participatory diagnosis is the analysis of causes of the problems. This helps to understand causes and linkages of the problems, making decisions on how to approach the problem much easier.

An example of a problem-cause relationship, as analysed by farmers during a participatory diagnosis on the problems related to raising livestock in Matalom village, Leyte, Philippines, is presented in Figure 1 (Gabunada, Stür and Horne, 1997).

The farmer group first identified the set of common problems they faced in raising livestock. This random list was then sorted in order of importance and the interactions between them identified. Next the farmers discussed each problem to identify what actions they had already taken to alleviate that problem. Encouraged by the many steps they had already taken, they finally reassessed each problem to see if there were any other steps they could take to improve the situation. The result is a clear summary of the current status of livestock rearing in that village which the farmers had developed, understood and owned. The whole process took two hours.

In this case the farmer group identified "better forage species" as an important step they could take to improve livestock husbandry. The researchers used this as a basis to suggest a range of forages which might fit into their livestock and cropping system. The farmers selected what they wanted to try from the options provided and plans for the trial were made.

Table 1. Major problems identified by farmers during PDs

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		✔					✔

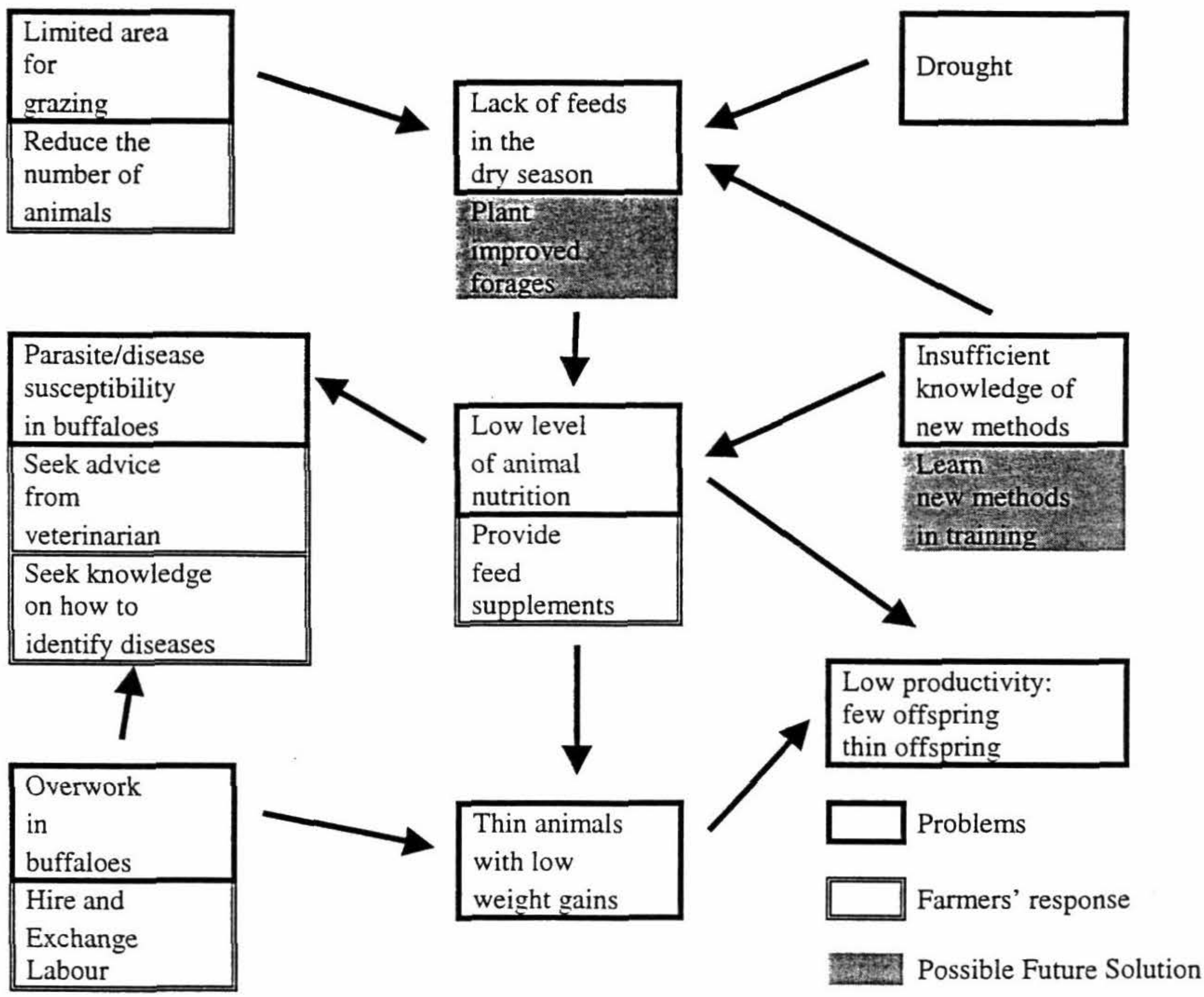


Figure 1. Feed resources problem diagnosis by smallholder farmers in Matalom, Leyte, Philippines

(Werner Stür and Francisco Gabunada, FSP-CIAT; Peter Horne and Phonepaseuth Phengsavanh, FSP-CSIRO, Maimunah Tuhulele, DGLS, Indonesia; Ed Magboo, PCARRD, Philippines; Viengsavanh Phimphachanhvongsod, DLF, Laos, Le Hoa Binh, NIAH, Vietnam)

New approaches for targeting technology development
(1.1.4; S. Fujisaka and R. Howeler)

Main achievements

- Developed and conducted a course for trainers in FPR in Thailand and Vietnam.
- Incorporated lessons from the first course to improve the second course.
- Trained researchers and extensionists – Thailand 25, Vietnam 27, Laos 2, China 1.

Report

"Training of Trainers" courses were conducted in FPR in Paakchong, Thailand (03-12 September) and in Thai Nguyen, Vietnam (17-26 September), as part of PE-5's involvement in CIAT's Nipon Foundation-supported work in Asia. The course was conducted with funds from the NIPPON funded project 'Improved Sustainability of Cassava-based Cropping Systems' but there was close collaboration with the 'Forages for Smallholders Project' which provided trainers and materials and sent trainees to the course.

The course was organized and coordinated by Reinhardt Howeler. Resource persons were Sam Fujisaka, Hans Dieter Bechstedt (IBSRAM-Bangkok), Francisco ("Papang") Gabunada (FSP/CIAT, Philippines), and Suchint Simaraks (Khon Kaen University) in Thailand, and Peter Horne (FSP-CSIRO/CIAT, Vientiane), Guy Henry (CIRAD), and Nguyen Van Dinh (CARE, Hanoi).

Participants in Thailand represented the Field Crops Research Institute and the Field Crops Promotion Division of the Extension Service of the Department of Agriculture, the Thai Tapioca Development Institute, the Livestock Department and the Land Development Department. Vietnamese participants represented the Institute of Agricultural Science in South Vietnam, universities (of Agriculture and Forestry at Thy Duc, Hue University of Agriculture and Forestry, Thai Nguyen University), and several Provinicial Departments of Agriculture.

We found that a 10 day course in FPR is possible, useful, but not necessarily easy to design and conduct.

Initial Overview. The first day of each course was a "show-and-tell" overview targeting "decision makers" and bosses of trainees. The goal was to sensitize bosses to the degree that they would support future FPR activities. We were successful with short, concept-plus-case-example presentations. More attention is needed in the difficult task of involving science administrators.

Course Presentations. Initial presentations regarding principles and case studies were largely acceptable. Concise presentations which emphasize or highlight key ideas, concepts, and tools were most needed. Participants needed inputs as to differences and similarities among RRA and PRA or PD, on-farm research and FPR. Handouts in Thai and Vietnamese were appreciated and needed. Trainees received a copy of a FPR manual adapted from CIAT IPRA materials by the FSP and translated into the local languages.

Tools and Exercises. Classroom exercises in use of participatory diagnostic and evalutaion tools such as scoring and weighting, mapping, calendars, preference ranking, matrix ranking, and problem diagnosis and diagramming were largely successful, especially with exercises which required trainees to participate based on their own lives and experience. An exercise in working up a partial or enterprise budget from "manufactured" data appeared to be useful. Although necessary, I am not certain that exercises on listening, neutrality and communication skills were effective: people are sensitive or insensitive to others/farmers to the degree that such a short course is unlikely to make desired impacts.

Field Exercises. Participants practiced the use of participatory diagnosis and evaluation tools at selected project sites. Farmers appeared to have fewer difficulties in working on multidimensional calendars and matrix rankings than did trainees. Trainees need to carefully consider the differences between researchers' and farmers' evaluation criteria. Cassava breeders, for example, were surprised that the Vietnamese farmers did not use duration as an evaluation criteria and were not interested in shorter duration cultivars (because of highly diversified farms on which cassava was harvested at different ages between multiple times of peak labor demand).

In discussing problems, farmers--especially in Vietnam--appeared programmed to say they "needed new technologies". Getting trainees to further elicit farmers' specific problems and solutions was a challenge. Once farmers did turn their attention to real problems, however, they had few difficulties in diagramming interacting causes and effects.

Travel time to sites was excessive: future training courses need to increase field practice time and decrease travel time (which was high due to travel to actual project sites). Of course, participatory evaluations could only be conducted at project sites where farmers had tested new alternatives.

Trainees were not very adept at making whole-systems field observations. For example and perhaps because of their cassava orientation, Vietnamese trainees failed to note the extensive and severe tungro virus in rice, the farmers' main crop or an insect defoliator of tea, another major crop.

Trainees did not appear to have many communication problems with farmers, although a few spoke more than they listened. Trainees were quite good in involving male and female, young and old, and poorer and richer.

Making Sense of Data. In feedback (to farmers) sessions, trainees tended to present essentially the same data obtained via participatory diagnosis and evaluation. Trainees did not easily synthesize and informally analyze data. Some effort was required in demonstrating how data provided by farmers could be presented in simple graphs and figures and how such data could lead to identification of possible new relationships, hypotheses, questions and conclusions. Trainees were not experienced in making concise, to the point presentations.

Participatory Research. We discussed different types of participatory research from relatively informal technology adaptation by many farmers to more controlled varietal or fertilizer trials conducted by fewer farmers (eg as in the CIALs). Trainees needed to be reminded that FPR refers to participatory research and not only participatory diagnosis. We discussed experimental design, especially possible problems and complications associated with the erosion control trials. The need for the "farmers' practice" treatment to be accurate in order for comparisons to be relevant to farmers was emphasized.

Trainees visited farmer participatory research varietal (cassava), fertilizer, and soil erosion control trials. Farmers evaluated trial results. Varietal evaluations were insightful in terms of farmers' criteria and weighing. The soil erosion control trails were less conclusive (see following).

The Research. Lands are gently sloping and per ha soil losses are relatively low in Thailand; and farmers carefully and intensively--in time and space--manage a range of crops and resources in lowland and adjacent upland fields (with practices which include bench terracing and contour ridging) in Vietnam. As such, SF considers that that farmers would not further invest in soil erosion control in these two areas; and that farmer participatory research on soil erosion control may be counterproductive in terms of the desired institutionalization of the approach by national programs.

Proposals. As a last part of the course, participants developed proposals for further work in either or both farmer participatory research and training in FPR methods.

The Course. We developed a reasonably useful course through experiences gained during the two courses. From trainees' evaluations we need to spend more time in the field for exercises with farmers and need to provide more written materials. Use of "icebreaking" songs and exercises were useful in creating a team spirit and daily cartoons in demonstrating principles.

Output 2. Integrated technology and management options

Collaborative research and development

(2.1, PE-5 team)

The project 'Sustainable systems for smallholders' is aimed at the integration of strategic research outputs from germplasm improvement and natural resource management in CIAT to improve the productivity and sustainability of farming systems at the farm level. Thus it is essential that we work with the collaboration of other projects in CIAT. Likewise it is our aim that the adaptive research that is undertaken is done so in collaboration and indeed largely through national partners.

The degree that integration has been achieved in CIAT varies. Among the germplasm projects, there is close integration with forages and increasing integration with cassava, in particular, in South East Asia. The forage and cassava scientists in South East Asia are coordinating some activities, in particular, methodology development in FPR and impact assessment. It is likely that we will develop close linkages with the rice research project in the proposed adaptive systems project in Pucallpa, Peru.

A visit was made to Africa to become familiar with the research in systems where beans are an important crop. The conclusion was that closer linkages should be developed with the systems researchers in Africa but that the research is best managed from there. The following is an extract from the trip report.

" The team in Africa expressed a desire for closer involvement with others in CIAT, particularly, in the area of natural resource management. Charles Wortmann has planned activities with PE-2 and PE-5. It would be desirable if other CIAT scientists could make themselves more familiar with the work in Africa and consider how they might complement activities of the bean team and the other IARC Centers with whom the team collaborates.

PE-5, Sustainable Systems for Smallholders, would benefit from closer interaction with the Systems activities within the Bean Research Team for Africa. Firstly, Charles Wortman and others (Carey Farley and Sonii David) working in systems work in Africa could make a useful contribution to those working with small farmers in LAC and Asia. This collaboration will commence with the Systems workshop planned for early December where experiences in FPR and systems research will be shared. Scientists in different regional areas could arrange to visit during other travel, e.g. on return to CIAT or associated with home leave. There could be more exchange of reports and draft papers rather than just the flood of administrative circulars.

There is opportunity for CIAT to increase the extent of adaptive systems work in Africa. Other IARC's are less involved in adaptive systems research than CIAT at the present time, though they are involved in IPM/ICM studies focusing on their particular commodity mandate. However, systems research should continue to be associated with the bean research team and grow from within this base rather than to establish a separate systems project which might bring resistance from other IARC partners. Leadership should be encouraged from within this team. Adaptive systems research would best be associated with the Ecoregional Program, the African Highlands Initiative (AHI) where it is in higher altitude areas (>1500 masl). In the mid-altitude areas (1000-1500 masl) there might be some association with the proposed EU funded project.

Areas of mutual interest are:

Use of legume as green manure in farming systems
Development of FPR methodologies for technology development
Development of methodologies for dissemination of results achieved through FPR
Assessment of impact of FPR technology development.
Policy issues "

Close liaison is maintained with the NRM management programs through twice-monthly meetings. Closer links will evolve as we develop adaptive systems research in the reference sites for the Ecoregional Program for Tropical Latin America, in Pucallpa, Peru (Forest Margins), Nicaragua and Honduras

(Hillsides) and the Llanos, Colombia (Savannas).

Considerable effort was expended during the year towards building collaborative research teams in the Ecoregional Reference or Benchmark sites – Pucallpa, Central American Hillsides and Savannas, with initial emphasis on the Forest Margins site in Pucallpa. A participatory planning workshop was held within CIAT to develop a consensus on overall priorities for research in Pucallpa, CIAT initiated a meeting of DG's of ICRAF, CIAT and CIFOR in Pucallpa (to be held 4-6 November 1997) and has taken responsibility for facilitating a participatory planning workshop with all stakeholders in Pucallpa to be called by CODESU and funded by IDRC. in early1998. The key to continued development of a CIAT research team in Pucallpa will be the ability to raise or transfer funds for research in that site.

The specifically funded sub-projects: Forages for Smallholders, Improved Sustainability of Cassava-based Cropping Systems and Tropileche were designed with the concept of close collaboration. Each of these sub-projects has its specific research network of close and occasional collaborators. The FSP and Tropileche produce six-monthly newsletters.

Tropileche is a project associated with the Systemwide Livestock Program coordinated by ILRI. It is seen as a platform on which the IARC's may interact with national livestock programs in the area of feed improvement for livestock in the Latin American tropics. It initially commenced operating with partners in Peru and Costa Rica. However, partnerships are actively sought with other countries and livestock groups. This was initiated through a workshop on methodology for research related to dual-purpose cattle production held in July 1996.

Nicaragua became a partner of the Tropileche consortia in 1996 and on-farm forage technology development was commenced during 1997. Our partner in Nicaragua is the Dairy Development Project (MAG). Nicaragua is fully funding its research with funds from the World Food Program. The project has requested CIAT to expand the Tropileche activities in 1998 from one site (Muy-Muy –Matiguas watershed, an intermediate zone between the humid and the dry lowland tropics) to three sites (dry, intermediate, and humid tropics). Another partner which joined Tropileche in mid-1997 was Honduras through DICTA. Like Nicaragua, Honduras is fully funding its research in Tropileche with funds obtained from the Government of Japan.

Tree trips were made to Panama during 1997 to establish contacts based on the interest of IDIAP to join Tropileche, but the financial resources to finance the research costs in Panama have yet to be found. Likewise, a trip was made to Brazil in September 1997 to develop with Embrapa a project proposal to start research activities with CPAC, the University of Uberlandia, and the Cooperative of Milk Producers of Prata, the watershed selected by Brazil as the Tropileche site. If funding becomes available, Tropileche will start research activities with our colleagues in Brazil during 1998.

During the year we have developed proposals to establish adaptive research teams in Central America and Pucallpa, Peru. It appears that some funding will become available to allow us to expand research activities in these places.

New crop and livestock technologies (2.2)

Legume-based forage components for dual-purpose cattle in tropical Latin America - Tropileche and Nestle projects

(2.2.1; C. E. Lascano, P. Argel, F. Holmann)

Main achievements

- Documented that with the introduction of *Arachis pintoi* in association with *Brachiaria* spp in degraded pastures in forest margins there is an increase in milk yield, less weeds in the pasture and more earthworms in the topsoil where compaction is a problem.
- Found that performance of pre-weaned calves grazing *Stylosanthes guianensis* pastures was similar to that in the traditional system (calf with the dam during part of the day) but that there was one more liter of saleable milk.

On-farm evaluation of grass-legume mixtures in the NESTLE Project in Caquetá, Colombia

(2.2.1.1; C. Lascano, G. A. Ruiz, F. Holmann and L. Rivas)

The NESTLE Project entered into its third year of activities in dual-purpose cattle farms in the piedmont region of Caquetá, Colombia. A total of 102 ha each of *Brachiaria* alone and in association with *Arachis* have been established in 16 farms since the Project began in 1995.

Pasture establishment: During 1997, two new accession of *Arachis pintoi* (CIAT 18744 and 18748) were established in the less fertile soils found in the topography named "mesones" were the commercial cultivar (CIAT 17434) did not perform well. A total of 27 ha each of *Brachiaria* spp alone and in association with *Arachis* were established in 5 new farms. The area planted with a mixture of *Brachiaria* species (*B.decumbens*, *B. humidicola* and B. *brizantha* cv Marandu) in association with the legume ranged from 3 to 10 ha.

Measurements in the pastures: The botanical composition of pastures in participating farms has been continuously monitored using BOTANAL and results for the grass/legume pastures are shown in Table 1.

Table 1. Botanical composition of legume-based pastures sown in farms participating in the Nestlé Project (Caquetá, Colombia).

Farm	Months after	Botanical composition (%)			
		Brachiaria	*Arachis*	Native grass	Weeds
1	29	46	31	15	8
2	29	49	40	5	6
3	27	47	35	13	5
4	21	37	27	23	13
5	18	39	16	25	20
6	11	29	15	53	3
7	10	49	20	23	8

The legume content has ranged from 15% in newly established pastures to 40% in two or more year- old pastures. The high proportion of *Arachis* in the biomass on offer is partly due to good seed germination and to early grazing of the pastures to reduce competition from the grass, as has been recommended to farmers.

It was interesting to observe that in pastures with *Arachis* there were less native grasses and broad leaf weeds that in the grass pastures (Table 2). This was particularly evident in the older pastures (Farms 1, 2 and 3) and clearly indicates that the introduction of *Arachis* in association with *Brachiaria* is contributing to more edible biomass and to less need to control weeds either manually or with herbicides with obvious economic and environmental benefits.

Table 2. Weed content in pastures sown with grass alone and with grass in association with *Arachis pintoi* in farms in the Nestle Project (Caquetá, Colombia).

Farm	Months after planting	*Brachiaria*		*Brachiaria + Arachis*	
		Native grass	Broad leaf weeds	Native grass	Broad leaf weeds
		(%)		(%)	
1	29	28	6	15	8
2	29	24	10	5	6
3	27	19	6	13	5
4	21	12	14	23	13
5	18	15	9	25	20

Measurements of the soil fauna: In one of the farms collaborating in the NESTLE Project we surveyed contrasting pasture for earthworms and results are shown in Table 3. The earthworm count in the *Arachis* based pasture was 4 to 5 times higher than in the introduced *Brachiaria* and native grass pastures. It was also interesting to note that the highest proportion of earthworms was in the topsoil (0-5 cm), where most of the compaction in the Caquetá soils occurs. Thus the introduction of *Arachis* in degraded pastures in forest margins is contributing not only to improve milk production, but also to also to improve soil biological activity and probably to reduce soil compaction, which causes major internal drainage problem in these high rainfall areas.

Table 3. Earthworm count in grass and grass-legume pastures in farms in the Nestlé Project (Caquetá, Colombia).

Pastures	No. of samples	Depth (cm)			
		0-5	5-10	10-20	Total
		(No. earthworm/m^2)			
Native grass	6	11	3	3	17
*Brachiaria**	6	21	5	-	26
*Brachiaria/Arachis**	6	69	11	-	80

*Two-year old pastures.

Milk yield measurements: An important aim in the NESTLE Project is to monitor milk yield in grass and grass/legume pastures established in the different farms. However, it has been difficult to get farm owners and workers to routinely measure milk from cows grazing contrasting pastures. Fortunately in one of the farms it has been possible to make detailed measurements of milk yield in individual cows and results are summarized in Table 4. Increments in milk yield due to *Arachis* are dependent on the cow genotype and

Table 4. Milk yield of cows grazing *Brachiaria* spp. with and without *Arachis pintoi* in one farm of the Nestlé Project, (Caquetá, Colombia).

Item	No. of observations	Pastures	
		Brachiaria spp.	*Brachiaria* spp. + *Arachis*
		(Milk yield, kg/cow/d)	
Cows			
Holstein crosses	403	6.4 b	6.9 a
Other crosses	320	4.5 b	4.7 a
Stage of lactation			
1/3	250	6.1 b	6.6 a
2/3	220	5.9 b	6.2 a
3/3	253	4.9	5.1

a,b Means in the same row with different letters are different ($P<0.05$).

lactation stage. Cows with Holstein blood grazing *Arachis*-based pastures produced 0.5 liters more/day on average than when grazing the grass pasture. In contrast, cows with a different genotype produced only 0.2 liters more of milk /day when grazing the legume-based pasture. These results are consistent with previous results from controlled grazing experiments in Quilichao that had shown a significant interaction between cow genotype and responses in milk production due to improved feeding.

It is evident that the economic benefits to farmers of the *Arachis* technology will depend to a great extent on the type of cow used in the farm. In most dual-purpose cattle systems in tropical America cows have very low genetic potential to produce milk and thus it should be stressed to pasture improvement programs need to be accompanied with genetic improvement of the milking herd.

Diffusion of *Arachis*: It was felt from the beginning, that the success of the NESTLE Project would depend on ensuring that a major area of improved pastures were planted in 10 to 15 farms of the region. The strategy also considered that the10-15 key farmers initially selected to participate in the project would act as promoters of the *Arachis* technology to surrounding farmers. This in turn would ensure that a minimum of 100 farmers would be exposed and become adopters of the new pasture technology at the end of the 4 year-project.

The above strategy did not work given the prevalence of absentee owners in the region, lack of agriculture machinery and high cost of the *Arachis* seed available in the market. Consequently an alternative diffusion approach of the *Arachis* technology had to be put in place for the extension phase of the project.

The strategy promoted by NESTLE consisted of:

1) Creating a technology Transfer Fund managed by NESTLE
2) Conducting a survey among all milk producers that sell milk to NESTLE to define interest in recuperating degraded pastures using *Arachis*
3) Contracting the multiplication and purchase of commercial seed of *Arachis* to fulfill demand among interested producers
4) Contracting tractors for timely land preparation
5) Allowing farmers to pay for the total cost of pasture establishment with milk sold to NESTLE, with no interest on the money.

During 1997, 50 farmers were involved in the diffusion program launched by NESTLE and most plantings (3-10 ha/farm) of *Arachis* in mixture with *Brachiaria* were successful. The program will continue in 1998 with emphasis on the introduction of new genotypes of *Arachis pintoi* (CIAT 18744 and 18748) to the less fertile soils in "mesones" which cover over 60% of the piedmont region in Caquetá. Seed multiplication of the new *Arachis* ecotypes to support the Nestle Project was contracted by CIAT with SEFO-SAM in Bolivia.

During 1997 two Newsletters dealing with the activities of the on-farm activities of the NESTLE Project and recommendations on pasture establishment and management were distributed among technical assistants and producers in the region. In addition, interested farmers were invited to visit *Arachis* pastures in different farms participating in the project.

Adoption study: During May of 1997 a survey instrument was developed to analyze the demand for *Arachis pintoi* in Caquetá, Colombia. This study is a follow-up of an earlier ex-ante analysis executed during 1996. The survey format was tested and personnel were trained in its proper use. A total of 226 producers were surveyed (174 randomly selected Nestle's milk producers plus 52 early adopters) between the months of June and July. The information was coded and analyzed during the months of August through November, and it is expected that a first draft of the study will be ready by December of 1997.

On-farm evaluation of grasses and legumes in Peru, Costa Rica, Nicaragua and Honduras – Tropileche Project

(2.2.1.2; C. Lascano, P Argel, F. Holmann , K. Reategui and NARS partners)

The on-farm evaluation of improved grasses and legumes in Peru, Costa Rica and Nicaragua form part of the research activities in TROPILECHE. The on-farm activities include: (a) improved grass and grass-legume pastures for milking cows; (b) dry season forage-based energy and protein supplements for milking cows, and (c) improved feeding/management practices for pre-weaned calves. In the following sections we summarize the main activities carried out in the two benchmark sites of TROPILECHE (Pucallpa, Peru-forest margins and Central Pacific region, Costa Rica- subhumid hillsides) and in Nicaragua and Honduras, which are new partners in TROPILECHE.
Peru (Partners: M. de la Torre, Cesar Reyes-IVITA, and J. Vela-IIAP)

Establishment of forage alternatives: During 1996 and 1997 activities were concentrated in the establishment of improved grasses (*Brachiaria* spp.) associated with *Arachis pintoi* on 5 farms. Pastures were established after secondary forest, after native grass, and after degraded grass. Due to erratic weather conditions and poor seed germination, *Arachis* had to be replanted. It is expected that by the end of 1997 the associated grass-legume paddocks will be fully established to begin recording animal performance (i.e. milk production) as well as forage attributes (biomass production, feed quality) during 1998.

Costa Rica (Partners: C. Hidalgo and M. Lobo -MAG, F. Romero and J. Gonzalez -ECAG, M. Ibrahim and M. H. Franco –CATIE)

Establishment of forage alternatives : Fodder banks of *Cratylia argentea* and sugar cane were established during 1996 for dry season feeding in 3 of the 7 farms that are participating in TROPILECHE. Two other farms were selected to establish *Stylosanthes guianensis* (CIAT 184) pastures for pre-weaned calves, and three farms to establish *B. brizantha* cv La Libertad associated with *Arachis pintoi* for the milking herd. Fodder banks of *Cratylia argentea* and sugarcane are well established in three farms and evaluations will start in the dry season next year.

Pastures of *Arachis pintoi* in association with B. bryzantha cv La Libertad are well established in one farm and at ECAG. In the remaining two farms the introduction of Arachis in pastures with *B. dictyoneura* cv Llanero was to be carried out during the rainy season of 1997, but lack of rainfall due to "Él Niño" have delayed the plantings. Thus, it is expected that by the end of 1997, farms collaborating with TROPILECHE in Costa Rica will have some of the new forage alternatives fully established and ready to generate results during 1998 and subsequent years.

Management and utilization of *Cratylia* fodder banks: Banks of the shrub *C. argentea* are well established at ECAG and in three farms located in Orotina, Miramar and Esparza. A uniformity cut was carried out in all the forage banks at the end of September 1997 in order to have vigorous regrowth for the dry period that commences in November 1997 and ends in may 1998. In two farms the available foliage following the uniformity cut was made into silage in mixture with king grass and mature material of the grass Jaragua (*H. rufa).* This is an additional use of *C. argentea* that was not contemplated initially at the beginning of the TROPILECHE project, and that will help to reduce the severe lack of forage experienced in the area during the 6 months dry period.

In another very hilly farm close to Esparza and not presently with the TROPILECHE project, *C. argentea* has been under evaluation for more than four years (MAG/ODA Reforestation Project). This shrub performed better (more DM and more tolerance to drought) than the shrubs *L. leucocephala* CIAT 17263, Morera (*Morus* sp.) and Guásimo (*Guazuma umleifolia*).

The farmer has expanded the area of *Cratylia* and utilizes it to supplement either sugar cane or the Jaragua grass in both the dry and the wet season of the year. Milk production of the cows (12 cows presently) ranges from around 3.5 to 5.0 l/cow/day, the farmer states that the soil cover of the paddocks has improved since the cows are maintained half of the day in the cattle yard feeding on *Cratylia.* It is interesting to comment that now that the farmer has developed a more efficient system to feed the cows is actively reforesting the more steeped areas (not appropriate for grazing) of the farm.

The Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), a member of the Tropileche consortium, has taken advantage of this farm to conduct postgraduate studies on *C. argentea* cattle intake. Table 5 shows that both wilting and spraying *Cratylia* and Jaragua grass with molasses increased the DM intake by milking cows. Similar effect was recorded for total nitrogen and metabolic and digestible energy intake.

Table 5. The effect of wilting and the addition of molasses on DM intake (kg/100 Kg LW) of *Cratylia argentea* and the grass H. *rufa* (Information supplied by M. H. Franco, CATIE 1997).

Variable	Intake (kg DM/100 kg LW)		Mean
Cratylia	Fresh	Wilted	
Without molasses	0.281	0.372	0.327 b*
With molasses	0.395	0.432	0.413 a
Mean	0.338 b	0.402 a	
Grass			
Without molasses	2.075	2.346	2.211 b
With molasses	2.404	2.426	2.415 a
Mean	2.239 b	2.386 a	
TOTAL			
Without molasses	2.356	2.719	2.538 b
With molasses	2.799	2.858	2.828 a
Mean	2.578 b	2.788 a	

*Means followed by the same letter are statistically different, Tukey's test ($P<0.05$)

Nicaragua (Partners: T. Fariñas, R. Soza)

Establishment of forage alternatives: The Proyecto de Desarrollo Lechero funded by the World Food Program of the United Nations, is the Tropileche partner for the evaluation of on-farm research components in the localities of Matagalpa and Muy Muy in Nicaragua. Four farms have either planted *Brachiaria* spp./ *Arachis pintoi,* banks of *C. argentea* for dry season supplementation or *Stylosanthes guianensis* paddocks for pre-weaned calves. Replanting during the growing season of 1997 has been impaired because of bad weather conditions due to El Niño.

On-farm pasture evaluation: In one TROPILECHE farm in Esquipulas the farmer wanted to compare milk production in his traditional pasture (*Hyparrhenia rufa*) against B. *brizantha cv.* La Libertad during the middle of the dry season. Twenty-two milking cows grazed during 27 days a 5-ha paddock of *H. rufa*, then the same cows grazed during the next 27 days in a 5-ha paddock of *B. brizantha* alone. Milk production per cow in *B. brizantha* increased by 10% (0.72 kg/cow/d) relative to *H. rufa*. In both pastures, milking cows were offered the same amount of supplement, consisting of 0.5 kg molasses/cow/d, 4.5 kg/cow/d of poultry manure, and 1 kg/cow/d of Dolichos Lab Lab. It is expected that the difference in milk production will be larger once *Arachis pintoi* is associated with *B. brizantha* compared to the traditional grass pastures utilized in this region.

Honduras (Partners-G. Galo and C. Burgos, DICTA)
Research components of the Tropileche project are under implementation through the Proyecto de Pastos y Forrajes (PROPASTO) of the Dirección de Ciencia y Tecnología (DICTA) of Honduras. Following a letter of agreement between CIAT and DICTA a consultancy was made to this country and the following research components recommended:

1) Evaluation of milk production of dual purpose cows during the dry season fed with sugar cane supplemented with *C. argentea.*
2) Evaluation of milk production of dual purpose cows in grass/legume pastures of *B. decumbens, B. dictyoneura/A. pintoi,* and
3) Evaluation of liveweight gains of pre-weaned calves on *Stylosanthes guianensis* pastures.

These research components are being implemented in 12 farms disseminated along the humid and subhumid tropics of Honduras in the localities of Catacamas, Juticalpa, Guaymaca, Danlí and San Francisco de Becerra. Planting of the components was initiated in July 1997.

On-farm evaluation of legumes for pre weaned calves in Peru and Nicaragua (2.2.1.3; C. Lascano, F. Holmann and NARS partners)

A common practice in dual-purpose cattle systems is for pre-weaned calves to spend the day grazing with the dams , and then separated from the cows during the afternoon and placed in a corral. Under this traditional system there is high calf mortality and low weaning weights.

Peru: In five farms collaborating with TROPILECHE we are evaluating the effect of *Stylosanthes guianensis* (CIAT 184) on weight gains of pre-weaned calves. Initial results from one farm indicate that with 2.5 to 3.5 month old calves, the highest weight gains were obtained with Style grazing + concentrates + residual milk (Table 6). However, it was observed that weight gains under the traditional system (calves with dam all day long) were similar to those obtained with an improved system (calves drinking residual milk after milking + Style grazing all day long without dam), but that saleable milk increased by 1 kg/cow/day (22%). Thus, producers could benefit from this technology because it allows an improvement in income due to more milk without affecting weight gains of calves. The use of Style pastures in these systems could also contribute to the reduction of slash and burn of secondary forest for the establishment of annual crops, since the areas established with Style could form part of a rotation with crops.

Table 6. Performance of pre-weaned calves and milk production in different feeding/ management systems (Farm in Pucallpa, Perú).

Variable	Treatment 1 (*Stylosanthes* only)	Treatment 2 (*Stylosanthes* +concentrate)	Treatment 3 (control, dam w/calf at foot)
Weight gain of calves (g/d)	543 (67)*	763 (31)	527 (69)
Saleable milk (l/cow/d)	4.73 (0.57)	4.71 (0.95)	3.86 (0.74)
Milk consumed by calves (l/d)	0.73 (0.09)	0.89 (0.34)	0.68 (0.17)

*Standard deviations are in parenthesis.

Nicaragua: In a TROPILECHE farm in Muy-Muy, Stylo was used to feed 24 pre-weaned calves during the dry season. Calves were separated by phenotype in four breed groups: Brahman (8), Brahman/Holstein (6), Brahman/Brown Swiss (3), and 7 Holstein/Reyna calves (Reyna is a local syntethic breed). Calves grazed the *Stylo* pasture for 30 days, and then the farmer rested the paddock to allow the Style to regrow in order to collect seed to expand the area during the rainy season in 1997.

Results shown in Table 7 indicate that calves gained weight at an average of 300 g/d during the 30-day grazing period, ranging from 227 g/d for Brown Swiss/Brahman crossbred to 323 g/d for Holstein/Brahman calves. In the traditional management system calves usually loose about 20% of their body weight by the end of the dry season

These results indicate that Style is an excellent alternative either to produce more milk in the bucket such as the case in Pucallpa, or in the case in Nicaragua, for improving performance of pre-weaned calves in dual-purpose cattle systems.

Table 7. Weight gains of pre-weaned calves of different phenotypic groups grazing *Stylosanthes guianensis* (CIAT 184) during a dry period by (Farm in Muy-Muy, Nicaragua).

Phenotype	Initial weight	Final weight gain	Daily gain	
			Total	Average
	(k)	(kg)	(kg)	(g/d)
Brahman (8)*	134.6 (30.2)	143.5 (32.7)	8.75	292
Brown Swiss/ Brahman (3)	104.3 (12.2)	112.0 (14.8)	7.70	257
Holstein/ Brahman (6)	132.8 (47.6)	142.5 (47.0)	9.70	323
Holstein/ Reyna (7)	124.7 (32.1)	133.9 (33.7)	9.20	307
Overall Mean	**127.5**	**136.5**	**9.00**	**300**

**Figures in parenthesis are standard deviation of the mean

Forage-based systems for dry season supplementation of dual-purpose cattle in tropical Latin America – Tropileche Project (2.2.2)

Main achievements

- Demonstrated that there was a 25% increase in milk yield with the addition of *Cratylia argentea* in forage-based supplement when forage availability in the pasture was limiting.
- Demonstrated that increasing proportions of *Cratylia argentea* in a forage -based supplement resulted in daily milk yield increases of up to 24% with cows that had the genetic potential to produce milk

Evaluation of shrub legumes as dry season supplements for milking cows

(2.2.2.1; P. Avila, C.Lascano and F. Holmann)

An objective of the work carried out in the Quilichao Station as part of TROPILECHE research agenda is to determine the effect on milk yield of supplementing shrub legumes to cow of different genetic background grazing pastures with contrasting quantity and quality of forage on offer. The forage supplements to carry out this work are King grass and sugarcane as energy sources and the shrub legume *Cratylia argentea* as protein source, given that these are the feed resources being tested in farms at benchmark sites in TROPILECHE.

During 1997 an experiment was designed to study milk yield responses to supplements based on King grass alone or in combination with *Cratylia argentea* fed to cows grazing *Brachiaria decumbens* pastures with contrasting forage on offer. Results shown in Table 8 indicate that there was no effect of including *Cratylia* in combination with King grass when forage availability in the pasture was not limiting (2 AU/ha). However, when forage availability became limiting (4 AU/ha), the inclusion of the shrub legume in combination with the grass resulted in a 25% increase in milk yield.

Table 8. Effect of forage-based supplements on milk yield of Holstein crossbreed grazing *Brachiaria decumbens* at two stocking rates (CIAT's experiment station in Quilichao, Colombia).

Treatment	Intake of Supplement (kg DM/cow/d)	Milk yield (kg/cow/d)
Low Stocking Rate (2 AU/ha)		
- *Cratylia*	2.4	8.8 a
+ *Cratylia*	3.5	7.9 a,b
Mean	3.0b	
High Stocking Rate (4 AU/ha)		
- *Cratylia*	4.3	6.9 b
+ *Cratylia*	4.5	8.6 a
Mean	4.4 a	

a,b Means for each response variable with different letters in the same column are different ($P<0.05$)
- *Cratylia* = 1.5% BW DM king grass
+*Cratylia* = 1.0% BW DM king grass + 0.5% BW DM *Cratylia*

These results suggest that there will be little benefit of including legume in forage supplements when forage availability in the pastures is not limiting. In contrast, the inclusion of the legume is justified when forage availability is limited, which is the case under dry season conditions or in situations where opportunities for grazing in intensive systems are limited.

In another experiment we studied the effect of increasing the proportion of *Cratylia* in combination with sugarcane. Results presented in Table 9 show a strong interaction of animal genotype in milk yield response to forage-based supplements. With low grade Zebu crosses there was no response to the inclusion of different levels of *Cratylia* in the diet. In contrast, with the high grade Holstein crosses there was a linear response to increasing levels of *Cratylia* in combination with sugarcane. With the combination of 25% sugarcane – 75% *Cratylia* there was a 24% (1.6 kg milk/d) increase in milk yield relative to sugarcane alone.

Table 9. Effect of feeding increasing levels of *Cratylia argentea* (*Cratylia*) in combination with sugarcane (SC) on milk yield of high grade Holstein and low grade Zebu cows grazing *Brachiaria decumbens* (CIAT's experiment station in Quilichao, Colombia).

Treatment	Intake of Forage Supplement (kg DM/cow/d)	Milk Yield (kg cow/d)
High grade Holstein[1]		
- 100% SC	5.0	6.6 b,c
- 75% SC – 25% *Cratylia*	4.5	7.4 a,b
- 50% SC – 50% *Cratylia*	4.0	7.8 a
- 25% SC – 75% *Cratylia*	5.1	8.2 a
Mean	4.6 a	
Low grade Zebu[1]		
- 100% SC	3.8	5.9 c,d
- 75% SC – 25% *Cratylia*	3.1	5.8 c,d
- 50% SC – 50% *Cratylia*	3.5	5.5 d
- 25% SC – 75% *Cratylia*	4.3	5.4 d
Mean	3.7 b	

a, b, c, d means for each response variable with different letters in the same column are different ($p<0.05$)
[1] Stocking Rate = 2.7 AU/ha

These results confirm previous findings and indicate that the genetic potential of cows to produce milk could be an important determinant for adoption by farmers of legume-based feeding systems in dual-purpose cattle systems in LAC.

Improved livestock feed supplies for smallholder farms in Southeast Asia – Forages for Smallholders Project

(2.2.3; W. Stür, CIAT; Peter Horne, CSIRO; Francisco Gabunada, FSP-Philippines; Phonepaseuth Phengsavanh, FSP-Laos, Maimunah Tuhulele, DGLS, Indonesia; Ed Magboo, PCARRD, Philippines; Viengsavanh Phimphachanhvongsod, DLF, Laos, Le Hoa Binh, NIAH, Vietnam)

Main achievements

- Established 17 sites where the FSP is developing forage technologies with farmers in Indonesia, Laos, Philippines and Vietnam

Summary of activities

The following forage technologies are being evaluated by farmers at FSP sites in Indonesia, Laos, Philippines and Vietnam:

- Intensively managed plots (grasses)
- Protein banks (herbaceous and tree legumes)
- Tree legumes in fence lines
- Contour hedgerows (grasses, herbaceous and tree legumes)
- Legumes in crop fallows or grown in association with crops (herbaceous legumes)
- Cover crops (herbaceous legumes)
- Grasses and legumes for grazing (mono culture or in association)

A summary matrix of forage technologies by 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.

A list of the main forage species evaluated by farmers is presented in Table 2. The most promising species, so far, are mentioned in the text describing activities at each site.

Table 1. Forage technologies evaluated by farmers

SITES	FORAGE TECHNOLOGY						
	Intensively managed cut plots	**Protein bank**	**Tree legumes in fence lines**	**Contour hedgerows**	**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.)	✔			✔			

Table 2. Main forage species under evaluation by farmers

SPECIES	FORAGE TECHNOLOGY						
	Intensively managed cut plots, and	**Protein banks**	**Tree legumes in fence lines**	**Contour hedgerows**	**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		✔	✔				✔

Summary of site activities

Indonesia

In Indonesia, the FSP work is coordinated by Mrs. Maimunah Tuhulele of the Directorate General of Livestock Services (DGLS) overall and locally by staff of provincial or district Livestock Services Offices. Exceptions are the sites in Marenu and Pulau Gambar which are supervised by Tatang Ibrahim of the Assessment Center for Agricultural Technologies for North Sumatra in conjunction with the local Livestock Services Offices.

Gorontalo, North Sulawesi

In Gorontalo, on-farm activities are carried out in two villages, Reksonogoro and Molalahu in subdistrict Timbawa. Local collaborators are Susilan and Idrus of the local Livestock Services office. Farmers are particularly interested in grasses and legumes for grazing. Following a regional evaluation of forages in 1996, promising forages were distributed to two farmer groups for evaluation in 1997. In Molalahu, these were planted by a local farmer group, while individual farmers planted forages in Reksonogoro. Emphasis has been placed on involving more farmers in the evaluation and to extend the range of forage technologies tested.

Makroman, East Kalimantan

Activities at this site are reported in section 2.2.4

Marenu, Tapanuli Selatan

The FSP commenced development of forage technologies with transmigrant farmers whose livelihood is based on sheep production on a 1ha infertile upland area in late 1996. About 30 farmers are evaluating intensively managed cut plots to supplement existing feed resources. Some farmers are also evaluating tree legumes as protein banks. Promising species include *Paspalum atratum* and *P. guenoarum.*

Pulau Gambar, North Sumatra

The project collaborates with a women's sheep raisers cooperative in a lowland rice area. About 15 farmers are evaluating different provenances of *Gliricidia sepium* and other tree legumes, grown as protein banks and fence lines. These are grown to supplement naturally occurring vegetation along fields and roadsides, and crop residues.

Saree, Aceh

The province of Aceh has large areas of hilly and mountainous areas which traditionally have been used for grazing of cattle. Declining access has resulted in farmers forming cattle cooperatives. These farmer groups can then apply to the government for the granting of grazing leases. The FSP is working with one such farmer group in Aceh Besar to develop forage technologies to increase animal production from their grazing area. Farmers are evaluating intensively managed cut plots, protein banks and grasses and legumes for grazing. Promising species include *Panicum maximum*, *Brachiaria* spp., *Stylosanthes guianensis*, *Desmodium rensonii* and *Gliricidia sepium.*

Sepaku II, East Kalimantan

Farmers in this area are transmigrants from Java who arrived in this *Imperata cylindrica* grassland area the early 1970s. Wild pig and *Imperata cylindrica* make cropping of the vast upland areas almost impossible and many farmers have resorted to cattle production (mainly breeding) for their livelihood. The FSP works with farmers who are organised in a livestock production group. In 1995-96, the group evaluated a range of forage species on a common area. In 1996-97, farmers planted small areas of forages as intensively managed cut plots and grasses and legumes for grazing on their own land. Many of these farmers are now expanding their areas. A few farmers are also evaluating oversowing of *Stylosanthes guianensis* CIAT 184 into *Imperata* grassland with the aim of suppressing the growth of *Imperata* and to improve the quality of the pasture. Promising species include *Stylosanthes guianensis* CIAT 184, *Brachiaria brizantha*, B. decumbens, *B. humidicola* and *Andropogon gayanus*.

Laos

In Laos, on-farm evaluation and development of forage technologies commenced at two locations in 1997, under the supervision of Viengsavanh Phimphachanhvongsod and Phonepaseuth Phengsavanh of the Lao Department of Livestock and Fisheries.

Luang Phabang
On farm evaluations of forage technologies commenced with 58 individual farmers and 7 groups farmers in eleven villages (Houay Hia, Kiew Nya, Nam Awk Hu, Sen Oudom, Kieuw Talun Nyai, Nasai Chaleun, Tha Po, Chong, Nong Phu, Na Ang and Don Xai) in June 1997. Initially, the main interest of the farmers has been in intensively managed plots for feeding animals at critical times of year. The most promising species so far have been *Stylosanthes guianensis* CIAT 184, *Panicum maximum* T-58, *Brachiaria decumbens* cv Basilisk and *Brachiaria brizantha* cv Marandu. The focus for next years' activities will be on the remoter villages where livestock assume a much greater role in sustaining village livelihoods.

Xieng Khouang
On farm evaluations of forage technologies commenced with 17 farmers in four villages (Ta, Phousi, Sang, Piang Louang, Khang Pa Nyian and Nyot Kha) in June 1997. The work is being coordinated by Hong Thong Pimmasan in collaboration with the GtZ Nam Ngum Watershed Development project. Farmers were initially interested in intensively managed plots for feeding animals at critical times of year, forages for fallow improvement and forages for weed control. The most promising species so far have been *Stylosanthes guianensis* CIAT 184, *Panicum maximum* T-58, *Brachiaria decumbens* cv Basilisk and *Brachiaria brizantha* cv Marandu. One cross visit of interested farmers from villages neighbouring Ta village was facilitated. The project will expand the number of farmers in those villages where the success of some farmers has generated demand from others for seed. Farmers from nearby villages with similar problems will also be invited, after PD, to participate.

Philippines

In the Philippines, the FSP is coordinated by the Philippines Council for Agriculture and Natural Resources Research and Development (PCARRD). The coordinator is Eduedo Magboo of the Livestock Research Division. At FPR sites, the project collaborates with livestock officers of the local government, universities and National Agricultural Organisations such as the Philippine Coconut Authority and the Philippine Carabao Centers.

Cagayan de Oro
The area is an extensive, hilly upland area with corn being the most commonly grown food crop. Many farmers have 1 or more cattle or buffaloes for land preparation and to generate cash income. The local government is assisting poor farmers to acquire livestock through a livestock dispersal program. The project works with a farmer group which initially planted a range of forages in a common area before individual farmers proceeded to plant forages on their own land. Forage technologies being tested include intensively managed plots, hedgerows and legumes for improved fallows. Promising species include *Paspalum atratum*, *Pennisetum* hybrids and *Stylosanthes guianensis*.

M'lang and Carmen, North Cotabatu
Farmers in two villages, one an upland area and the other a rainfed lowland area, are evaluating forages to supplement existing feed resources. Activities started in late 1996 and no feedback is available so far.

Davao, Mindanao
The project started to work with Small Coconut Farmers' Cooperatives whose members also belong a dairy cooperative near Davao City in 1997. Increasing pressure on existing feed resources and increasing prices of concentrate supplements are forcing farmers to look for alternative feed supplies for their dairy cows. Farmers are currently in the process of planting a range of forage species in communal and individual nurseries to propagate promising species. This work is backed up by a regional evaluation of forages under coconuts by the Philippine Coconut Authority in Davao.

Guba, Cebu
Farmers in Guba are located in mountainous areas behind Cebu City. They intensively crop sometimes terraced areas producing grapes, flowers and vegetables for the Cebu Market. Most farmers also have 1-3 cattle, buffaloes or goats that are kept either in a stall or are tethered on their land. The manure from animal production is an important part of the farming system. Forages are grown along contour hedges, intercropped with crops or as cover crops among fruit trees and grapes. The FSP collaborates with farmers belonging to an NGO, the Mag-uugmad Foundation, to develop forage technologies for this intensive system. Promising species include *Arachis pintoi*, *Setaria sphacelata var. splendida*, dwarf napier and a variety of tree legumes.

Malitbog, Bukidnon
The FSP works with farmer groups in this extensive, hilly upland area to develop forage technologies for intensively managed plots, protein banks and contour hedgerows. Locally, activities are organised by the agricultural office of the municipality. In 1997, farmers started to plant forages on their own land to individually evaluate forages they selected from a regional evaluation site (1995-96) in the area.

Matalom, Leyte
In Matalom, the FSP collaborates with the Visayan State College of Agriculture (ViSCA). The area is a mixture of extensive and intensive upland farms. Animals play an important role for draught power and as a source of readily-available cash when needed by the family. On-farm evaluation of forages follows a regional evaluation of forages in Matalom. Forage technologies tested by farmers include protein banks, intensively managed plots and contour hedgerows. Promising species include *Stylosanthes guianensis* CIAT 184, *Pennisetum* hybrids and *Paspalum atratum*.

Vietnam

On farm evaluation of forages commenced at three broad locations in Vietnam during 1997, under the overall supervision of Le Hoa Binh from the National Institute of Animal Husbandry. Towards the end of 1997, he will be joined by two new project staff; Le Van An (seconded from the University of Agriculture and Forestry, Hue) and Bui Xuan An (seconded from the University of Agriculture and Forestry, Ho Chi Minh City). Both have experience in Farmer Participatory Research methodologies.

M'Drak
On farm evaluation of forages commenced with 30 farmers in Chu' Caroa commune, M'Drak, Daklak province in May 1997. The area is dominated by *Imperata* grassland. The main interest of the farmers was in grasses and legumes for reclamation of *Imperata* areas and for providing dry-season supplementation for grazing cattle. The most promising species so far have been *Stylosanthes guianensis* CIAT 184 and *Brachiaria decumbens* cv Basilisk. In response to considerable demand from farmers for help with reclamation of *Imperata* areas, the future focus of the project will be both on the Chu' Caroa commune and an area of *Imperata* to the southwest of M'Drak. In addition to supervising this work, Truong Tan Khanh from Tay Nguyen University in Buon Ma Thuot, has been conducting an evaluation of forage tree species with potential for dry season feeding.

Vietnam-Swedish project sites
In collaboration with Bui The Hung of the Vietnam-Swedish Mountain Region Development Project, on farm evaluations of forage technologies commenced with 50 farmers in five northern provinces (Lao Cai, Yen Bai, Ha Giang, Tuyen Quang and Phu To). The most promising species so far have been *Panicum maximum* T-58, *Brachiaria decumbens* cv Basilisk, *Stylosanthes guianensis* CIAT 184 and *Brachiaria brizantha* cv Marandu. The most common concern of farmers was to find green feed for fish and to supplement pigs. The future focus of the project in this area will be on farmers in Ha Giang and Tuyen

Quang, with expansion next year into areas where World Vision is working with the Hmong ethnic minority, who raise cattle in remote highland areas.

Xuan Loc
On farm evaluations of forage and tree legume technologies commenced with 8 farmers at Xuan Loc, near Hue. The main concern of the farmers was to find forages for year-round feeding as their traditional grazing resources have disappeared as a result of expanded cropping and forestry activities. The most promising species so far have been *Panicum maximum* T-58, *Stylosanthes guianensis* CIAT 184 and several lines of *Brachiaria brizantha*. With staff of the University of Hue (Le Duc Ngoan, Nguyen Thi Hoa Ly and Ho Trung Thong), the FSP will expand the number of farmers evaluating forage technologies at Xuan Loc and commence on-farm work with farmers at Hong Ha commune in nearby A Luoi district.

Legumes and grasses incorporated by farmers for fallow improvement, green manure, soil cover, erosion control and disease control

Activities of the Forages for Smallholders Project - Asia

(2.2.4; Ir. Ibrahim, Livestock Services of East Kalimantan, Indonesia; Maimunah Tuhulele, DGLS, Indonesia; Werner Stür, CIAT)

Main achievements

- Establishment of FPR sites where forages are used by farmers for improved natural resource management as well as improving their feed supply (multiple benefits)

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.

Exceptions, to some degree only, may be legumes grown for soil improvement or weed control, and tree legumes grown as fence lines. Soil improvement, weed control and the control of animals may be the overriding motivation for farmers growing these forage technologies. However, farmers at FSP sites, use the forage legumes also for animal feed. It would be difficult to separate these benefits.

Many of the sites, reported in section 2.2.3, have both an animal feeding component and a NRM component. The only site reported here is the village of Makroman, where the entry point for the FSP was legumes grown for fallow improvement and weed control. However, even at this site the relative benefits of soil improvement and weed control on one side and livestock feed on the other has become increasingly blurred.

Makroman, East Kalimantan, Indonesia

This village is a transmigration area where farmers from Java were settled in 1974. The area consists of a mixture of hilly upland and rainfed lowland areas. Land holdings vary from 2-3 ha per family. Most families own 1-2 ha of lowland and 1 ha of upland. In most years farmer can grow 2 rice crops/year. Apart from rice, farmers grow maize, cassava, sweet potatoes, baby corn and peanuts, on their upland areas. Farmers also maintain intensive home gardens with fruit trees and vegetables around their houses. Not all upland areas are planted with crops. Often only 0.2-0.4 ha are planted to crops while the remaining area is dominated by *Imperata cylindrica*. Some farmers continuously crop the same area with inputs of manure while others practice a crop-fallow system. The main limitation to planting all of their upland area with crops is labour for land preparation and weeding, and declining soil fertility with continuous cropping.

Many families raise 1-3 cattle and some also raise 5-10 goats. Cattle tend to be kept in stalls or tethered near houses during the night and morning and are tethered in the farmer's own fields in the afternoon. Additionally farmers cut naturally occurring grasses (*including Imperata cylindrica*) anywhere in the village areas. Farmers spend 2-4 hours/day cut and carry feed for their animals. Rice straw or stubbles after harvesting belong to the owner and there is no free grazing of animals. Goats are kept in pens and farmers feed grasses, leaves of cassava, jackfruit, giliricidia and banana leaves/stem during the dry season.

A PD was organized with members of a farmer group called Maju (22 families owning 45 cattle and about 100 goats). It was also attended by several farmers from another farmer group called Sidodadi. The latter specialize in goat production and many of their members have no access to lowland areas. The most important problem identified by farmers was *Imperata cylindrica* invading upland areas. Farmers mentioned several other problems, none related to animal feeding. The overwhelming problem was the presence of *Imperata* requiring enormous labour inputs for upland crops. Coping mechanism were to grow only small areas of upland crops, and to concentrate more on animal production.

Now farmers are evaluating growing herbaceous legumes in association with maize and cassava. The legumes are cut regularly during the crop growing season to limit competition with the food crop and the cuttings are fed to their animals. Farmer claim that the legumes reduce their weeding requirements substantially and that the crop yield are as high or higher than those areas grown in monoculture. After harvesting of the food crop, the area is left uncropped for some time and the forage legumes are allowed to grow. These legumes successfully suppress the growth of *Imperata cylindrica* during the fallow period, making land preparation for subsequent food crops less labour demanding. The preferred herbaceous legume is *Centrosema pubescens* CIAT 15160, although some farmers are also testing *Stylosanthes guianensis* CIAT 184. Communally, the farmers are now conducting an experiment evaluating the effect of legume fallow on subsequent crop yield. Emphasis for 1997-98 has been placed on supplying more farmers with seed of herbaceous legumes for more extensive on-farm testing.

Interestingly, there are now many farmers who also evaluate forages in intensively-managed plots for supplementary feeding. . Although feeding was not seen as a problem during the PD, the entry point for stimulating interest among farmers was the reduction in labour requirements for collecting feed for animals.

Legumes for use as green manure or fallow improvement – Cauca, Colombia
(2.2.4; L.H. Franco, P.C. Kerridge and G. Sturni-Univ. Firenze)

Main achievement

- *Canavalia brasiliensis* and *Mucuna pruriens* were shown to be potentially useful as green cover crops in Cauca

Introduction

Farmers in the hillsides of Cauca (Colombia) utilize a rotational system in which a period of cropping is followed by a natural fallow which may or may not be utilized for grazing.

The incorporation of legumes into the soil as green manure can benefit crops in the zone through increasing available soil nitrogen for the following crop. An earlier study showed that the amount of labile N (NO_3 + NH_4) was doubled in comparison to the amount under a natural fallow (Proc. XVIII Int. Grass. Congr. 16:25-26). Maize yield was increased following fallow improvement with *Centrosema macrocarpum* and *Cajanus cajan* in comparison with the natural fallow.

Following this initial demonstration, an experiment was conducted to identify other legumes that would establish rapidly and minimize competition from weeds.

Locality

The experiment was conducted in Pital, Cauca, Colombia (2° 50' N, 76° 25' E, a 1350 m.a.s.l.). The site has a moderate to steep slope and the soil had had been highly eroded and dissected during a cropping period of maize. beans and cassava. At the time of land preparation, it had been left in a fallow condition for several years.

The precipitation is bi-modal, with and average annual rainfall of 1700 mm and dry periods between June and September and January and March. The soil is a clay (54-66%) with pH, 4.1, OM, 6.0%, P, 1.2 ppm (Bray), and exchangeable bases (meq/100g) – Ca, 0.37, Mg, 0.35 and K, 0.11, with Al saturation of 80%.

Treatments: A. Legumes:

1. *Cajanus cajan* CIAT 913
2. *Calopogonium mucunoides* CIAT20709
3. *Canavalia brasiliensis* CIAT 17009
4. *Crotalaria juncea* CIAT 21709
5. *Mucuna pruriens* CIAT 9349
6. *Pueraria phaseoloides* CIAT 7182
7. Caupi - Verde Brasil
8. *Stylosanthes guianensis* CIAT 11844
9. Coctel : *C. mucronata* 20553, *C. schideanum* 15727, *C. macrocarpum* 5713 y *S. guianensis* 11833
10. Testigo : Barbecho Natural

Fertilizer: Phosphorus was applied at 40 kg/ha P as either single superphosphate or chicken manure (with analysis -3.08% N, 3.17% P, 2.95% K, 3.64% Ca y 0.71% Mg)

There were three replications in a randomized block design. The legumes were planted at the end of October 1996 in rows.

Results

Heavy rain immediately after planting caused some loss of some seed on the steeper slopes. The following table gives information on the emergence and density of seedlings.

Table 1. Emergence density of plants at establishment.

Species	No. plants /m^2	Emergence (%)
Canavalia brasiliensis 17009	3.2	71
Cowpea - verde brasil	1.5	58
Calopogonium mucunoides 20709	13.1	46
Mucuna pruriens 9349	1.7	34
Stylosanthes guianensis 11844	6.7	34
Cajanus cajan 913	3.2	29
Pueraria phaseoloides 7182	4.1	22
Crotalaria juncea *21709*	4.8	21
Mixture *		

* Estimation not made in this treatment due to the number of species

During the period of establishment there were significant differences (P=0.01) in rate of coverage. At four months after planting, *C. brasiliensis* 17009 covered 67% cover, followed by *M. pruriens* 20709 with 43% cover, respectively. The other species established very slowly and competed poorly with the weeds (Tables 3 and 4). However, there was low amount of weeds associated with *S. guianensis* despite its poor coverage of the soil.

Table 2. Coverage of the soil during establishment.

Species	Date			
	28-01-97	07-03-97	20-03-97	03-04-97
Natural fallow	80	80	80	84
C. brasiliensis 17009	55	67	76	70
M. pruriens 9349	48	43	47	55
S. guianensis 11844	11	26	39	30
C. cajan 913	14	24	37	28
C. mucunoides 20709	28	32	38	45
Mixture	18	23	33	49
P. phaseoloides 7182	7	19	26	27
Cowpea-Verde Brasil	33	33	29	0 *
C. juncea 21709	12	21	19	11

*Leaves eaten by insects

A significant effect of chicken manure over super phosphate was only observed at the final phase of establishment where there was a greater percentage cover with chicken manure (Table 3).

Table 3. Percentage cover of legumes and weeds after establishment

Treatments		Cobertura%			
P source (kg/ha P)	Species	Legumes	Weeds		
			Grasses	Other	Total
Manure P_{40}	Natural fallow	-	68	24	92
	C. brasiliensis 17009	76	7	2	85
	C. mucunoides 20709	58	27	4	89
	M. pruriens 9349	54	17	8	79
	Mixture	46	16	12	74
	P. phaseoloides 7182	37	28	6	71
	S. guianensis 11844	36	33	1	70
	C. cajan 913	33	24	14	71
	C. juncea 21709	13	49	10	72
Super P_{40}	Barbecho Natural	-	53	23	76
	C. brasiliensis 17009	64	11	7	82
	M. pruriens 9349	56	13	10	79
	Mixture	52	12	9	73
	C. mucunoides 20709	32	39	5	76
	S. guianensis 11844	24	36	7	67
	C. cajan 913	23	35	8	66
	P. phaseoloides 7182	18	34	8	60
	C. juncea 21709	10	39	23	72

The biomass production was significantly different between species but not for P source. The treatments that produced the greatest biomass after 5 months were 'natural fallow' (2.7 t/ha DM), *C. brasiliensis* 17009 (2.33 t/ha DM), 'mixture'(2.0 t/ha DM), and *M. pruriens* 9349 (1.5t/ha DM). The biomass production of other species was much less and below the overall average (1.3 t/ha DM), as can be seen in Table 4.

Table 4. Biomass of legume and weeds after establishment

Treatments		Yield (DM kg/ha)			
P Source (kg/ha P)	Species	Legumes	Weeds		
			Grasses	Other	Total
Manure P_{40}	Barbecho Natural	-	1950	570	2520
	C. brasiliensis 17009	2325	35	0	2360
	Coctel	1520	235	240	1995
	M. pruriens 9349	1460	133	373	1966
	C. cajan 913	1195	130	300	1625
	C. mucunoides 20709	795	475	25	1295
	C. juncea 21709	767	453	253	1473
	S. guianensis 11844	425	370	10	805
	P. phaseoloides 7182	355	270	70	695
Super P_{40}	Barbecho Natural	-	2225	670	2895
	Mixture	2480	245	295	3020
	C. brasiliensis 17009	2345	120	40	2505
	M. pruriens 9349	1533	107	427	2067
	C. juncea 21709	853	380	627	1860
	C. cajan 913	880	115	255	1250
	C. mucunoides 20709	355	515	40	910
	S. guianensis 11844	330	300	130	760
	P. phaseoloides 7182	165	510	260	935

The performance of the species was affected by the rather dry season in 1997. Currently, a crop of maize has been sown following incorporation of the legumes in order to evaluate nitrogen input. At the time of incorporation, those treatments with the most standing dry matter were *C. brasiliensis, S. guianensis* and the legume mixture, the others being completely defoliated due to the dry severe dry season still being experienced. *S. guianensis* CIAT 11844 y 11833 which established slowly were vigorous at the time of incorporation while cowpea and *C. juncea* had completely disappeared.

Value added options for farmers – Forages for Smallholders Project

(2.2.5; (Ed Magboo, PCARRD, Philippines; Liu Guodao, CATAS, China; Francisco Gabunada and W. Stür, CIAT)

Main achievements

- Commencement of pilot forage seed production by farmers in the Philippines
- Support of leaf meal production of *Stylosanthes guianensis* in China

Summary of activities

Seed production in Isabela, Philippines

Seed production *Stylosanthes guianensis* CIAT 184 and *Centrosema pubescens* CIAT 15160 commenced at Gamu, a Department of Agriculture livestock station in the province of Isabela, Philippines in 1996. In early 1997, more than 200 kg of seed of these species were harvested on station and distributed to farmers in the region. In 1997, several farmers near the station received seed of *Stylosanthes guianensis* CIAT 184 and planted 1,000 m^2 each with the aim to pilot seed production. If successful, the DA station will buy the seed from farmers and sell on their behalf. This system is based on the smallholder seed production scheme in Thailand. A revolving fund to buy seed from participating farmers is available.

Leaf meal production in Hainan

Leaf meal production in Hainan, China is a lucrative enterprise for farmers. It has been described by Guodao and Kerridge (1997) as follows:

"Plants are allowed to grow until there is a complete cover of the ground. When mature but still green, plants are then cut with a small tractor mower or by hand and allowed to dry in the field. The dry material is then passed through a hammer mill. In some localities a cooperative supplies a portable mill and markets the meal. In other areas the dried plants are carried to a central point for hammer milling. Stands last for 3 years. Farm yields average 15 t/ha and the meal is sold for USD 140/ton. Because of this high return, growing *S. guianensis* for meal production has spread rapidly in Hainan and Guandong. It is estimated that more than 3,000 ha are grown annually in Hainan and Guandong.

The largest use of the meal is in poultry feed to increase the depth of yolk color and its inclusion has been observed to reduce cannibalism. Beef and draft cattle can be grazed on a grass-stylo association while dairy cows are fed cut stylo along with other cut grass, though use for cattle feed is not widespread. Pigs can be fed a feed ration containing 10-15% of stylo meal or green stylo cut into 2-4 cm pieces and cooked with other food wastes before feeding. Poultry are fed a ration containing 3-5% stylo meal and for ducks it is included in a swill. For ponded fish, green stylo material is thrown directly into the pond as with grasses or use 1% leaf meal in the compound feed.

An advantage of this intensive cultivation for cover crop, fodder or meal production is that *S. guianensis* maintains high productivity for 3-4 years whereas under grazing it does not usually persist more than 2 years. The limiting factor in meal production is the rate at which air-dried material can be hammer milled with the limited machinery available. Timing of harvests also depend on availability of machinery and as a result some stands become over mature and the protein content of the meal is low. Thus there is a need to (i) improve harvesting and processing, (ii) increase persistence and leaf proportion through management, and (iii) secure long-term production through the identification of new *S. guianensis* germplasm with broad-based resistance to anthracnose and alternative legume species for leaf meal production."

The FSP is assisting the Chinese Academy of Tropical Agricultural Crops (CATAS) through collaborative research on searching for more anthracnose resistant accessions of *Stylosanthes guianensis*, and on developing management strategies to maximise field persistence of *Stylosanthes guianensis*.

New Cassava Options for Asia
NIPON Project – Improved sustainability of cassava-based cropping systems
(2.2.6; R. Howeler)

Main achievements

- Critical levels of soil parameters for cassava were determined: 3.2% organic matter (OM), 7 ppm Bray-II actractable P and 0.14 me K/100g.
- Promising new management options to reduce erosion in cassava fields identified: contour hedgerows of *Paspalum atratum, Setaria spacelata* or *Brachiaria brizantha*; and intercropping with peanut, pumpkin or cucumber.

Strategic and applied research.

Strategic and applied research on improved cassava technologies was conducted in collaboration with universities and research institutes in Thailand, Indonesia, Vietnam, China and the Philippines.

Long-term fertility trials

The objective of these trials, conducted in eight locations in China, Vietnam and Indonesia, is to study the long-term effect of cassava on soil fertility and to determine the fertilizer requirements to maintain soil productivity. Most of these trials have completed 7-8 consecutive cassava cropping cycles. During the latest cycle, harvested in 1996 or 1997, there were significant responses to application of N in six, to P in two, and to K in five of the eight sites. This clearly indicates the importance of N and K application in most cassava growing soils in Asia, while P application is seldom necessary. The responses to N and K application tended to increase over time, as indicated by the relative yield in the absence of N and K in a long-term NPK trial in Nanning, China (Figure 1); it is mainly due to the removal of relatively large amounts of N and K in the successive root harvests. This, however, was seldom reflected in a marked decrease in exchangeable K or OM in the soil.

Using the combined results of nine trials conducted between 1993 and 1996, critical levels of various soil parameters for cassava were estimated to be 3.2% OM, 7 ppm Bray II-extractable P and 0.14 me K/100g (Figure 2). The levels for P and K are slightly higher than those reported earlier, i.e. 4.5 ppm P and 0.13 me K/100 g, but fall within the "medium" range that have been recently reported elsewhere (Howeler, 1995a; 1995b; and 1996b). Critical levels for OM had not previously been reported. Similarly, critical levels for N and K in youngest fully-expanded cassava leaf blades (YFEL), sampled at 3-4 months after planting, were estimated to be 5.7% N and 1.9% K (Figure 3), which again are slightly higher than those reported earlier, i.e. 4.6% N and 1.7% K (Howeler, 1995b and 1996b). There was no clear relationship between P response and the P concentration of YFEL-blades, as there were few cases of a significant P response observed in the NPK trials included in the analysis. The above-mentioned critical levels, which correspond to 95% of maximum yield, are a useful guide in the interpretation of soil and plant tissue analyses. From soil and tissue analyses results, reasonable fertilizer recommendations can be formulated.

Erosion control experiments

The objective of these trials is mainly to indentify effective crop/soil management practices to reduce erosion when cassava is grown on slopes. Past experiments have shown the effectiveness of fertilizer application, contour ridging, minimum or zero tillage, intercropping with peanut, planting at closer spacing and the planting of contour barriers of vetiver grass, *Tephrosia candida* or elephant grass in reducing soil loss (Howeler, 1996a; 1996c; 1996d; 1998a; and 1998b).

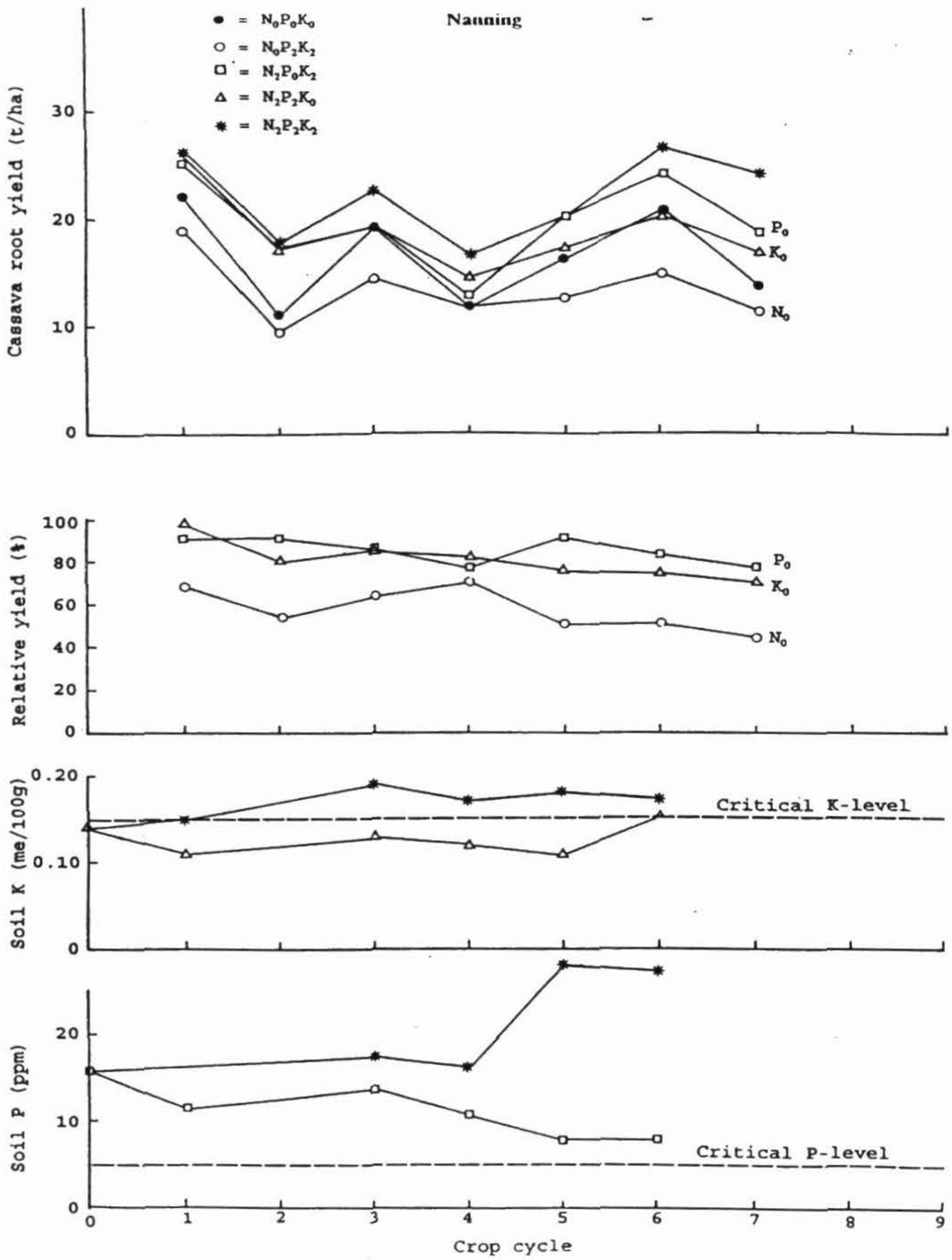


Figure 1. Effect of annual applications of N, P and K on cassava root yield, relative yield (yield without the nutrient over the highest yield with the nutrient) and the exchangeable K and available P (Bray 2) content of the soil during eight years of continuous cropping at the Gunagxi Subtrop. Crops Research Institute, Nanning, Guangxi, China.

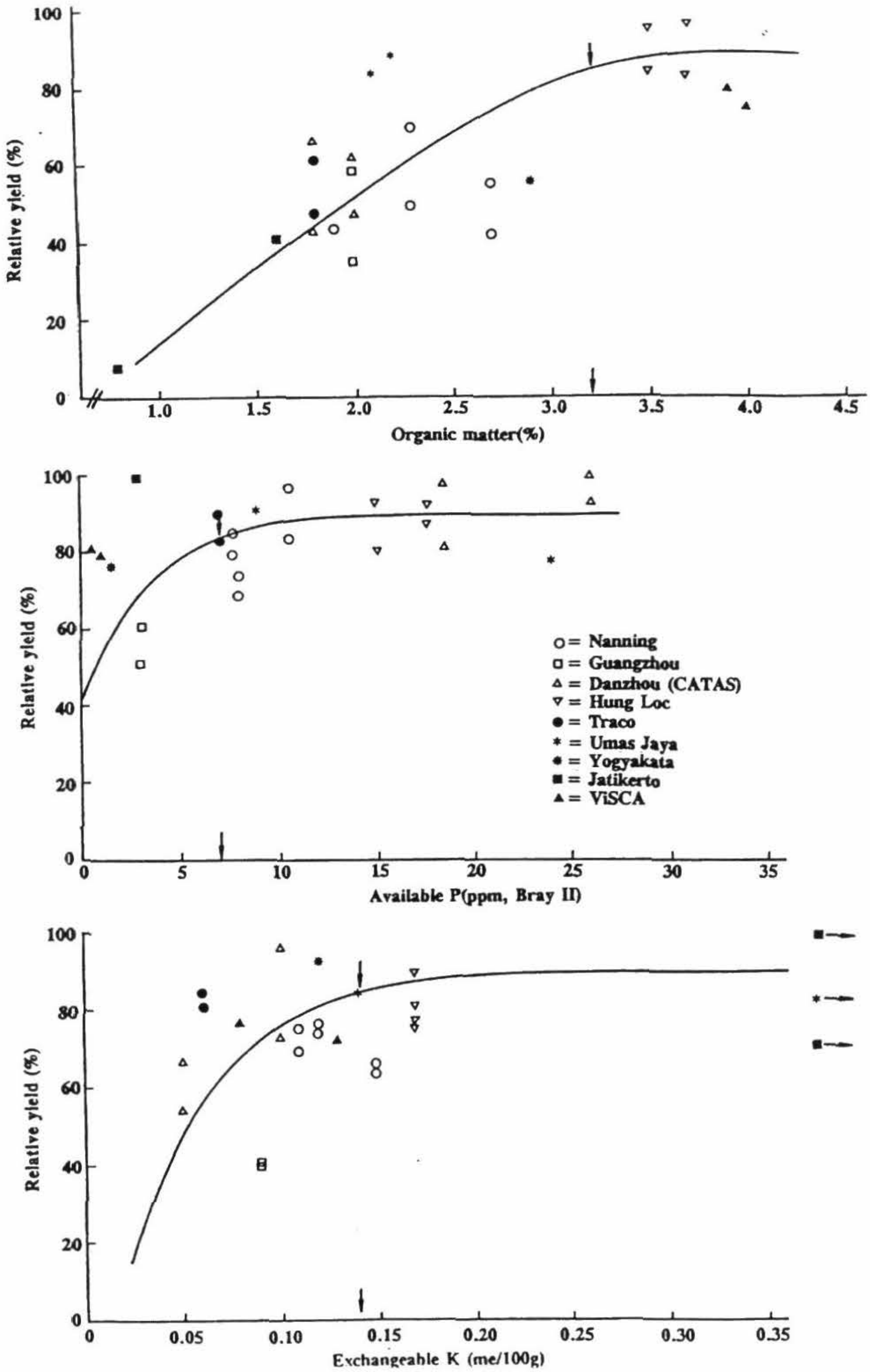


Figure 2. The relation between the relative yield of cassava, i.e. the yield without the nutrient as a percent of the highest yield with the nutrient, and the organic matter, available P and exchangeable K contents of the soil in ten long-term NPK trials conducted in Asia from 1993 to 1996.

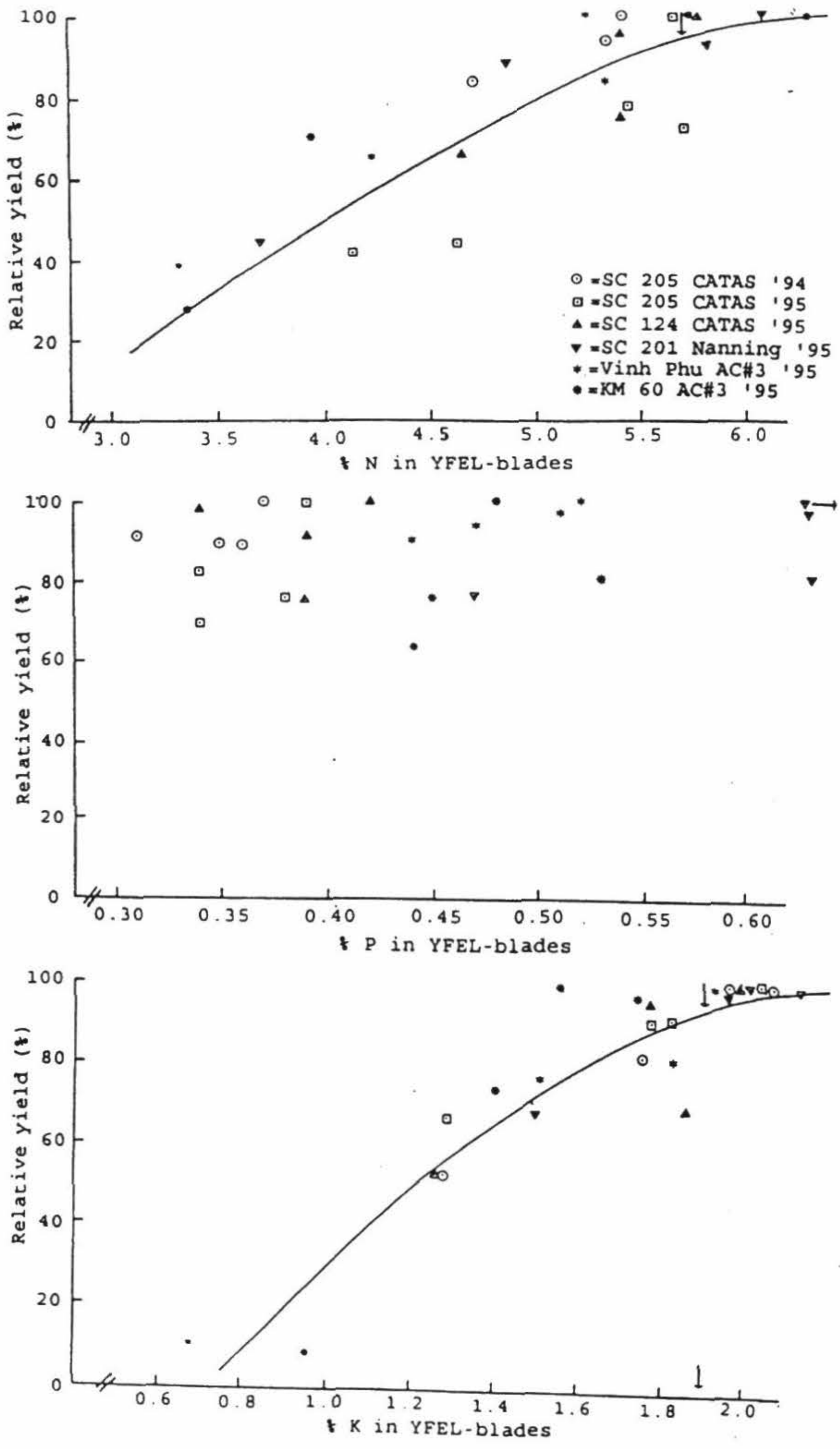


Figure 3. The relation between the relative yield of cassava, i.e. the yield without the nutrient as a percent of the highest yield with the nutrient, and the concentration of N, P and K in the youngest fully-expanded leaf(YFEL)-blades at 3-4 months after planting of various cultivars planted in four long-term fertility trials in China and Vietnam.

Initial data from an experiment conducted in collaboration with the Field Crops Research Inst. of DOA in Thailand showed that changing the date of planting of cassava from the early to the late rainy season reduced erosion and actually increased yields. However, more recent data obtained from the same trial indicates that soil losses vary markedly from year to year and are mainly related to the amount and intensity of rainfall. Erosion tends to be higher when cassava is planted in the early or mid rainy season, but planting in the late rainy or early dry season can still result in considerable erosion if rainfall is high during the following wet season (Figure 4). The amount of soil loss is also dependent on the extent of canopy cover during the rainy period.

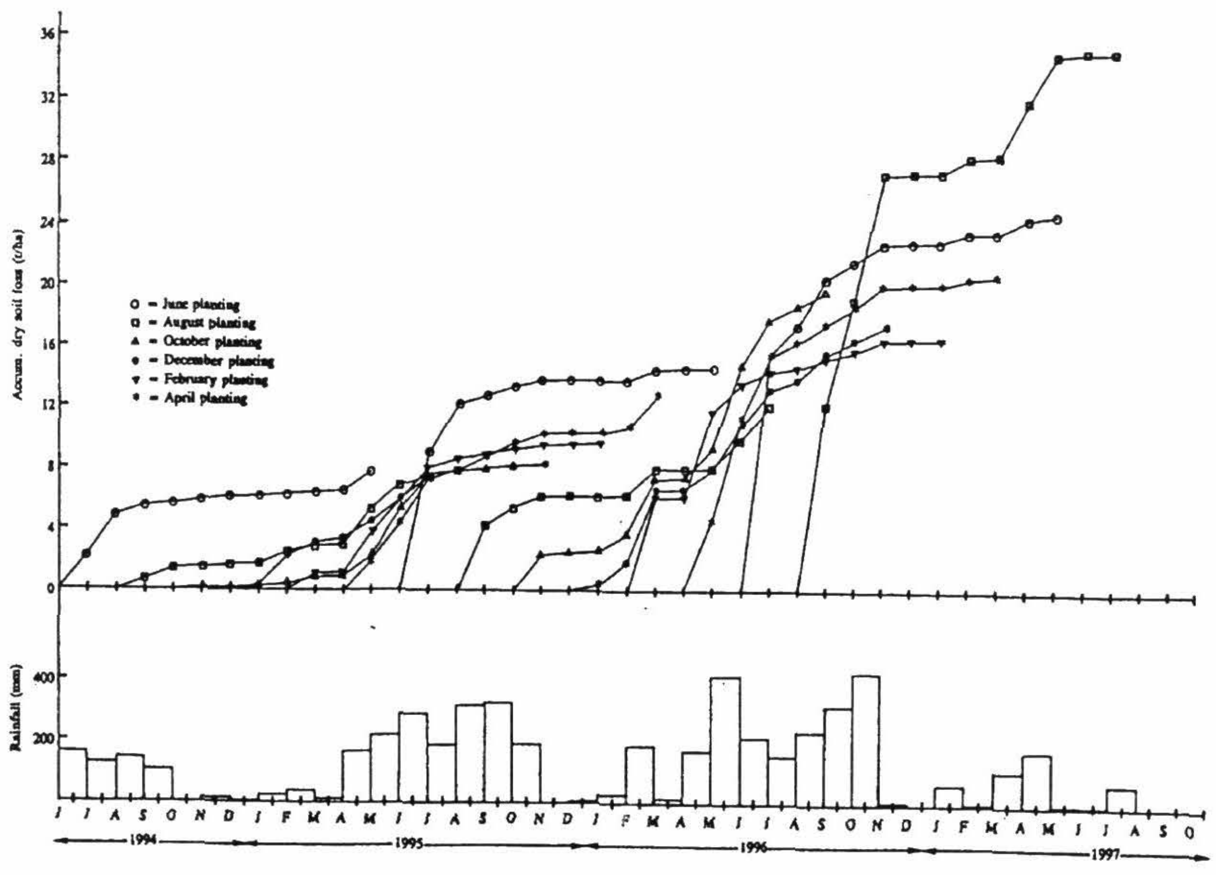


Figure 4. Effect of date of planting cassava, cv Rayong 90, on the accumulated dry soil loss due to erosion on 4.2% slope in Rayong Field Crops Research Center, Rayong, Thailand from 1994 to 1997. Rainfall distribution is shown below.

In another experiment, conducted for three consecutive years, it was found that intercropping cassava with peanut was always most effective in reducing erosion, while total gross income increased compared with monocropping. Intercropping with pumpkin, muskmelon or cucumber was slighty less effective than peanut in reducing erosion, but greatly increased the total gross income of the intercropping system (Table 1). Although the gross income obtained with pumpkin was less than with cucumber or muskmelon, pumpkin production is less risky as the crop is more tolerant of drought.

Table 1. Effect of intercropping cassava with various crops on soil cover, cassava and intercrop yields, gross income, and soil loss due to erosion in Pluak Daeng, Rayong Thailand. Data are average values for three years (1994-1997).

Cropping systems	Soil[1] Cover (%)	Yield (t/ha)		Gross income ($/ha)			Dry soil loss (t/ha)
		Cassava	Intercrop	Cassava	Intercrop	Total	
1. Cassava monoculture	-	18.21	-	671	-	671	42.6
2. C+peanut	67	13.06	0.87	462	322	784	18.1
3. C+watermelon	23	15.51	1.40	582	278	860	35.2
4. C+muskmelon	57	16.81	2,72	595	845	1440	25.1
5. C+cucumber	57	16.79	3.01	629	804	1433	23.8
6. C+pumpkin	72	16.64	3.09	632	548	1180	24.8
7. C+watermelon (at 1MAP)[2]	5	16.84	0	628	0	628	35.9
8. C+muskmelon (at 1MAP)[2]	9	23.79	0	905	0	905	33.5
9. C+cucumber (at 1MAP)[2]	9	16.73	0	650	0	650	28.2
10 C+pumpkin (at 1MAP)[2]	16	18.61	0.11	672	22	694	28.3

1) Soil cover by intercrop at 2 months after planting (visual estimation)
2) Intercrops planted one month after planting cassava; in Treatments 2-5 planted simultaneously

On-farm trials on erosion control practices, conducted in four locations of Rayong province during three consecutive years, indicate that the combination of contour ridges, closer spacing (0.8x0.8m) and fertilizer application was the best package of practices to reduce erosion and increase yields (Table 2). However, the results of this treatment were not significantly different from the "farmers' practice", because neighboring farmers have over the years already adopted most components of these recommended practices. The data indicate that contour ridging was the most effective single practice to reduce erosion, while it also increased cassava yields.

Table 2. Effect of various crop/soil management practices on cassava yield and dry soil loss due to erosion in on-farm trials conducted in four locations of Rayong province of Thailand. Data are average values for three years (1994-1997).

	Row yield (t/ha)	Soil loss (t/ha)
Farmer's practice1	17.69	19.76
1.0x1.0 m spacing; no ridging; no fertilizers	11.26	29.33
1.0x0.6 m spacing; no ridging; no fertilizers	12.58	25.61
1.0x0.6 m spacing; no ridging; with fertilizers2	15.96	34.15
1.0x0.6 m spacing; contour ridging; with fertilizers2	20.34	17.71
0.8x0.8 m spacing; contour ridging; with fertilizers2	21.09	15.78

1) Farmer's practices generally include contour ridging, planting at 1.0x0.6 m, and application of 200 kg/ha 15-15-15 fertilizers.
2) With fertilizers is 312 kg/ha 15-15-15

Another preliminary trial conducted in Khaw Hin Sorn, Thailand, in collaboration with Kasetsart University, indicates that contour hedgerows of *Paspalum atratum* BRA 9610 and *Setaria spacelata* actually increased cassava yields as compared to the check of cassava without hedgerows. This might have resulted from better moisture retention during the dry season due to the application of grass mulch from the pruned hedgerows. Moreover, these two species showed little competition with neighboring cassava plants, as cassava yields near the hedgerows were nearly as high as those of plants farther from the hedgerows (Figure 5). The same trial also showed that tall and/or highly productive grasses like king grass (*Saccarum sinense* Roxb.), sugarcane (*S. officinarum* L.), and dwarf or normal elephant grass (*Pennisetum purpureum*) are highly competitive, reducing cassava yields not only in neighboring rows, but also in the next row away from the grass. This competition is particularly serious during periods of drought stress. The three varieties of vetiver grass included in the trial were intermediately competitive. Another experiment conducted in Vietnam in collaboration with the Agro-forestry College of Thai Nguyen, showed that intercropping cassava with peanut reduced erosion losses from 72 to 18 t/ha, while increasing gross income from 7.8 to 11.4 mil. dong/ha. This practice combined with contour hedgerows of vetiver grass further reduced erosion losses to only 6.6 t/ha, while the gross income remained the same (Table 3).

Table 3. Effect of various cropping systems and management practices on the yields of cassava, intercropped peanuts and hedgerow species, as well as on total dry soil loss due to erosion when cassava was planted on 10% slope at Agro-forestry College of BacThai, Thai Nguyen, Bac Thai, Vietnam in 1996.

Treatments	Yield (t/ha)			Gross income[2] ('000d/ha)	Dry soil loss (t/ha)
	cassava	peanut[1]	hedgerows		
1. No ridging, no intecrop, no hedgerows	15.70	-	-	7,850	72.2
2. No ridging, peanut intercrop, no hedgerows	15.42	0.733	-	11,375	18.3
3. No ridging, peanut intercrop, *Tephrosia* hedgerows	16.62	0.448	0.86	10,550	11.3
4. No ridging, peanut intercrop, vetiver grass hedgerows	16.60	0.640	2.00	11,500	6.6
5. Contour ridging, peanut intecrop, *Tephrs.*+vetiver hedgerows	15.48	0.810	0.83	11,790	9.4

1) peanut dry pods
2) prices: cassava fresh roots: d 500/kg
peanut dry pods: d 5000/kg

In a trial conducted in collaboration with the Bogor Research Institute for Food Crops (BORIF), in Lampung, in the southern part of Sumatra island of Indonesia, it was found that cassava grown in monoculture resulted in more erosion than two consecutively grown crops of maize, soybean or peanut, or rice-soybean relay crops. However, cassava intercropped with maize and upland rice followed by soybean (after the rice harvest) caused less erosion than any of the crops grown in monoculture (Figure 6). Soil losses were considerably reduced with the application of adequate amounts of fertilizers. Farmers in Indonesia usually intercrop cassava with maize or with maize, rice and legumes (in the wetter areas), but generally do not apply sufficient fertilizers to obtain high yields and reduce erosion.

Improved management practices for cassava production in Asia

The above-mentioned experiments clearly show that various soil/crop management practices in cassava-based cropping systems have a potential to not only increase cassava yields or gross income, but also to significantly reduce soil losses by erosion. These practices include: 1) intercropping with peanut (Vietnam), with peanut or pumpkin (Thailand), or with upland rice, maize and a legume crop (Indonesia); 2) adequate fertilizer or manure application; 3) contour ridging; 4) planting at closer spacing; and 5) contour hedgerows of vetiver grass or *Tephrosia candida*, or possibly *Paspalum atratum*, *Setaria sphacelata* or *Brachiaria brizantha*. However, farmers usually face certain constraints which limits the adoption of these practices. For example, in China, intercropping with peanut has not been successful

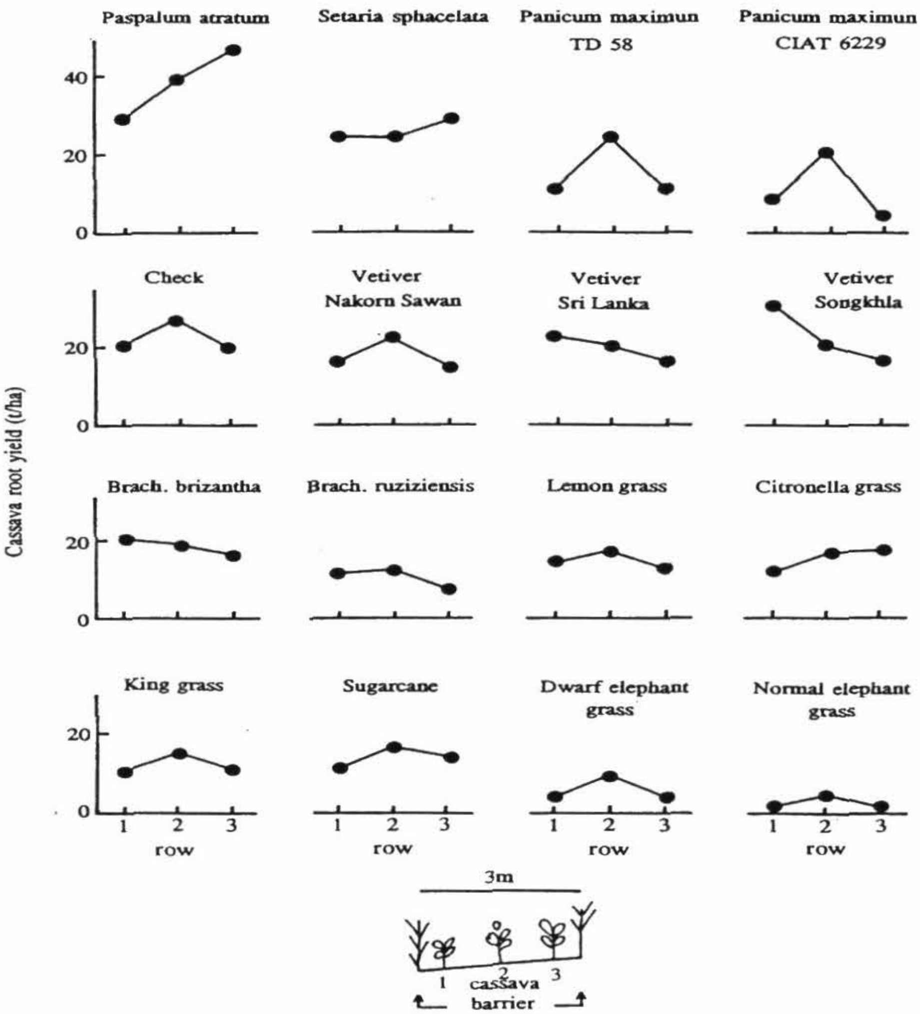


Figure 5. The effect of different grass species used as contour barriers on the fresh root yield of cassava, cv. KU 50, grown in three rows between barriers in Khaw Hin Sorn, Chachoengsao, Thailand in 1996/97.

since the peanuts are often damaged by rats. In Thailand farmers seldom intercrop cassava because of scarcity of labor and frequent intercrop failures due to the unpredictability of rainfall. In addition, contour ridging and contour hedgerows make land preparation more difficult and thus more costly. Almost anywhere, cassava farmers are poor and do not have the money to apply adequate amounts of chemical fertilizers, while animal manures are not always available (especially in Thailand). Thus, while there are many options to improve cassava management practices, there are also many constraints to the adoption of these practices. Which practices are most effective and most acceptable to farmers in a particular region can best be determined by farmers themselves through farmer participatory research (FPR), followed by dissemination of the most useful practices by farmer-to-farmer extension.

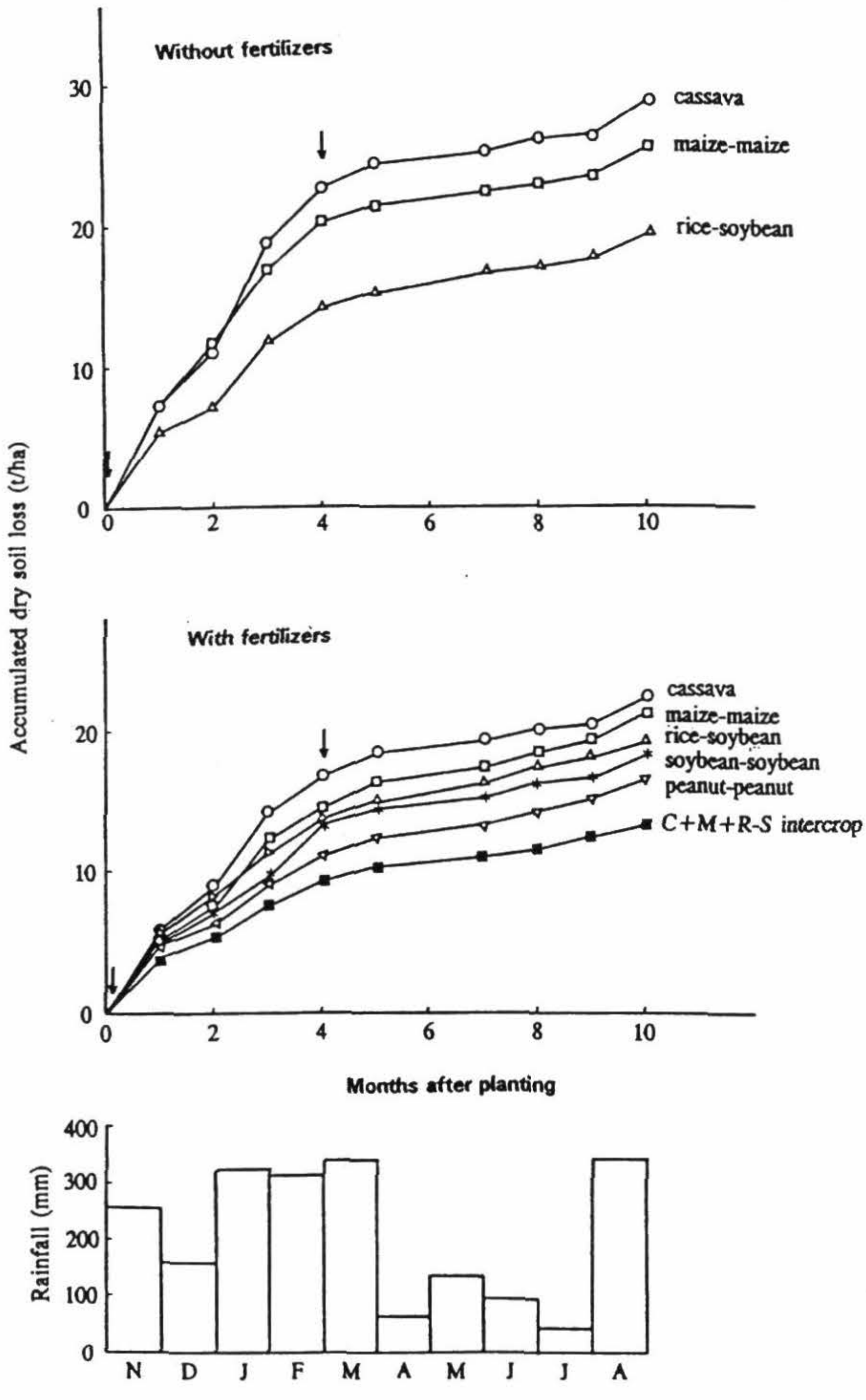


Figure 6. Accumulated dry soil loss due to erosion in various crops grown in monoculture or intercropped with ot without fertilizers on 5% slope in Tamanbogo, Lampung, Indonesia in 1995/96. The rainfall distribution during the cropping cycle is shown below. Arrows indicate time of planting of first and second crop.

Integrated soil conservation and soil improvement strategies (2.3)
Adoption of Improved Management Practices for Cassava Production in Asia
NIPPON Project – Improved Sustainability of Cassava – based cropping systems
(2.2.3; R. Howeler)

Main achievements

- 13 farmers in FPR pilot sites in Thailand and Vietnam have now planted the best erosion control practices, identified previously in FPR trials, on small areas of their cassava production fields.

Farmer Participatory Research

In 1996/97 about 128 FPR trials were conducted in nine pilot sites in Thailand, Vietnam, China and Indonesia. Of these, 54 trials were on erosion control practices, 37 on varieties, 26 on fertilizers and 11 on inter-cropping systems (Table 4).

These trials were conducted by the farmers on their own fields, but with assistance from researchers and extensionists involved in the project. Most trials had 3-6 treatments without replication. Farmers in each pilot site had generally decided among themselves which practices or varieties they wanted to test, so within one pilot site the treatments within each type of trial were the same. Thus, each farmer could be considered as one replication. In the FPR erosion control trials the effect of each treatment on soil loss due to erosion could be measured by weighing the soil sediments that had collected in plastic-covered ditches along the lower side of each plot. At time of harvest farmers and researchers harvested the plots together. The combined results were presented and discussed with the farmers. Based on the data of yield, gross and net income as well as soil losses by erosion, farmers selected the most promising treatments for further testing or adoption.

Tables 5 to 8 show some of the results of FPR erosion control trials conducted in Thailand, Vietnam and China; in Indonesia farmers did not use the same treatments in all trials, making the interpretation of the results difficult. In the two pilot sites in Thailand (Table 5), most farmers preferred either vetiver grass or sugarcane (for chewing) as contour hedgerows, planting on contour ridges or intercropping with mungbean. In the three sites in Vietnam (Tables 6 and 7), farmers preferred intercropping cassava with peanut, while planting also contour hedgerows of either vetiver grass or *Tephrosia candida*. In China (Table 8), farmers in one site also preferred cassava intercropping with peanut and vetiver grass barriers; other intercrops like maize, soybean or sesame did not produce any yield, while *Stylosanthes* or *Indigofera* barriers did not establish well. At the Blitar site in Indonesia most farmers preferred planting *Gliricidia sepium* as contour hedgerows, since the prunings of these leguminous trees can be used either as animal feed or as greenmanure. Elephant grass is also often used as a contour barrier and animal feed, but this grass competes seriously with neighboring cassava plants.

Tables 9 and 10 show examples of FPR variety trials conducted in Thailand and Vietnam, respectively. In Soeng Saang district of Thailand yields were low due to a drought in June/July 1996, but highest yields were obtained with the variety Rayong 90. This variety was also preferred because of its high starch content. However, in a matrix ranking of varieties, conducted with about 15 farmers in Soeng Saang as part of a practice in PE during the FPR training course in Thailand, farmers indicated a clear preferrence for either Rayong 5 or Kasetsart 50 (KU 50) over Rayong 90. Farmers indicated that Rayong 90 was more difficult to weed and harvest because of bent stems; this variety also had lower germination and less drought tolerance than Rayong 5 or KU 50. In the Wang Nam Yen site in Thailand, farmers also preferred

Table 4. Number and types of Farmer Participatory Research (FPR) trials with cassava conducted in four countries in Asia in 1996/97.

Type of trial	Thailand			Vietnam		China		Indonesia	
	Soeng Saang Nakorn Ratchasima	Wang Nam Yen Sra Kaew	Pho Yen Bac Thai	Thanh Hoa Vinh Phu	Luong Son *Hoa Binh*	Baisha Hainan	Tunchang Hainan	Dampit Malang	Wates Blitar
Erosion control	8	7	5	7	3	4	1	10	9
Varieties	3	6	11	3	3	4	1	1	5
Fertilization	8	-	6	4	3	4	-	1	-
Intercropping	-	-	11	-	-	-	-	-	-
Total	19	13	33	14	9	12	2	12	14

Table 6. Average results of five FPR erosion control trials conducted by farmers in Tien Phong and Dac Son villages of Pho Yen district,Bac Thai province, Vietnam in 1996.

	Dry soil loss[1] (t/ha)	Yield (t/ha) cassava[2]	Yield (t/ha) intercrop[3]	Gross Income	Production Costs[4]	Net Income	Farmers' Preference (%)
				<-------------(mil.dong/ha)		------------>	
1. Farmer's practice[5]	8.33	11.53	-	6.92	2.25	4.67	0
2. *Tephrosia* hedgerows, no ridging, peanut intercrop	6.62	11.02	0.372	8.47	2.30	6.17	0
3. Vetiver grass hedgerows, no ridging, peanut intercrop	6.34	12.82	0.280	9.09	2.30	6.79	39
4. *Tephrosia* hedgerows, contour ridges, peanut intercrop	4.85	12.30	0.318	8.97	2.30	6.67	58
5. Vetiver+*Tephrosia* hedgerows, no contour ridges, no intercrops	4.17	12.78	-	7.67	1.94	5.73	3

[1] dry soil loss during 1996. [2] final yield of fresh roots [3] dry pods [4] includes cost of manure, fertilizers and peanut seed

[5] monoculture cassava with 15 t/ha of pig manure, 144 kg urea, 107 *SSP* and 95 KCl/ha

Table 5. Average results of six FPR erosion control trials conducted by farmers in Wang Sombuun village of Wang Nam Yen destrict, Sra Kaew province of Thailand in 1996/97.

	Gross income[1] ('000B/ha)			Production Costs[2]	Net Income	Soil loss	Farmer
	Cassava	Mungbean	Total	<--('000B/ha)-->		(t/ha)	Preference[3]
T_1= up-and-down ridging	22.10	-	22.10	12.50	9.60	47.79	0
T_2= contour ridging	20.67	-	20.67	12.50	8.17	28.27	9
T_3= vetiver grass hedgerows	18.10	-	18.10	13.12	4.98	10.16	9
T_4= grass mulch	21.45	-	21.45	13.12	8.33	29.14	1
T_5= mungbean intercrop	12.65	5.38	18.03	13.37	4.66	15.53	6

1) Prices:cassava:B 0.75/kg fresh roots
mungbean: 8.00/kg dry grain
1US$ = 25 baht

2) Production costs(B/ha): normal practices: 12,500
planting/maintenance vetiver grass: 620
application grass mulch: 620
intercropping of mungbean: 875

3) Out of 12 farmers at meeting

Table 8. Average results of FPR erosion control trials conducted in four farmer's fields in Kongba village, Baisha county, Hainan, China in 1996.

	Yield (t/ha)		Gross Income[1)]	Dry soil loss
Practices	Cassava	Intercrop	(Y/ha)	(t/ha)
Farmer's practice (cassava monoculture)	13.5	-	2970	125
C+peanut, vetiver grass barriers	14.0	0.625	5892	89
C+soybean, *Indigofera* barriers	16.5	-	3630	97
C+maize, *Stylosanthes guianensis* barriers	20.7[2)]	-	4554[2)]	62[2)]
C+sesame, *Stylosanthes guianensis* barriers	6.5[3)]	-	1430[3)]	216[3)]
C monoculture, contour ridges	13.5	-	3322	77

1)prices: cassava fresh roots: Y 0.22/kg
peanut dry pods: 4.5/kg
1US $ is about 8.1 yuan

2)based on only two trials

3)based on only one trial

Table 7. Average results of an FPR erosion control trial conducted by three farmers on 16% slope in Dong Rang village of Luong Son district, Hoa Binh province, Vietnam in 1996.

Treatments[1]	Yield (t/ha) Cassava	Yield (t/ha) intercrop	Gross income[3]	Fertilizer costs[3]	Net Income	Biomass Incorp.[2] (t/ha)	Dry soil loss (%)	Farmers' preference
			<----------(mil.dong/ha)		---------->			
1. Cassava(C)+taro(T), no fertilizers, no hedgerows	9.00	2.260	6.99	0.74	6.25	-	43.13	-
2. C+T, with fertilizers, vetiver grass hedgerows	13.02	1.800	8.49	1.53	6.96	0.144	19.67	-
3. C+T, with fertilizers, *Tephrosia candida* hedgerows	14.09	1.800	9.02	1.53	7.49	0.864	15.95	-
4. C+peanut, with fertilizers, vetiver grass hedgerows	15.66	0.660	11.13	1.53	9.60	1.570	2.39	+
5. C+peanut, with fertilizers, *Tephrosia candida* hedgerows	14.29	0.693	10.61	1.53	9.08	2.165	3.99	+

1) All plots recceived 5 t/ha of FYM; fertilizers = $40N+40P_2O_5+80K_2O$
taro or peanut received seperately: $7N+20P_2O_5+20K_2O$ in all treatments

2) Dry biomasss from peanut and leaves of hedgerows

3) Prices:

cassava fresh roots:	d 500 /kg
taro fresh corms:	1100 /kg
peanut dry pods:	5000 /kg
FYM:	100 /kg
urea (45%N):	3000 /kg
SSP (17%P_2O_5):	1000 /kg
KCl (60%K_2O):	2200 /kg

Table 9. Average results of three FPR cassava variety trials conducted in Soeng Saang district of Nakorn Ratchasima province and of six trials conducted in Wang Nam Yen district of Sra Kaew province of Thailand in 1995/96.

	Soeng Saang			Wang Nam Yen		
Varieties	Root Yield (t/ha)	Starch Content (%)	Farmer preference	Root Yield (t/ha)	Starch content (%)	Farmer preference[1)]
Rayong 1	11.42	27.1	-	24.03	26.5	0
Rayong 60	9.91	26.5	-	29.70	27.1	0
Rayong 90	18.40	33.0[2)]	+++	29.44	28.2	9
Rayong 5	11.85	25.8	+	32.82	29.4	5
KU 50	14.56	28.7	++	32.90	29.5	1

[1)]Out of 12 farmers

[2)]Average of only 2 trials

Rayong 90 over other varieties, even though in the FPR trials the yield and starch content of Rayong 90 were slightly lower than those of Rayong 5 and KU 50.

Table 10 shows that in Pho Yen district of Vietnam farmers strongly preferred the new variety KM 95-3 even though it produced a similar yield as CM4955-7 or SM981-3. A participatory evaluation (PE) of these varieties, conducted as part of the field exercises in the FPR training course in Vietnam, revealed that farmers did not like CM4955-7 because of low starch content, poor plant type and poor storability of planting material.

Table 10. Average results of eleven FPR variety trials conducted by farmers in Tien Phong and Dac Son villages of Pho Yen district, Bac Thai province, Vietnam in 1996.

Varieties/lines	Cassava Yield (t/ha)	Gross income	Net income[2]	Farmers' Preference (%)
		<-----(mil. Dong/ha---->		
1. Xanh Vinh Phu (local)	20.22	12.13	10.06	0
2. KM 60	22.49	13.49	11.42	33
3. 0MR 25-33-105	21.80	13.08	11.01	33
4. SM 937-8	20.77	12.46	10.39	0
5) CM 4955-7	23.76	14.26	12.19	58
6) SM 981-3	23.35	14.01	11.94	42
7) SM 1557-3 (KM 95-3)	23.81	14.29	12.22	100

[1)] Price: cassava fresh roots: d 600/kg

[2)] Cost of application of 10 t FYM+174 kg urea+250 kg SSP+133 kg KCl/ha is 2.065 mil. dong/ha

Tables 11 and 12 show the results of fertilizer trials in Thailand and Vietnam, respectively. In Thailand highest yields and net income were obtained with the application of 50 kg/ha each of N, P_2O_5 and K_2O.

Table 11. Average results of six FPR fertilizer trials conducted by farmers in Noon Somboon village of Soeng Saang district, Nakorn Ratchasima province of Thailand in 1996/97.

Fertilizer rate $N\text{-}P_2O_5\text{-}K_2O$ (kg/ha)	Root yield (t/ha)	Starch contest (%)	Gross Income[1)]	Fertilizer cost[2)]	Net Income
			<------------('000 B/ha)------------->		
0-0-0	20.36	28.3	15.47	0	15.47
50-0-0	24.02	28.2	18.25	0.78	17.47
50-50-0	22.86	28.0	17.37	1.72	15.65
50-0-50	21.90	28.5	16.64	1.23	15.41
25-25-25	25.76	29.6	20.61	1.10	19.51
50-50-50	28.82	29.2	22.48	2.20	20.28

1)Cassava price: B 0.80/kg fresh roots at 30% starch
0.78/kg fresh roots at 29% starch
0.76/kg fresh roots at 28% starch

2)Cost fertilizers:

urea	B350/bag of 50 kg
TS P	425/bag of 50 kg
KCl	270/bag of 50 kg
15-15-15	330/bag of 50 kg

Table 12. Average results of four FPR fertilizer trials conducted by farmers in Tien Phong and Dac Son villages of Pho Yen district, Bac Thai province, Vietnam in 1996.

Treatments	Cassava yield (t/ha)	Gross income[2)]	Fertilizer costs[3)]	Net Income	Farmers' Preference (%)
		<------------(mil. dong/ha)------------>			
1. Farmer's practice[1)]	8.93	5.36	1.84	3.52	0
2. 10 t/ha of FYM; $40N+40K_2O$	10.56	6.34	1.41	4.93	0
3. 10 t/ha FYM; $80N+80K_2O$	12.40	7.44	1.82	5.62	79
4. 10 t/ha FYM; $80N+40P_2O_5+80\ K_2O$	13.22	7.93	2.06	5.87	21

1)Average farmer application: 13.3t FYM+115.8 kg urea+39 kg SSP+56.5 kg KCl/ha

2)Prices: cassava fresh roots: d 600 /kg

3)Costs:

FYM:	d 100 /kg
urea (45%N):	3000 /kg
SSP (17%P_2O_5):	1000 /kg
KCl (60%K_2O):	2200 /kg

However, a similar net income could be obtained with the application of half this rate. Because of limited financial resources, farmers decided that 25 kg/ha of each nutrient was a more practical rate. In Vietnam, farmers apply large amounts of pig manure to cassava. Results of the FPR trial (Table 12), however, indicate that a higher net income could be obtained with a lower rate (10 t/ha) of manure combined with 80 kg N and 80 kg K_2O/ha applied as chemical fertilizers. This was the fertilization practice most farmers preferred. Of the three cropping systems tested in Vietnam, farmers overwhelmingly preferred the system of intercropping cassava with peanut, as compared to intercropping with black bean or planting cassava in monoculture.

After conducting these FPR trials in various sites, ten collaborating farmers in Thailand decided to plant contour barriers of either vetiver grass or sugarcane at 1 m vertical intervals in small areas (about 2000 m^2) of their cassava production fields; similarly, three farmers in Vietnam planted vetiver or *Tephrosia candida* barriers in their fields as a hedge against erosion. Moreover, most of our collaborating farmers in Thailand are now planting new varieties and use about 200 kg/ha of 15-15-15 fertilizers in their cassava fields; those in Vietnam are planting new varieties, intercrop cassava with peanut and apply chemical fertilizers as well as animal manures. In China many collaborating farmers are now planting new higher-yielding varieties, and are experimenting with the application of a special fertilizer mix containing NPK and Zn as well as some chicken manure. In Indonesia most farmers have not yet implemented any improved practices as few of the tested treatments were clearly superior to their present practices.

Soil erosion and conservation practices in Cauca

(2.3.1; K. Müller-Sämann, Felicits Floerchinger, Kai Sonder

Contributors: Werner Doppler, Cesareo Gallego, Luis.E. Mina , Jose Luis Adarve, Disnardo Peña Universidad de Hohenheim, Germany)

- University of Hohenheim Sub-project. Soil Degradation and Crop Productivity Research for Conservation Technology Development in Andean Hillsides

Main achievements

- Environmental and economic impact of soil-crop management alternatives in cassava was calculated on the basis of long term measurements of soil losses by combining an empirical soil loss model (USLE) with a modified soil loss-productivity model (PI).
- With traditional cassava in tilled plots, the shallow soils of the pilot area of the northern Cauca department will loose their productivity within 25 (pessimistic scenario) and 84 Years (optimistic scenario).
- Applying soil conservation practices allows cassava production for over 90 years (pessimistic case) or with only minor yield depressions between 4-14 % in 100 years (optimistic scenario).
- Based on actual cassava prices and a 25 years planning horizon annual investments between 181 to 875 $ US per hectare are economically justifiable to support conservation practices for cassava in the northern Cauca hillside environment.

Characteristics of degradation, its effect on productivity and the economic implications of soil erosion

Soil erosion is a major environmental and agricultural problem worldwide. Each year, 75 billion tons are removed from the land by wind and water erosion, with most coming from agricultural land. The loss of topsoil degrades agricultural land and possibly renders it unproductive. Worldwide, about 12 x 10^6 ha of arable land are destroyed because of mismanagement (Pimentel et al., 1995). These are alarming facts, especially as in the end of the 20^{th} century we are facing a remarkable transition in the history of agriculture (Rutton, 1992). Prior to this century almost all of the increase in food production was obtained by bringing new land into production. Yet in the next century, almost all increases in world food production must come from higher yields - from increased output per hectare. To adequately feed people a 0.5 ha of arable land is needed, yet only 0.27 ha per capita is available. In 40 years, only 0.14 ha per capita will be available because of loss of land and rapid population growth. In many regions, limited land is already a major cause of food shortages and inadequate distribution. Soil erosion rates are highest in Asia, Africa, and South America, averaging 30 to 40 tons ha^{-1} $year^{-1}$ (Pimentel et al., 1995).

Economic Costs of Soil Erosion

Under natural conditions, the topsoil that is lost is largely replenished from the subsoils. Topsoil can be defined as a renewable resource with a threshold level below which resource use renders it nonrenewable. Many of the land-use practices adopted in the developing countries appear to be consistent with measures that transform topsoil into a nonrenewable resource. The extraction of a natural resource in the current period reduces net benefits to the future generations. This loss is defined as the user cost. The user cost of soil exploitation is likely to be low in situations where the net returns without soil conservation exceed those with soil conservation for substantial lengths of time.

The user concept is clearly relevant in heavily eroding environments where the net returns with conservation are higher than those without conservation.

A farmers wealth may influence the adoption of soil conservation practices but decisive are expectations about future income. These expectations are conditioned by the farmer's planning horizon and discount rate. A farmer who expects the net returns with soil conservation to be lower than those without conservation is certainly likely to postpone conservation. The length of time over which the net returns without conservation exceed those with conservation is often too long for the planning period to be a significant influential variable. If the effects of land degradation are perceived unlikely in the near future, the adoption of soil conservation practices would correspondingly remain unlikely.
Also, we can not expect subsistence farmers in developing countries to be concerned about soil degradation and have a long planning horizon if they are struggling for survival, not knowing if they can make a living from this year to the next.

In a study undertaken by the Soil Conservation Project in 1994 (CIAT, 1995) in a cassava growing zone of the northern Cauca department, Colombia, farmers were asked about their perception of soil erosion and their soil management practices. The mean gradient of slopes being cultivated was 35 percent. 97 % of the 60 farmers interviewed asserted to have observed soil being eroded by rainfalls. Almost all of them (96 %) considered soil loss was reducing the productivity of their land. Asked about their soil conservation strategies 31 % admitted not to employ any conservation method and another 30%mentioned the traditional zone tillage (loosening only the planting site) and the tradition of rotation as the only means to alleviate the extent of soil losses from their fields.

The reasons for not using erosion control practices were the following:

No materials available	4 %
No technical assistance	45 %
Too expensive	22 %
No time	15 %
Don't know	19 %

All those reasons can be summarized in two reasons: No or inadequate technical assistance and costs implied in the application of specific soil conservation technology. The argument 'no material available' signifies that the farmer might know conservation practices like living barriers or mulching, but does not know where and how to get mulch material or planting material for barriers. Good technical assistance, developing conservation strategies with the farmers and making available those materials or introducing other control practices like minimum tillage, planting on contour ridges or whatever might be suited for the conditions is therefore needed to assist farmers in the adoption and development process. 'Too expensive' and 'no time' are problems that should be solved with the aid of the government, either by giving access to favorable credits, with the development of economically attractive conservation alternatives (see also output 1.3) or subsidizing the employment of conservation practices. However before the latter will happen realistic estimates of erosion's impact on the productivity and its economic consequences must be available to facilitate political decisions in this respect.

Costs of conservation practices

The costs of conservation practices are hard to evaluate. The prices of some practices are variable enough to make it difficult to obtain accurate averages.

Opportunity costs are a means of considering many of the less obvious costs of conservation. For example, one must forgo the opportunity to grow a crop on the area where a grassed waterway is planned. The opportunity to make a profit is real, even though a gully might destroy it later.

The costs of conservation do not stop when a practice is installed. Opportunity costs remain like a ghost in the background and someone will surely be tempted to plow up the waterways and steep slopes even if the erosion hazard is great. Maintenance is an obvious continuing cost of conservation. Terrace channels and waterways need to be cleaned and occasionally reshaped. Drainage systems must be kept open. Vegetation must be fertilized, managed or replanted.

Material and methods

Topsoil loss by erosion in different growing systems

The data for the estimation of soil erosion under different management options were obtained from a study conducted at the CIAT (International Center of Tropical Agriculture) research station at Santander de Quilichao, Cauca department, Colombia, on an Inceptisol. Since 1986 an erosion trial is run by the joint CIAT/ University of Hohenheim Project, where the USLE (Universal Soil Loss Equation) is tested and calibrated for its applicability under tropical conditions. Over the years on several test plots soil loss by water erosion has been measured with different tillage and cropping techniques (Reining, 1992; 1995) (Table 1). These data were used for the calculation of long term soil and productivity losses by soil erosion.

Table 1. Soil loss by water erosion of different cassava cropping and cultivation systems in Santander de Quilichao in the 1987 to 1994 growing seasons.

Treatment	Soil loss (t ha^{-1})					
	87/88	88/89	90/91	91/92	92/93	93/94
Cassava traditional	5.1	17.2	8.2	4.9	4.6	7.5
Cassava on contour ridges	3	5.1	n.d.*	0.4	0.5	n.d.
Cassava between contour grass strips	5.3	15.3	1.7	1.6	1	1.1

*soil loss was not determined

The following treatments were considered:
- Cassava planted on the flat as a sole crop at 1 m x 1 m.
- Cassava planted on parallel contour ridges at a distance of 1 m as a sole crop at 1 m x 1 m.
- Cassava planted as a sole crop at a distance of 0.90 m x 1 m with contour strips of Vetiver grass (*Vetiveria zizanioides*) of 1 m width at a distance of 10 m.

Soil loss was measured on plots with slope gradients ranging from 7-13 % and a length of 22.1 m (bare fallow) and 16 m (cropped plots). Data were corrected for the LS-factor (Length-Slope factor of the USLE; Wischmeier and Smith, 1978) to obtain data corresponding to a plot with 9 % slope gradient and 22.13 m length (LS-factor = 1).
According to IGAC (1976) 77 % of the soils of the Cauca department are classified as Inceptisols. Usually smallholders in the Cauca department cultivate soils on much steeper and longer slopes. As an average

value slopes with a gradient of 25 % and 50 m length were assumed. In order to estimate soil losses under smallholder conditions in the same period, data from table 1 were taken as a basis to calculate soil loss on slopes with a gradient of 25 % and 50 m length using the slope-effect chart from Wischmeier and Smith (1978). A field with 25 % gradient and 50 m length has a LS-factor of 7.5 and consequently data from Table 1 were multiplied by 7.5 to obtain the estimated soil loss on smallholder fields (Table 2).

Table 2. Estimated soil loss in different cassava cultivation systems on plots with 25 % slope gradient and 50 m length.

Treatment	Soil loss ($t\ ha^{-1}$) 87/88	88/89	90/91	91/92	92/93	93/94
Cassava traditional	38.3	129	62	36.8	34.5	56.3
Cassava on contour ridges	22.5	38.3	n.d.*	3	3.8	n.d.
Cassava between contour grass strips	39.8	114.8	12.8	12	7.5	8.3

*soil loss was not determined

With an average bulk density of 0.84 $g\ cm^{-3}$ (Reining, 1992) 1000 $kg\ ha^{-1}$ of eroded topsoil correspond to a loss in topsoil depth of 0.012 cm.

Lowest and highest soil losses of the different cultivation systems were assumed to estimate the impact on productivity in an optimistic and in a pessimistic case scenario.

Impact of topsoil loss on cassava yields

The impact of topsoil loss on cassava yields was estimated with the Productivity Index model.

The relation between the productivity index (PI) and the amount of topsoil loss was calculated with the following equation (see CIAT, Project No. 10 , Annual Report 1996):

$PI = 0.21 - 5.18 * 10^{-3}$ cm.
Then the impact of topsoil loss on cassava yields was determined with the equation
$Y = -0.1 + 8.3\ PI - 15.5\ PI^2$,
where Y is the normalized cassava yield, with Y = 1 corresponding to 33125 $kg\ ha^{-1}$.

Calculation of the economic impact of topsoil loss

Annual gross returns per hectare were calculated using the equation :
$BR = Y * P_C$,
where
BR = gross returns (US \$ ha^{-1});
Y = fresh root yield ($kg\ ha^{-1}$);
P_C = local market price for cassava (starch factories).

With the gross returns for each cultivation system and erosion rate the value of the soil was determined. Following Van Kooten et al. (1989) the marginal user cost was calculated. The marginal user cost denotes the impact of current exploitation of the soil on future profits via the level of the soil stock. Once a soil is exploited beyond its regeneration rate, the society looses resources that otherwise could be used in the future. The marginal user cost was calculated with the equation:

$$MUC_t = \sum_{t=1}^{n} (BR_c - BR_t) / (1+r)^t ,$$

where
MUC_t = Marginal user cost at time t,
BR_c = Gross return with soil conservation,
BR_t = Gross return without soil conservation,
r = Discount rate.

In other words the marginal user cost represents the present value of the soil that would be lost if no soil conservation was done. Once the soil value was determined, its equivalent level annuity was calculated following Williams and Tanaka (1996), using the equation:

$$A_t = MUC_t * [r * (1+r)^n / (1+r)^n - 1]$$

where
A_t = annualized value of soil (US \$ ha^{-1}).
The annualized value of soil is equivalent to the amount that could be spent each year to conserve soil to year t. An annual discount rate of 12 % was assumed.

Results

The highest erosion rates were observed in the traditional cassava growing system. Soil losses in the experimental plots varied consistently from one year to another depending on the climatic conditions.

Data of Table 1 were multiplied by the LS factor 7.5 to obtain an estimation of the average soil losses in the Cauca department with average field length of 50 m and a slope gradient of 25 % (Table 2).

In the pessimistic case, when the highest erosion rates were taken for the calculation of long term soil losses, after 25 years no yield would be obtained on the traditional cassava plots, after 30 years on the plots with contour grass strips, and after 84 years on the plots with contour ridges. In the optimistic case only a slight yield decline would occur on the plots with soil conservation, but on the traditional system still a substantial yield reduction would occur.

Figure 1 shows the yield decline in the different treatments caused by topsoil erosion.

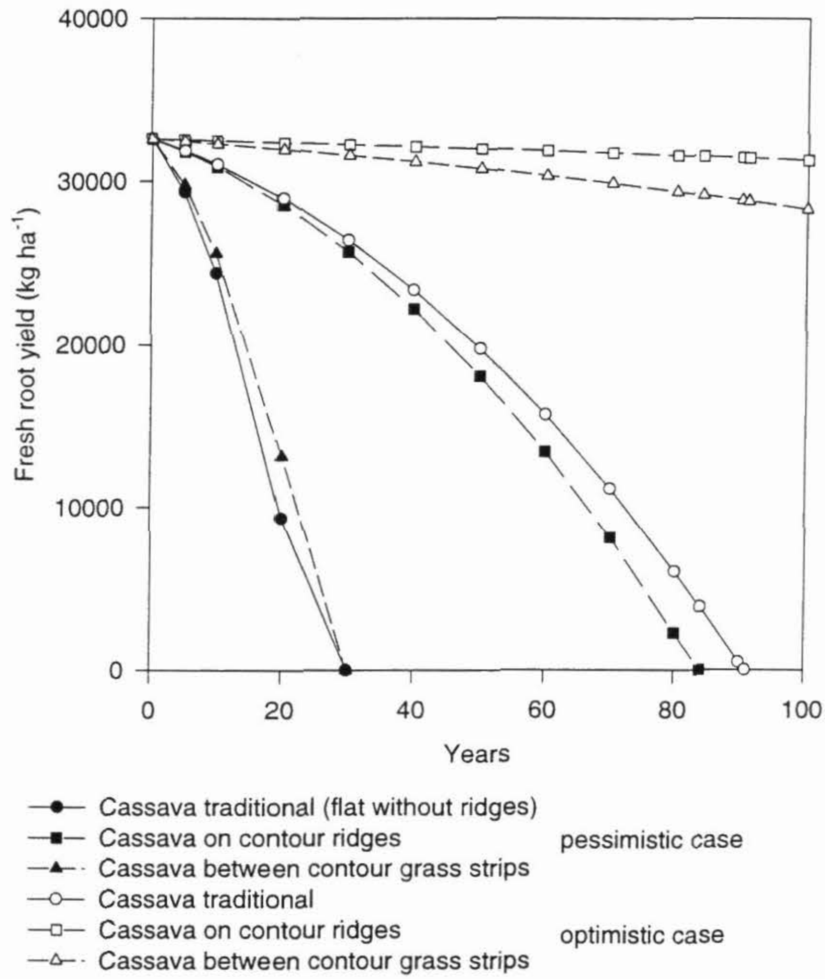


Figure 1. Erosion effect on cassava yields in different cropping systems for a time period of 100 years. Slope gradient 25 %, field length 50 m. Optimistic case: lowest soil loss assumed; Pessimistic case: highest soil loss assumed. Cauca Department, Colombia.

Tables 3a and 3b show how soil erosion would influence yields, gross returns, marginal user costs, and equivalent annuities in the pessimistic and optimistic case over a time period of 100 years. The local market price for cassava was assumed to be 0.155 US \$ kg^{-1} (price paid by the starch factories in 1997).

Discussion

Comparing the efficiency of the two soil conservation techniques it might be concluded that contour grass barriers are not very effective in erosion control. But the high soil losses in 1987/88 and 1988/89 were due to poor establishment of the barriers. Once the grass forms a dense barrier erosion is reduced more efficiently.

Table 3a. Cassava yields, gross return, marginal user cost, and equivalent annuity of two different soil conservation methods (contour ridges, contour grass strips) compared to the traditional method, Cauca Department, Colombia. Highest erosion rates were assumed.

Years	Yields (kg ha^{-1})			Gross return (US \$ ha^{-1})			Marginal user cost Year 1 to n (\$ ha^{-1})		Equivalent Annuity Year 1 to n (\$ ha^{-1})	
	trad.	ridges	Strips	trad.	ridges	Strips	ridges	strips	ridges	strips
0	32579	32579	32579	5050	5050	5050	0	0	0	0
5	29323	31797	29759	4545	4929	4613	694	119	192	33
10	24360	30867	25582	3776	4784	3965	2146	386	380	68
15	17690	29789	20049	2742	4617	3108	3852	714	566	105
20	9312	28563	13159	1443	4427	2040	5479	1036	733	139
25	0	27189	4912	0	4214	761	6866	1316	875	168
27	0	26598	1233	0	4123	191	7341	1343	924	169
30	0	25666	0	0	3978	0	7968	-	989	-
40	0	22177	0	0	3437	0	9408	-	1141	-
50	0	18095	0	0	2805	0	10136	-	1220	-
60	0	13421	0	0	2080	0	10474	-	1258	-
70	0	8154	0	0	1264	0	10622	-	1275	-
80	0	2295	0	0	355	0	10685	-	1282	-
83	0	422	0	0	65	0	10695	-	1284	-
84	0	0	0	0	0	0	-	-	-	-

Calculations were done based on the gross returns because production costs until delivery to the starch factories vary from farm to farm. Also the costs of soil conservation were not considered, because data are not yet complete and sufficiently representative.

The results of this study indicate that remuneration of erosion control depends on the erosion rate and the planning horizon. In the pessimistic case after 25 years no yields are obtained from the traditional cassava plots. If the farmer has a planning horizon of 25 years, the present value of the soil saved by contour ridges is 6866 \$ US ha^{-1}. That is the amount that could be invested at the present time to prevent soil erosion. With a discount rate of 12 %, the 6866 \$ US are equivalent to an annual invention of 875 \$ US.

If erosion rates were lower, less money could be invested. Assuming the optimistic case and a planning horizon of 25 years, the present value of soil (= the marginal user cost of not controlling erosion) would be 1419 \$ US, corresponding to an equivalent annuity of 181 \$ US. Colombia is a country with a relatively high discount rate. The higher the discount rate, the lower is the appraisal of future values. If the discount rate was lower, the cost of erosion would be much higher, in other words the soil would be much more precious. But even so, Colombia is loosing millions of dollars annually by erosion. Baquero (1993)

Table 3b. Cassava yields, gross return, marginal user cost, and equivalent annuity of two different soil conservation methods (contour ridges, contour grass strips) compared to the traditional method, Cauca Department, Colombia. Lowest erosion rates were assumed.

Years	Yields (kg ha^{-1})			Gross return (US \$ ha^{-1})			Marginal user cost Year 1 to n (\$ ha^{-1})		Equivalent Annuity Year 1 to n (\$ ha^{-1})	
	trad.	ridges	Strips	trad.	ridges	Strips	ridges	strips	ridges	strips
0	32579	32579	32579	5050	5050	5050	0	0	0	0
5	31864	32523	32427	4939	5041	5026	198	169	55	47
10	31024	32465	32268	4809	5032	5002	541	464	95	82
15	30058	32407	32102	4654	5023	4976	890	766	131	112
20	28966	32348	31931	4490	5014	4949	1187	1026	159	137
25	27749	32288	31752	4301	5005	4922	1419	1230	181	157
30	26406	32227	31567	4093	4995	4893	1591	1382	198	172
40	23343	32102	31177	3618	4976	4832	1800	1568	218	190
50	19777	31974	30761	3065	4956	4768	1897	1655	228	199
60	15709	31842	30318	2435	4936	4699	1939	1639	233	203
70	11138	31706	29850	1726	4914	4627	1957	1709	235	205
80	6065	31567	29355	940	4893	4550	1964	1716	236	206
90	488	31424	28833	76	4871	4469	1967	1718	236	206
100	0	31277	28286	0	4848	4348	1968	1719	236	206

calculated for the department of Nariño in the Colombian Andes an annual loss of 2.3 to 7 million US \$ US by not controlling erosion.

Depending on the erosion rate and the planning horizon investment in erosion control will pay back sooner or later. The longer the period, the less likely farmers will invest their money in conservation technology. Results of this study and the study of Baquero (1993) show clearly that the Colombian economy is suffering high losses by soil erosion. Policy makers and governments should possess a longer planning horizon than individual farmers and take into account the needs of future generations. Subsidies and credits for erosion control and investments in sustainable land management research and conservation politics would benefit the whole nation.

Based on the results of this study a detailed analysis of the Cauca department could be done to obtain an estimation of the erosion costs in that region. Inclusion of soil loss data in different crop rotations and the costs of establishment and maintenance of erosion control techniques would be useful and can in part be provided by the end of this ongoing project.

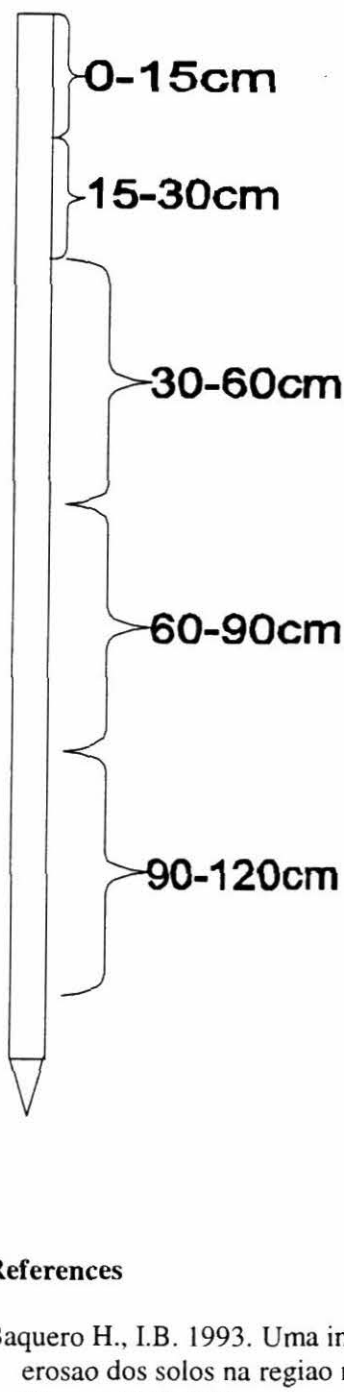
Characterization of conservation practices with respect to soil water balance

In order to evaluate the possible effects of different cassava cropping systems on the retention of soil water, measurements of the soil moisture content with a TDR (Time Domain Reflectancy) system were to be performed from April 96 until March 98.

Due to problems with the provider (late and not complete delivery) of the Moisture Point MP-917 TDR system, the soil moisture contents measurements started with a one-year delay. In April 20, 1997 TDR probes were installed in 6 erosion plots on the field station in Santander de Quilichao. The plots and the respective treatments chosen for evaluation and monitoring are given in the following table.

Table 4 Long term treatments, no. of probes and rotation elements chosen for soil moisture studies on runoff plots in Santander de Quilichao Experimental Station.

Long term treatment or cropping pattern	Number of probes	Crop from 4.97-7.97	Crop from 10.97-3.98
Cassava based Traditional rotation	4	Cowpea	Bare fallow
Cassava rotation with Minimum tillage	4	Cowpea	Bare fallow
Grass/legume ley (true meadow)	4	*Brachiaria decumbens* and *Centrosema macrocarpum*	Bare fallow
Cassava with Vetiver (*Vetiveria zizanioides*) grass barriers	8	Cowpea	Bare fallow



In all plots (16 x 8 m) but the grass barrier treatment, 2 probes were installed in the middle of the plot, one probe being positioned 3 m down the slope from the first one. One repetition was installed.

To see possible effects of the Vetiver grass barrier on the subsurface water flow, 4 probes were installed each in two plots with Vetiver hedgerows. Two were placed above the barrier and two below.

Due to the high clay content of the soil, especially in the deeper horizons, insertion of the probes was delayed almost two weeks. According to the instructions of the manufacturer a hole has to be preformed by inserting a pilot rod once. At the plot site the pilot rod had to be inserted up to 7 times and still the insertion of the probe itself was difficult. Each probe has a total length of 140 cm and is divided into five measuring segments as illustrated in the drawing on the left .

Daily measurements were performed from Monday to Friday and after heavy rainfalls also on Saturdays. Routine measurements were performed by a field worker and take approximately 2 hours for 200 lectures. The probes are permanently installed in the soil and custom cables of 10 m length allow measurements of the soil moisture content without stepping on the erosion plots in order to avoid compaction by trampling.

From October 1997 on a system comparison will start with a neutron probe system to explore the relative advantages of the two soil moisture monitoring systems in a tropical soil environment with high contents of sesqui-oxides. The installation of the neutron probe aluminum tubes will be used to calibrate the TDR system both according to the manufacturers instructions to compensate for the probe material and for differences between real soil moisture content and the one measured by the TDR system.

From the experiences already made with the equipment, it can be said that the handling of the TDR equipment is far easier and faster than a neutron probe system. More important still, there is no danger to the handler of the equipment as no radiation is involved in the measuring process.

References

Baquero H., I.B. 1993. Uma interpretacao dinamica dos efeitos da modernizacao da agricultura sobre a erosao dos solos na regiao monhosa nariñense. Tese de doutorado. Universidade Federal de Vicosa. Vicosa, M.G. 232 pp.

CIAT, 1995. Diagnostico sobre condiciones socio-economicas y de manejo de recursos naturales en una zona yuquera del norte del departamento del Cauca. Documento de trabajo No. 1, Proyecto especial de conservacion de suelos, CIAT, Programa de Yuca.

Flörchinger F. and Müller-Sämann K.M. 1996 El efecto de la erosión en la productividad del suelo. Memorias del "Seminario Nacional sobre Actualización en Conservación de Suelos en Ladera. Feb. 6-8, 1996, Santafé de Bogotá. INAT, JICA, CECIL . pp 131-136

Hook, Livingston, Sun & Hook:: Remote Diode Shorting Improves Measurements of Soil Water by Time Domain Reflectometry: SSSJ, Vol.56#5'92

IGAC (Instituto Geografico Augustin Codazzi). 1976. Estudio general de suelos de los municipios Santander de Quilichao, Piendamo, Morales, Buenos Aires, Cajibio y Caldono (Departamento del Cauca). Vol. 12(4). Bogota. 472pp.

Pimentel, D., C. Harvey, P. Resosudarmo, K. Sinclair, D. Kurz, M. McNair, S. Crist, L. Shpritz, L. Fitton, R. Saffouri, and R. Blair. 1995. Environmental and economic costs of soil erosion and conservation benefits. Science 267: 1117-1123.

Pierce F.J., W.E. Larson, R.H. Dowdy and W.A.P. Graham 1983. Productivity of soils: Assesing long term changes due to erosion. Journal of Soil and Water Conservation, Vol.38: 39-44

Reining, L. 1992. Erosion in andean hillside farming. *Hohenheim Tropical Agricultural Series* No. 1. Verlag Josef Margraf, Weikersheim, Germany. 219 pp.

Ruppenthal, M. 1995. Soil conservation in andean cropping systems. Hohenheim Tropical Agricultural Series No. 3. Verlag Josef Margraf, Weikersheim, Germany. 110 pp.

Rutton, V.W. 1991. Constraints on sustainable growth in agicultural production: into the 21st century. Outlook on Agriculture 20(4): 225-234.

Schofield T.G., G.J. Langhorst, G. Trujillo, K.V. Bostick, W.R. Hansen: Comparison of Neutron Probe and Time Domain Reflectometry Techniques of Soil Moisture Analysis: 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

Topp,G.C., S.J. Zegelin and I. White: 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

Van Kooten, G.C., W.P. Weisensel, and E. de Jong. 1989. Estimating the costs of soil erosion in Saskatchewan. Canadian Journal of Agricultural Economics 37: 63-75.

Williams, J.R., and D. L. Tanaka. 1996. Economic evaluation of topsoil loss in spring wheat production in the northern Great Plains, USA. Soil & Tillage Research 37: 95-112.

Wischmeier, W.H., and D.D. Smith. 1978. Predicting rainfall erosion losses - a guide to conservation planning. U.S. Department of Agriculture, Agriculture Handbook No. 537. Washington D.C.

Output 3. Enhanced ability to promote adoption of sustainable land use practices

Methods developed for increasing adoption of sustainable land use practices (3.1)

Activities contributing to this output in 1997 have been

i) Continued development and adaptation of Farmer Participatory Research principles that are applicable in different cultural contexts (see section in Targeting Research – New approaches for targeting technology development).

ii) A workshop on Systems Research in CIAT is being organized for 1-2 December 1997. This will be one of the topics discussed.

Integrated resource models to facilitate extension of results
(3.2)

Model for resource allocation at the farm level
(3.2.1; A. Gijsman)

Main achievements

- Linkage being established between the CENTURY soil organic model and the DSSAT model.
- A legume cover crop/green manure model is being developed in conjunction with CIMMYT.

DSSAT extended with a legume cover model and an improved soil-organic matter model

The DSSAT model is the most widely used model for simulating crop yields and economic returns. Modules exist for most commercial crops but not for cover crops/green manure. As the ultimate aim is to use DSSAT to simulate smallholder cropping systems and link it to physical GIS databases, it is imperative to have a model that included the use of green cover/green manure.

A training workshop on the application of the DSSAT model was attended, during which it was discussed extensively with several DSSAT authors what kind of modifications to the model would be needed for making it applicable to smallholder systems with legume cover crops or green manure. Three topics came to the front, around which the workplan was developed

i) The DSSAT model does not simulate the growth and development of green-manure/cover-crop legumes; it does, however, simulate several food legumes (soybean, bean, peanut). Since these crops do not differ much in their growth and development pattern, it was decided to use one of the existing legume sub-models and reformulate it for a green-manure/cover-crop legume.

An experiment is being conducted to obtain detailed growth and development data for these cover/green manure legumes in order to provide parameters for the model. The following legumes are being grown - *Mucuna pruriens* 9349, *Centrosema pubescens* 15160, *Canavalia brasiliensis* 17009, Cowpea, var. Verde Brasil and Common bean BAT 477, as reference crop.

This work is done in collaboration with Dr. Jeff White and Ir. Dewi Hartkamp (CIMMYT), who are applying DSSAT to similar green-manure/cover-crop systems, and with scientific support from Dr. Ken Boote (Univ. Florida) and Dr. Gerrit Hoogenboom (Univ. Georgia), co-authors of existing legume sub-models (Dr. Jeff White is also coauthor). Elements of the experiment will be replicated at other locations (e.g. Mexico, by CIMMYT), so as to obtain a wide range of temperature and photoperiod conditions.

ii) For simulating low-input systems in developing countries, it is absolutely crucial that the model is able to make a reliable estimate of the nutrient release from soil organic matter (SOM). The present SOM sub-model of DSSAT is too meager for this, since DSSAT was developed for systems where most nutrients are derived from chemical fertilizers. Given our earlier experience with the CENTURY SOM model, it was decided to link these two models. This is done in collaboration with Walter Bowen (CIP) and Paul Wilkens (IFDC), authors of several DSSAT soil modules, and Bill Parton (Colorado State Univ.), the leading CENTURY author.

iii) Presently, DSSAT only simulates the nutrient nitrogen, an important limitation for its application to systems that may not be primarily N limited (e.g. the low-P soils of South America). The University of Michigan (Dr. Samira Daroub) just started a collaborative project with IFDC and Dr Dennis Friesen of CIAT's soils' group to also incorporate phosphorus in DSSAT. Although initially the focus will be on inorganic (rock) phosphorus, the above-mentioned linkage between DSSAT and CENTURY facilitates a potential widening of the scope to also include organic P, because the CENTURY SOM sub-model already does include organic P. In earlier work we made suggestions on how to modify the P sub-model of CENTURY to accommodate the strongly P-sorbing soils we are dealing with (Gijsman et al. 1996 - Agronomy Journal 88: 894-903).

Besides these three topics, a fourth issue is the lack of a livestock grazing option in DSSAT, because many of the smallholder systems we are dealing with have an important livestock element. Contacts have been made with NRI (UK: Dr. Peter Thorne) and ILRI (Dr. Philip Thornton), who are working on such models, to see how we can incorporate this in DSSAT.

For the coming months, the focus will initially be on data collection from the legume experiment, and on the development of a modified DSSAT model that includes a green-manure/cover-crop legume option and has an improved SOM module. Data on weather, soil type, farm management, etc. will be collected for the sites where the model will be applied. Model application will follow these developments.

Funding is being sought for continued research on model application in system analysis through a joint application with Colombian coffee research station CENICAFÉ (Dr. Jaime Arcila) for a collaborative project on modification and application of DSSAT. Contacts have been made with several donors.

Models on livestock adapted to dual-purpose systems
(3.2.2; F. Holmann and R.D. Estrada)

Main achievement

- Farm simulation model expanded and validated.

The farm simulation model developed initially by CATIE and RISPAL was expanded this year in CIAT with Ruben Darío Estrada to incorporate additional agricultural (i.e. four crops instead of three), reforestation (two activities instead of one), and livestock activities (i.e. in addition to dairy, dual-purpose and beef activities, fattening was also incorporated). The model was validated by Ruben Darío in

Honduras in July of this year, and later by F. Holmann during the training of three CORPOICA colleagues in October of 1997.

Training approaches and materials on technology diffusion for use by farmers and technicians - Forages for Smallholders Sub-project

(3.3; W. Stür, CIAT; P.Horne, CSIRO; F. Gabunada (FSP, Philippines); Ed Magboo, PCARRD, Philippines)

Main achievements

- Produced training modules for in-country training on *"Developing forage technologies with smallholder farmers".*
- Conducted the first in-country training course on *"Developing forage technologies with smallholder farmers"* in the Philippines.
- Provided practical training for forage scientists and development workers from Southeast Asia

Summary of activities

Modules for in-country training courses on "Developing forage technologies with smallholder farmers".

Following a workshop on "Forage agronomy, seed supply systems and seed production" in Thailand in late 1996, a training manual was developed entitled *"Developing forage technologies with smallholder farmers".* The workshop in Thailand was attended by representatives from all countries participating in the FSP and it was designed to discuss content and training methods of subsequent in-country courses. This manual is now being translated into local languages by our national partners and will form the basis for a series of in-country courses.

First in-country training course on "Developing forage technologies with smallholder farmers" in the Philippines.

The first training course was held for 15 participants from FSP sites and related agencies in Los Baños from 3–15 August 1997. This course served as a pilot course for the in-country courses and the manual was edited based on feedback from participants and experience from this course.

Practical training for forage scientists and development workers from Southeast Asia

Practical training was provided to all collaborating forage research and development workers at FSP sites by Werner Stür and Peter Horne. Additionally, two key partners, Mr. Ibrahim of the Livestock Services of East Kalimantan, Indonesia and Mr. Viengsavanh Phimphachanhvongsod of the Department of Livestock and Fisheries, Laos received hands-on training in another country in the region. Mr Ibrahim, who is responsible for FSP activities in Makroman and Sepaku II in East Kalimantan, spent three weeks working with Mr Francisco Gabunada in the Philippines. He received training in forage agronomy and seed production, and participated in FSP site visits in the Philippines where he assisted with PD and PP sessions. Mr Viengsavanh, who is the FSP country coordinator for Laos, participated in a Farmer Participatory Research Training course arranged by CIAT in Thailand.

Output 4. Known impact and utility of new technologies and strategies

Economic impact and market opportunities evaluated
(4.1)

Latin America
(L. Rivas and F. Holmann)

During May of 1997 a survey instrument was developed to analyze the demand for Arachis pintoi in Caquetá, Colombia. This study is a follow-up of an earlier ex-ante analysis executed during 1996.

The survey was tested and personnel were trained in its proper use and 226 producers were surveyed (174 randomly selected Nestle's milk producers plus 52 early adopters) between the months of June and July. The information was coded and analyzed during the months of August and October, and it is expected a first draft of the study by December of 1997.

Asia-Forages for Smallholders Sub-project
(W. Stür, CIAT; P. Horne, CSIRO; S. CIAT)

Main achievements

- Initiated discussion with national partners on methodology of impact measurements through the visit of Sam Fujisaka, CIAT to FSP sites in Indonesia, Laos and Philippines

Summary of activities

The following paragraphs describe the current state of discussion on assessing the impact of forage technologies on human and natural resources, animal production and farm income within the Forages for Smallholders Project. These discussions were initiated with the visit and trip report of Sam Fujisaka, CIAT and will be further discussed during the Annual Review of PE-5 in December 1997.

Assessment of impact of forage technologies can occur only when the technology has been adopted by farmers. In most cases, farmers working with the FSP are still in the process of evaluating and modifying technologies in relative small areas before deciding if they will plant larger areas. In 1997, farmers at some sites decided to expand their area of forages from small plots to larger areas (>0.1 ha). These farmers will be the first to experience a significant impact of forage technologies on human and natural resources, animal production and farm income. Sites where this is occurring are Sepaku II and Marenu in Indonesia. In 1998, other sites such as Cagayan de Oro, Malitbog and Matalom in the Philippines and Makroman, Aceh and Gorontalo in Indonesia are likely to get to the same stage of development.

The key indicator of success of the FSP is **adoption of forage technologies** by farmers. This can be quantified at all FSP sites by estimating the number of farms using forage technologies and the areas of forages grown on each farm. Quantifying the impact of these technologies on people and environment is a more difficult task with many potential impacts and ways to quantify these impacts.

The approach of the FSP has been to work in partnership with farmers in developing forage technologies, and this approach has proven successful. There is no reason why farmers should not be fully involved in assessing the impact of the forage technologies they adopted. Clearly, farmers will only adopt forage technologies on a larger scale if they experience a positive impact of the technology on their lives. They are in the best position to define their reasons for adopting and to prioritize these reasons. This information may help to limit the number of indicators to be quantified.

Assessment of impact will require measurements of input and opportunity costs of the various forage technologies adopted by farmers. Also, indicators of impact of technologies must be compared with production systems that have not adopted these technologies (section 1.1.5, Figure 2). These may be (a) baseline data of the community collected before adoption occurred, (b) non-adopters in the same area, or (c) case studies of individual farms from testing to adoption.

The ability of carrying out impact assessment at FSP sites is, at some sites, constrained by the lack of suitable local development workers who are able to carry out the necessary measurements. A careful selection of sites and indicators is needed to provide information on impact across the range of forage technologies and agro-ecosystems covered in the project. Impact assessment will be one of the main topics for discussion of the next Annual Regional Meeting of the FSP in March 1998.

Below is a preliminary list of potential indicators, which may be of use in assessing impact of forage technologies, for discussion:

Forage indicators:
- Area of forage technologies grown
- Productivity of forages
- Contribution of forage technologies towards total feed requirements

Animal indicators:
Animal productivity
- Liveweight gain of small ruminants sheep and goats (difficult with large ruminants)
- Indirect measurements of productivity of large ruminants via sale price achieved, usefulness as draught animal, body condition, etc.
- Reproductive performance (calving interval, litter size, etc.)
- Off-spring mortality and growth
- Animal health (e.g. egg counts of internal parasites)

Human resources indicators:
Labour requirements (by family members) for
- Cutting naturally occurring forages along roads, etc.
- Herding cattle for grazing or tethering
- Weeding crops following legume fallow or with companion legumes
- Land preparation following legume fallow vs. natural fallow

Natural resources indicators:
- Amount and quality of manure produced
- Soil fertility through yield of subsequent crop
- Soil structure and biology (e.g. earthworms)
- Weed population
- Soil erosion

Farm income:

- Sale of animals
- Manure sales (in cash or alternative use of manure; e.g. how much forage can 50 kg manure grow and how much LWG could this produce?)
- Sale of forage

Environmental impact on soil, vegetation, water and atmosphere
(4.3)

Asia - Forages for Smallholders Sub-project
(W. Stür, CIAT; P. Horne, CSIRO; S. Fujisaka, CIAT)

Main achievements

- initiated discussion with national partners on methodology of impact measurements through the visit Sam Fujisaka, CIAT to FSP sites in Indonesia, Laos and Philippines

Summary of activities

These have been included under Targeting Research under Minimum data set for site characterization in on-farm studies.

Personnel trained
(4.4)

Latin America
(F. Holmann)

During October 1997 three research colleagues from CORPOICA (Oscar Duarte and José Pulido from headquarters in Tibaitatá and Jorge Silva from Valledupar's regional office) received training on the proper use of a farm simulation model with special emphasis on the livestock component taking as a case study the Valle del Cesar.

The training activity was divided in two parts: (1) An initial trip to Valledupar in June with the three research colleagues to understand the agricultural production systems of the Valle del Cesar's watershed. During this visit we held interviews with processing plants, milk producers, agricultural input stores, and research officers, plus the collection of information (farm gate prices, productivity, constraints, etc); and (2) The training period itself, which lasted 2 weeks in October 1997. During this period the objective was to understand the rationale of the simulation model, learn how to input data, and finally, interpret the results in order to apply the model to different scenarios in other watersheds.

Asia-Forages for Smallholders project
(W. Stur, P. Horne)

Details of training workshops were reported under Dissemination in the section, 'Training approaches and materials on technology diffusion for use by farmers and technicians'.

Asia-Improved Sustainability of Cassava-based Cropping Systems
(R. Howeler)

Details of training were provided under Targeting Technology in the section 'New approaches for targeting technology development'.

Results of research communicated
(4.5)

Latin America – Tropileche project
(F. Holmann)

Tropileche Newsletter

The Tropileche Consortia has produced three newsletters. Publication dates are March and October. The objective of this newsletter is to inform about the activities of the Consortia, on-going research trials, research results being produced at the different benchmark sites, and any other news our partners consider useful to inform. These newsletters can be obtained free of charge through the Tropileche HomePage on the Internet (see below).

Tropileche data base on research results from dual-purpose cattle

The Consortia developed in October 1996 a data base with research 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 1,300 references and about 100 additional ones are updated each month. All references include basic descriptors and about half of them also include an abstract. This data base was developed in micro CD/ISIS and follows the normative of the information system AGRIS-CARIS from FAO. This database is now operational and available through the Tropileche HomePage on the Internet (see below).

Tropileche on Internet

The Tropileche Consortia has just developed its own HomePage on the Web, which contains the two newsletters that have been produced as well as the data base containing research results generated in tropical Latin America. This HomePage can be accesed through the CIAT HomePage (http://www.ciat.cgiar.org) either through the "Soil and System" icon or through the "Information and Documentation Unit".

In addition, this HomePage has a list of researchers with affinities in research on dual purpose cattle in LAC with addresses to be contacted. Thus, researchers can access Tropileche from anywhere in the world and consult the database, solicit information, and communicate and interact with other colleages.

Workshop Proceedings

During July 1996 Tropileche held a workshop in CIAT about on-farm research methodologies in dual-purpose cattle farms in tropical Latin America. These proceedings were edited throughout 1996 and 1997 and are currently in the print shop. It is expected the procedings will be available in November 1997.

Latin America – BMZ Soil Conservation Project, Cauca

(K. Muller-Samann)

A manual on soil conservation was produced.

A database on results from strategic and applied research on soil conservation and management in Cauca has been maintained. It will be expanded to include the data on the K-factor from the research of Jesus Castillo and that on the R-factor by Kai Sonder.

Asia - Forages for Smallholders project

(W. Stür, CIAT)

Main achievements

- Held the second Annual Regional Meeting of the Forages for Smallholders Project in Hainan, China
- Published two issues of the SEAFRAD newsletter

Summary of activities

The second Annual Regional Meeting of the Forages for Smallholders Project was held at the Chinese Academy of Tropical Agricultural Sciences, Hainan, China from 19 to 24 January 1997. The meeting was attended by 15 of our research partners, 10 Chinese representatives, Bryan Hacker, Peter Kerridge, Werner Stür and Chunji Liu (CSIRO). Twelve of the participants were either partly or totally sponsored by their own organisations. The meeting consisted of two days of presentations and discussions, followed by a field visit to see *Stylosanthes* seed and leaf meal production systems. The proceedings of this meeting will be published as a Technical Report of the FSP. Editing is in progress and publication is scheduled for early 1998.

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 1996, it was based at the Department of Livestock and Fisheries, Lao PDR; in 1997 in the Livestock Research Center, MARDI, Malaysia; and in 1998 it will be based in the Directorate General of Livestock Services, Indonesia. In 1997, two issues of the SEAFRAD newsletter were produced and distributed in February and June. A further issue is in preparation by the editor for 1997, Dr. Wong Choi Chee, MARDI.

Asia-Improved Sustainability of Cassava-based Cropping Systems
(R. Howeler)

Activities

Results from our collaborative experiments and from the FPR project were presented by national program colleagues at the 5th Regional Cassava Workshop, held in Nov 1996 in Hainan island of China. Most of these papers have now been edited and the Proceedings of this Workshop will be printed and distributed in early 1998.

A paper on sustainable cassava production practices was presented at the International Cassava Starch Symposium, held in Nov 1996 in Nanning, Guangxi, China. This paper will appear in the Starch Symposium Proceedings in early 1998.

A paper on the CIAT Cassava and Forages-for-Smallholders projects was presented at an Ecoregional Planning Workshop for the Red River Basin in Vietnam, organized by IRRI and held in Oct 1997 in Hanoi, Vietnam.

Publications 1997-1998

Journal papers

Barahona Rolando, Lascano C.E., Cochran Robert, Morrill Jim, and Titgemeyer Evan. C.,1997. Intake, digestion, and nitrogen utilization by sheep fed tropical legumes with contrasting tannin concentration and astrigency. J of Animal Science 75:1633-1640

Chong, D.T. Tajuddin, I., Samat, Abd. M.S., Stür, W.W. and Shelton, H.M. 1997. Stocking rate effects on sheep and forage productivity under rubber in Malaysia. J. Agric. Sci. (Camb.) 128, 339-346.

Fujisaka, Sam. 1997. Pasture or permanent crops after slash-and-burn cultivation? Land use choice in three Amazon colonies. Submitted to Agroforestry Systems.

Fujisaka, Sam, German Escobar, and Erik Veneklaas. 1997. Plant community diversity relative to human land uses in an Amazon forest colony. Biodiversity and Conservation Vol. 6:

Fujisaka, Sam, and German Escobar. 1997. Towards a practical classfication of slash-and-burn systems. ODI Rural Development Forestry Network Paper 21c

Fujisaka, S, C Castilla, G Escobar, V Rodrigues, E Veneklaas, R Thomas, and M Fisher. 1997. Impacts of forest conversion: estimates of carbon emissions and plant species loss in a Brazilian Amazon colony. Submitted to Agriculture,Environment, and Ecosystems.

Fujisaka, S., F. Holmann, G. Escobar, N. Solórzano, L. Badilla, L. Umaña, and M. Lobo. 1997. Sistemas de producción de doble propósito en la región Pacífico Central de Costa Rica: Uso de la tierra y demanda de alternativas forrajeras. Pasturas Tropicales Vol. 19(1): 55-59.

Gijsman A.J. and Sanz J.I. 1997 Soil organic matter dynamics in a volcanic-ash soil under fallow or cultivation with applied chicken manure. *European Journal of Soil Science (revised and resubmitted).*

Gijsman A.J. 1997 Freezing roots for decomposition studies: an alternative to drying. *Communications in Soil Science and Plant Analysis (submitted).*

Gijsman A.J., Alarcón H.F. and Thomas R.J. 1997 Root decomposition in tropical grasses and legumes, as affected by soil texture and season. *Soil Biology & Biochemistry Biochemistry* 29: 1443-1450.

Gijsman A.J., Oberson A., Friesen D.K., Sanz J.I and Thomas R.J. 1997 Nutrient cycling through microbial biomass under rice-pasture rotations replacing native savanna. *Soil Biology & Biochemistry* 29: 1433-1441.

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, (in print).

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).

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

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.

Putthacharoen, S., R.H. Howeler, S. Jantawat and V. Vichukit. 1998. Nutrient uptake and soil erosion losses in cassava and six other crops in a Psamment in eastern Thailand. Accepted for publication in Field Crops Research

Ruppenthal, M., D. E. Leihner, N. Steinmüller and M. A. El-Sharkawy 1997. Losses of organic matter and nutrients by water erosion in cassava-based cropping systems. Expl. Agric., Vol. 33: 1-12.

Workshop and conference papers

Argel, P.J., Pizarro, E.A. and Kerridge, P.C. 1997. *Arachis pintoi* - a multi-purpose legume for sustainable land use. Proceedings of the 18th International Grasslands Congress, Canada, June 8-19, 1997. (in press).

Blair, G. and Kerridge, P.C. 1997. Nutrient management in tropical forage systems - What should be, and what is practised. Proceedings of the 18th International Grasslands Congress, Canada, June 8-19, 1997. (in press).

Barahona R., Lascano C.E. Cochrane R.C, Morrill J.L and Tiggemeyer E.C. 1997. Condensed tannins in tropical legumes: Concentration, aststrigency and effects on the nutrition of ruminants. In: XVIII Int. Grassl. Cong.June 8-19, Winnipeg, Manitoba and Saskatoon, Saskatchewan, Canada. Session 8, 7-8.

Binh, L.H. 1997. FSP activities in Vietnam. In: W.W. Stür (ed) Feed Resources for Smallholder Livestock Production in Southeast Asia. Proceedings of a regional meeting in Vientiane, Lao PDR, 16-20 January 1996. CIAT Working Document No. 156, Los Baños, Philippines, 47-48.

Chen C.P., Chee, W.C., Abdullah, A. 1997. FSP Activities and results in Malaysia. In: W.W. Stür (ed) Feed Resources for Smallholder Livestock Production in Southeast Asia. Proceedings of a regional meeting in Vientiane, Lao PDR, 16-20 January 1996. CIAT Working Document No. 156, Los Baños, Philippines, 53-54.

Cheng, Y. and Horne, P.M. 1997. Field experiments with forages and crops: practical tips for getting it right the first time. (FSP, Laos) 48p.

Faylon, P.S. and Lanting, E. 1997. FSP activities and results in the Philippines. In: W.W. Stür (ed) Feed Resources for Smallholder Livestock Production in Southeast Asia. Proceedings of a regional meeting in Vientiane, Lao PDR, 16-20 January 1996. CIAT Working Document No. 156, Los Baños, Philippines, 5-10.

Flörchinger F. and Müller-Sämann K.M. 1996 El efecto de la erosión en la productividad del suelo. Memorias del "Seminario Nacional sobre Actualización en Conservación de Suelos en Ladera. Feb. 6-8, 1996, Santafé de Bogotá. INAT, JICA, CECIL . pp 131-136

Gabunada Jr., F.G. 1997. Farmer participatory research activities at two sites in the Philippines – initial results and learnings. In: W.W. Stür (ed) Feed Resources for Smallholder Livestock Production in Southeast Asia. Proceedings of a regional meeting in Vientiane, Lao PDR, 16-20 January 1996. CIAT Working Document No. 156, Los Baños, Philippines, 31-36.

Gabunada, Jr. F.G. and Stür, W.W. 1997. Leucaena foundation collection at IRRI, Los Baños, Philippines. In: Co-ordination Meeting of ACIAR Project 9433 "New Leucaenas for Southeast Asian, Pacific and Australian Agriculture" held at the University of Queensland, Australia, 1-4 April 1997, 2: 1-16.

Gabunada Jr., F.G., Stür, W.W. and Horne, P.M. 1997. Development of forage components through farmer participatory research. Proceedings of the 18th International Grasslands Congress, Canada, June 8-19, 1997. Session 24, 33-34.

Guodao, L. and Kerridge, P.C. 1997. Selection and utilization of *Stylosanthes guianensis* for green cover and feed meal production in China. Proceedings of the 18th International Grasslands Congress, Canada, June 8-19, 1997. Session 19, 49-50.

Guodao, L., and Huaxian, H. 1997. FSP activities and results in China. In: W.W. Stür (ed) Feed Resources for Smallholder Livestock Production in Southeast Asia. Proceedings of a regional meeting in Vientiane, Lao PDR, 16-20 January 1996. CIAT Working Document No. 156, Los Baños, Philippines, 51-52.

Guodao, L. and P.C. Kerridge. 1997. Selection and utilization of *Stylosanthes guianensis*, for green cover and feed meal production in China. Proceedings of the 18th International Grasslands Congress, Canada, June 8-19, 1997. Session 19, 49-50.

Hacker, J.B. and Kerridge, P.C. 1997. The Forages for Smallholders Project – Aims, Activities and Achievements. In: W.W. Stür (ed) Feed Resources for Smallholder Livestock Production in Southeast Asia. Proceedings of a regional meeting in Vientiane, Lao PDR, 16-20 January 1996. CIAT Working Document No. 156, Los Baños, Philippines, 5-10.

Holmann, F. 1997. Dual-purpose cattle production in Pucallpa. CIAT Workshop Document no. 167. Workshop proceedings on integrated conceptual framework for tropical agroecosystem research based on complex systems theories. Cali.

Holmann, F. 1997. Reflexiones sobre la competitividad de distintos modelos de producción de leche en América Latina tropical. Paper presented at the VI Pan American Dairy Federation, April 23-25, Buenos Aires, Argentina.

Holmann, F. and C. Lascano. 1997. The contribution of Tropileche to the Livestock Research Agenda of Latin America. Paper presented at the Annual Programme Meeting of ILRI in Addis Ababa, Ethiopia, September 20-24, 1997.

Horne, P.M., Stür, W.W., Gabunada, F. and Phengsavanh, P. 1997. Prospects for introducing forages in smallholder farming systems in Southeast Asia. In: W.W. Stür (ed) Feed Resources for Smallholder Livestock Production in Southeast Asia. Proceedings of a regional meeting in Vientiane, Lao PDR, 16-20 January 1996. CIAT Working Document No. 156, Los Baños, Philippines, 11-19.

Horne, P. M. 1997. Securing the livelihoods of farmers in upland areas of Lao PDR: the role of livestock and opportunities for forage development. Proceedings of the ACIAR workshop "Upland farming systems in the Lao PDR: Problems and opportunities for livestock", Vientiane, 19-23 May, 1997. (ACIAR, Canberra; in press)

Horne P. M. 1997. Farmer-developed forage management strategies for stabilisation of shifting cultivation systems. Proceedings of the ICRAF workshop "Indigenous strategies for intensification of shifting cultivation in southeast Asia", Bogor, Indonesia, June 23-27 1997 (ICRAF, Bogor, Indonesia; press)

Horne, P. M. 1997. Let them eat grass: experiences in using participatory approaches to develop forage technologies. Proceedings of the ACIAR meeting "Red soil forages - from research into practice", Jianyang, Fujian Province, China, 6 to 9 October 1997 (ACIAR, Canberra; in press)

Howeler, R.H. (Ed.). 1998. Cassava Breeding, Agronomy and Farmer Participatory Research in Asia. Proc. 5th Regional Workshop, held Nov 3-8, 1996 in Dangzhou, Hainan, China. (in press)

Howeler, R.H. 1996a. Cassava agronomy research in Asia, 1987-1992. *In*: R.H. Howeler (Ed.). Cassava Production, Processing and Marketing in Vietnam. Proc. Workshop held Oct 29-31, 1992 in Hanoi, Vietnam. pp. 255-290.

Howeler, R.H. 1996b. Mineral nutrition of cassava. *In:* E.T. Craswell, C.J. Asher and J.N.O'Sullivan (Eds.) Mineral Nutrient Disorders of Root Crops in the Pacific. Proc. Workshop held April 17-20, 1995 in Nuku'alofa, Kingdom of Tonga. ACIAR Proceedings No.65, Canberra, Australia. pp. 110-116.

Howeler, R.H. 1996c. The use of farmer participatory research methodologies to enhance the adoption of soil conservation practices in cassava-based cropping systems in Asia. *In*: S. Sombatpanit *et al.* (Eds.). Soil Conservation Extension: From Concepts to Adoption. Proc. Intern. Workshop held June 4-9, 1995 in Chiangmai, Thailand. Dept. Land Development, Bangkok, Thailand. pp. 159-168.

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).

Howeler, R.H. 1998a. Cassava agronomy research in Asia - An overview. Paper presented at 5th Asian Cassava Research Workshop, held Nov 3-8, 1996 in Dangzhou, Hainan, China.(in press)

Howeler, R.H. 1998b. Cassava production practices in Asia - Can they maintain soil productivity? Paper presented at Intern. Symposium on Cassava, Starch and Starch Derivatives, held Nov 11-16, 1996 in Nanning, Guangxi, China. (in press)

Ibrahim, Lanting, E., Khemsawat, C., Wong, C.C., Guodao, L., Phimphachanhvongsod, V., Binh, L.H. and Horne, P.M. 1997. Forage grasses and legumes with broad adaptation for Southeast Asia. Proceedings of the 18th International Grasslands Congress, Canada, June 8-19, 1997. Session 1, 51-52.

Jones, P.G., Sawkins, M.C., Maass, B.L. and Kerridge, P.C. 1997. Gis and genetic diversity - Case studies in *Stylosanthes*. Proceedings of the 18th International Grasslands Congress, Canada, June 8-19, 1997. (in press).

Jones, P.C.; Rebgetz, Ross; Maass, B.L.; Kerridge, P.C. 1996. Genetic diversity in *Stylosanthes* species: A GIS mapping approach. Paper presented at the VIII Congreso sobre el Cerrado and the First International Symposium on Tropical Savannas, Brasília, DF, Brazil, 24-29 March 1996. 5 p.

Kerridge, P.C. and Franco, L.H. 1997. The use of legumes for improvement of fallow land in smallholder farming systems. Proceedings of the 18th International Grasslands Congress, Canada, June 8-19, 1997. Session 16, 25-26.

Lascano, C. and F. Holmann, eds.. 1997. On-farm research methodologies for dual purpose cattle farms. Workshop proceedings. CIAT, Cali, Colombia.

Lascano C.E. Ruiz G.A. Velasquez J. and Rozo J. 1997. Validation of Arachis pintoi as a forage legume in commercial dual-purpose cattle farms in forest margins of Colombia. In: XVIII Int. Grassl. Cong. June 8-19, Winnipeg, Manitoba and Saskatoon, Saskatchewan., Canada. Session 24, 31-32.

Leihner, D. E., J. A. Castillo y K. M. Müller-Sämann, 1997. Cuantificación y desarrollo de la erodabilidad de los inceptisoles Andinos en el suroccidente Colombiano. Paper presented at an International Workshop held in CIAT, 13-17 October 1997 (proceedings in preparation).

Maass Brigitte, Franco, L.H., Ramírez, G., Lascano, C.E. and Velasquez, J.E. 1997. Codariocalyx gyroides: A new forage option for the humid tropics. In: XVIII Int. Grassl. Cong. June 8-19, Winnipeg, Manitoba and Saskatoon, Saskatchewan, Canada. Session 1: 53-54

Müller-Sämann; K.M. 1997. Hacia conceptos integrales en la conservación de suelos y aguas en la zona Andina: - más interacción, más adopción, más impacto. Paper presented at an international workshop held in CIAT, 13-17 of October, 1997 (proceedings in preparation).

Müller-Sämann, K. M. 1997. Labranza mínima en ladera. Una opción para un manejo más sostenible de suelos y aguas. Conference held at the CORPOICA/PRONATA training course on June 17th, 1997 "Curso de Manejo y Conservación de Suelos bajo el Enfoque de Sistemas de Producción".

Müller-Sämann, K. M. 1997. Agronomic options for soil conservation based on results from research and extension. Conference held at the Hohenheim University, post graduate training course "Soil Degradation and Conservation in the Tropics". July 10-30, 1997.

Müller-Sämann, K. M., Castillo, J. A., 1997. Experiencias en conservación de suelos en el Centro Internacional de Agricultura Tropical, CIAT. Conference held at "II Semana Técnica de Ingeniería Agrícola". Universidad Nacional de Colombia, Sede Bogotá, 5-8 de Noviembre, 1997.

Mullen, B.F., Shelton, H.M., Gabunada, F., and Stür, W.W. 1997. Psyllid resistance in the leucaena genus. Proceedings of the 18th International Grasslands Congress, Canada, June 8-19, 1997. Session 6, 23-24.

Nursahramdani, E., and Ibrahim, Ir., 1997. FSP activities and results in East Kalimantan. In: W.W. Stür (ed) Feed Resources for Smallholder Livestock Production in Southeast Asia. Proceedings of a regional meeting in Vientiane, Lao PDR, 16-20 January 1996. CIAT Working Document No. 156, Los Baños, Philippines, 41-43.

Pham Van Bien, Hoang Kim and R.H. Howeler. 1996. Cassava cultural practices in Vietnam. *In*: R.H. Howeler (Ed.). Cassava Production, Processing and Marketing in Vietnam. Proc. Workshop held Oct 29-31, 1992 in Hanoi, Vietnam. pp. 58-97.

Phaikaew, C., Guodao, L., Abdullah, A, Tuhulele, M., Magboo, E., Bouahom, B. and Stür, W.W. 1997. Tropical forage seed production in southeast Asia: Current status and prospects. Proceedings of the 18th International Grasslands Congress, Canada, June 8-19, 1997. Session 28, 7-8.

Phaikaew, C., Nakamanee, G., and Klum-em, K. 1997. FSP activities in Thailand. In: W.W. Stür (ed) Feed Resources for Smallholder Livestock Production in Southeast Asia. Proceedings of a regional meeting in Vientiane, Lao PDR, 16-20 January 1996. CIAT Working Document No. 156, Los Baños, Philippines, 49-50.

Phengvichith, V. and Hacker, J.B. Diversity and Sustainability of the Pek Savannas of the Lao PDR. Proceedings of the 18th International Grasslands Congress, Canada, June 8-19, 1997. Session 1, 9-10.

Phimphachanvongsod, V. 1997. FSP activities in Lao PDR. In: W.W. Stür (ed) Feed Resources for Smallholder Livestock Production in Southeast Asia. Proceedings of a regional meeting in Vientiane, Lao PDR, 16-20 January 1996. CIAT Working Document No. 156, Los Baños, Philippines, 45-46.

Schmidt Axel, Lascano C.E., Shultze-Kraft R. and Maass B. 1997. An approach to define G x E interactions in a core collection of Desmodium ovalifolium. In: XVIII Int. Grassl. Cong. June 8-19. Winnipeg, Manitoba and Saskatoon, Saskatchewan, Canada (in press).

Stür , W.W. (ed.) 1997. Feed Resources for Smallholder Livestock Production in Southeast Asia. Proceedings of a regional meeting in Vientiane, Lao PDR, 16-20 January 1996. CIAT Working Document No. 156, Los Baños, Philippines. 93 pp.

Tuhulele, M. 1997. FSP activities and results in Indonesia. In: W.W. Stür (ed) Feed Resources for Smallholder Livestock Production in Southeast Asia. Proceedings of a regional meeting in Vientiane, Lao PDR, 16-20 January 1996. CIAT Working Document No. 156, Los Baños, Philippines, 37-40.

Book chapter

Howeler, R.H. 1996d. Diagnosis of nutritional disorders and soil fertility management of cassava. *In*: G.T. Kurup *et al.* (Eds.). Tropical Tuber Crops. Problems, Prospects and Future Strategies. Oxford and IBM Publishing Co., New Delhi, India. pp. 181-193.

Stür, W.W. 1997. Pasture seed production and marketing. (1997). In: J.V. Lovett and J.M. Scott (eds) Pasture Production and Management. Inkata Press, Melbourne, Australia, pp. 155-170

Other publications:

Müller-Sämann, K. M. 1997. La erosión de los suelos y sus efectos en la producción agrícola en zonas de ladera. "Alternativas tecnológicas para disminuir el efecto de la erosión en cultivos de ciclo corto". (16 Sept., 1997). FIDAR/U-Hohenheim training course on Environmental Education for Teachers of Rural Colleges. 15-18 Sept. 1997. Santander de Quilichao.

Müller-Sämann, K. M. 1997. Conservación de suelos en fincas de ladera, una cosa sencilla y muy difícil de hacer. Conference held at the training course of GTZ/IICA. Orientación de la investigación agraria hacia el desarrollo alternativo.

Müller-Sämann, K. M. 1997. Propuesta técnica para la producción de mora (*Rubus glaucus*) y de pasto Imperial como componentes de conservación de laderas. (Recommendations for the production of Blackberry (*Rubus glaucus*) and of Imperial grass (*Axonopus scoparius*) as components for soil conservation in hillsides. Documento de Trabajo No. 3, Proyecto de Conservación de Suelos. CIAT/Universidad de Hohenheim, 1997. pp. 16.

Villada, D., Cifuentes, R.D., Ayala, V., Doering, H., Müller-Sämann, K. M. 1997. Uso de *Brachiaria dictyoneura* (CIAT No. 6133) y de *Desmodium ovalifolium* (CIAT No. 13089) en la estabilización de cárcavas y terrenos degradados (the use of *B. dictyoneura* and *D. ovalifolium* in the stabilization of gullies and on degraded slopes). Documento de Trabajo No. 4. Proyecto de Conservación de Suelos. CIAT/Universidad de Hohenheim, 1997, pp. 19
(also accepted for publication in the journal of the Colombian Soil Conservation Network, "CONSERVANDO").

List of Donors

AusAID

Funding:	Forages for Smallholders Project (FSP)
Main contact::	Mr. Keith England Manager, South East Asia Regional Section AusAID GPO Box 887, Canberra ACT 2601 Australia

Oxford Forestry Institute (OFI)

Funding:	Providing supplementary funds to FSP for added emphasis on tree legumes with funds from DFID (Philippins and Central America)
Main contact::	Mr. Alan Pottinger Oxford Forestry Institute **Dept. of Plant Sciences, University of Oxford** South Parks Road, Oxford OX1 3RB **United Kingdom**

University of Queensland

Funding:	Supporting *Leucaena* evaluations as part of ACIAR PN 9433 ("New Leucaenas for Southeast Asian, Pacific and Australian Agriculture
Main contact::	Max Shelton Department of Agriculture The University of Queensland Brisbane, Qld 4072 Australia

ACIAR

Funding:	Supporting publication of the booklet "Field experiments with forages and crops"
Main contact::	Mr. Peter Lynch ACIAR GPO Box 1571 Canberra, ACT 2601 Australia

AusAID – Laos office

Funding:	Supporting publication on the booklet "Field experiments with forages and crops" through a community activities scheme grant
Main contact::	Mr. Robert Jauncey AusAID Australian Embassy, Vientiane Lao PDR

The Nippon Foundation, Tokyo, Japan

Funding:	Improving agricultural sustainability in Asia
Main contact:	Ms Ayako Sono Chairperson The Nippon Foundation Senpaku Shinko Bldg 1-15-16 Toranomon, Minato-ku, Tokyo 105 Japan

Colombia – The Government of Colombia

Funding:	Production systems components
Main contact:	Dr. Alvaro Uribe Director Unidad Estudios Agrarios Departamento de Planeación Nacional Santafé de Bogotá, Colombia

Nestlé of Colombia

Funding:	Improved legumes and grasses for small milk producers in Caquetá
Main contact:	Dr. Miguel Jervis P.O. Box 5959 Santafé de Bogotá, Colombia

Systemswide Livestock Program

Funding :	Legume-based forage systems for dual-purpose cattle
Main contact:	Dr. Hugo Li-Pun International Livestock Research Center, ILRI P.O. Box 5689 Addis Ababa, Ethiopia

BMZ

Funding:	Soil conservation
Main contact:	Dr. Jochen de Haas Agriculture and Rural Development Federal Ministry of Economic Cooperation and Development Friedrich – Ebert Allee 40 D-53113 Bonn Germany

Interamerican Development Bank (BID)

Funding:	Legume-based forage systems for dual-purpose cattle farm
Main contact:	Dr. Rubén Echeverría Economist,, Agriculture Div. PRA 1300 New York Avenue NW Washington DC 20577 USA

Staff List

Senior Staff

PETER C. KERRIDGE, Ph.D., *Forage Agronomist, Project Leader*
SAMUEL FUJISAKA, Ph.D., *Agricultural Anthropologist*
FEDERICO HOLMANN, Ph.D., *Animal Scientist, agricultural economist*
PETER HORNE, Ph.D., Forage Agronomist (Stationed in Vientiane, Lao PDR – CSIRO)
REINHARD HOWELER, Ph.D., *Agronomist (Stationed in Bangkok, Thailand)*
CARLOS E. LASCANO, Ph.D., *Ruminant Nutritionist*
KARL MUELLER-SAEMANN, Ph.D., *Agronomist (University of Hohenheim)*
WERNER STÜR, Ph.D., *Forage Agronomist (Stationed in Los Baños, Philippines)*

Consultant

PEDRO ARGEL, Ph.D., *Agronomist (Stationed in San José Costa Rica)*

Research Fellow

ARJAN GIJSMAN, Ph.D., *Soil Scientist/Modeller*

Research Associates

PHANOR HOYOS, Agronomist
LIBARDO RIVAS, Economist

Research Assistants

PATRICIA AVILA, Zootechnist
JESUS CASTILLO, Agronomist
GERMAN ESCOBAR, Biologist
FRANCISCO GABUNADA Jr.
LUIS H. FRANCO, Agronomist
LILIANA HURTADO
OTONIEL MADRID, Statistician
NORBEY MARIN, Statistician (left October 1997)
EMMA LUISA ORENCIA
PHONEPASEUTH PHENGSAVANH
GERARDO RAMIREZ, Statistician
KENETH REATEGUI, Agronomist
GUSTAVO RUIZ, Zootechnist
DINH XUAN TUNG (left in July 1997)

Administrative Assistant

MARIA DIADEMA BONILLA

Technicians

JOSE ADARVE
JOSE GALLEGO
MILLER GOMEZ
HERMAN USMA

Secretaries

BLANCA NHORA AGUIRRE
YUVIZA BARONA
CHINTANA CHANHDENG
MARGARITA PULGARIN