Integrated Cassava-based Cropping Systems in Asia

Working with Farmers to Enhance Adoption of More Sustainable Production Practices

Proceedings of the Workshop on the Nippon Foundation Cassava Project in Thailand, Vietnam and China, held in Thai Nguyen, Vietnam. Oct 27-31, 2003.

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Editor: R.H. Howeler

Organized by the Centro Internacional de Agricultura Tropical (CIAT) and Thai Nguyen University of Agriculture and Forestry, Vietnam

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Cover Photos:

Left: Cassava field on seriously degraded soil in Thong Nhat commune of Phu Tho province in north Vietnam in Sept 1999, before the Nippon Foundation project started

Right: Mr. Le Thanh Xuan in Thong Nhat commune in his "new" cassava field in Oct 2001, after planting a new high-yielding variety, KM 94, intercropped with peanut (already harvested), with balanced fertilization and contour hedgerows of *Tephrosia candida* to control erosion. His yields increased from 8 t/ha in 1999 to 27 t/ha in 2001

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I. Cassava in Asia, Breeding, Agronomy, Farmer Participatory Research (FPR) and Extension (FPE), Thailand, Vietnam, China.

PREFACE

Cassava has been an important food crop in many countries in Asia, especially in times of food shortages due to war or other serious calamities. Presently, it remains an important source of food in some countries, while in others it is now mainly used for on-farm animal feeding, for small-scale processing into a wide range of food products, or for industrial processing into commercial animal feed, starch, and many starch-derived products. As incomes have risen sharply in most countries in Asia during the past 10-20 years, demand for cassava products have also risen, mainly because people can afford to consume more meat and milk, and they require more starch for food, paper and textiles. More recently, demand for cassava roots has also markedly increased due to its use as a feedstock for production of fuel-ethanol.

To meet this increasing demand, and in response to higher prices, farmers are trying to either expand their cassava growing area or to increase their yields – or both. Area expansion is often possible only by planting cassava on ever steeper slopes, thus exacerbating soil losses due to erosion. Research conducted in Colombia and in several Asian countries during the 1980s and early 90s has clearly shown that cultivation of cassava on slopes may result in more serious erosion than that of other crops, due to the crop's wide spacing and slow initial growth. This research also showed that several simple agronomic and soil conservation practices could be used to markedly reduce erosion. However, these practices were seldom being adopted by farmers, as most farmers were either not aware of the seriousness of the soil losses due to erosion, did not know what to do to reduce erosion, or considered the recommended practices impractical, too costly or time consuming, and without providing much immediate economic benefits.

It seemed that more widespread adoption of these practices could only be achieved by working directly with farmers, using a farmer participatory approach in research and extension. In 1993 the Nippon Foundation in Tokyo, Japan, agreed to fund a 5-year project, to be implemented by CIAT's Cassava Program in Asia, aimed at developing and using a farmer participatory research (FPR) methodology to enhance the adoption of more sustainable cassava production practices that would increase yields while also protecting the soil from degradation by nutrient depletion and/or erosion. The first phase of the project, from 1994 to 1998, was conducted in close collaboration with cassava researchers in China, Indonesia, Thailand and Vietnam. During this phase the FPR methodology was developed and tested in 2-3 pilot sites in each country. Towards the end of this phase farmers had tested and selected new high-yielding varieties, improved intercropping systems, balanced fertilization and effective soil erosion control practices, and some had started to adopt these practices in their cassava production fields. Encouraged by these results, the Nippon Foundation agreed to fund a second phase, from 1999 to 2003, to be implemented in China, Thailand and Vietnam, with the aim to rapidly expand the project to more pilot sites in order to reach many more farmers and achieve more widespread adoption of the farmer-tested and selected practices. This was largely achieved – in some cases way beyond expectation – but in some areas the adoption was slow, or only temporary while the project staff made regular visits, but discontinued when the project moved on to other sites. The objective of this End-of-Project Workshop, held in Thai Nguyen, Vietnam, in Oct 2003, was to review the activities, the results and achievements of the project, and to discuss which aspects were successful and which were less so, and why. Although the publication of the *Workshop Proceedings* was delayed, it is hoped that the various papers presented at the Workshop, and here included, are still useful in summarizing the methodology that was developed, the results obtained and the impact achieved, while also indicating the lessons learned, and the reasons for some failures. This will hopefully help in the successful execution of similar projects in the future.

I want to take this opportunity to thank the many researchers, extensionists, government officials and farmers who participated in the project and who worked enthusiastically together to make it successful. I particularly want to thank the Nippon Foundation for their long and very generous financial support and their encouragement of the project. Working together we were able to help many farmers improve their livelihoods, and to contribute to the use of more sustainable cassava production systems in Asia.

R.H. Howeler
CIAT, Bangkok
January, 2008

CONTENTS

Workshop Program

Monday – October 27 Arrival of participants in Viet Tri, Vinh Phu

Tuesday – October 28 – Field trip

0700-0800 Viet Tri – Thong Nhat (Phu Tho)
0800-0930 visit FPR trials in Thong Nhat and Bao Thanh (in two groups)
0930-1200 Thong Nhat – Van Yen (Yen Bai)
1200-1300 lunch at Van Yen district office
1300-1630 visit FPR trials, cassava fields and starch factory (in three groups)
1630-1730 Van Yen – Yen Bai; overnight in Yen Bai
1830-1930 dinner

Wednesday – October 29 – Field trip

0730-0930 Yen Bai – Thuong Am (Tuyen Quang)
0930-1100 visit FPR trials together with farmers (in three groups) in farmers' fields
1100-1230 discussion of results of FPR trials with farmers in Thuong Am
1230-1330 lunch with farmers
1330-1430 Thuong Am – Thai Nguyen University
1430-1630 visit NPK trial and breeding plots (in two groups)
1700 Check-in at hotel in Thai Nguyen
1830-2000 dinner

Thursday – October 30

Chairman: Dr. Hoang Kim

0800-0810 Welcoming Address – Dr. Tu Quang Hien, Rector of TNUAF
0810-0820 Opening of Workshop – Pham Van Bien
0820-0830 Objectives of Workshop – Mr. Kentaro Ogiue from the Nippon Foundation
0830-0900 Background and general methodology used in the NF project – Reinhardt Howeler
0900-0920 FPR project in Hainan province of China – Huang Jie/Li Kaimian
0920-0940 FPR project in Guangxi province of China – Li Jun/Tian Yinong
0940-1000 Adoption of new technologies and their impact on cassava production in China – Li Kaimian/Tian Yinong
1000-1020 coffee break

Chairman: Mr. Tian Yinong

1020-1040 Evolution of FPR methodologies used and results obtained in Thailand – Kaival Klakhaeng
1040-1100 FPE methodologies and their effect on adoption of new technologies in Thailand – Wilawan Wongkasem
1100-1120 Training of researchers, extensionist and farmers using farmer participatory approaches – Banyat Vankaew/Wilawan Vongkasem

1120-1140 The Use of a Farmer Participatory Approach in the Development of New Technologies for Erosion Control for Sustainable Cassava Production in Thailand – Watana Watananonta

1140-1200 Working together for success in Thailand – The case of Khut Dook "Cassava Development Village" – Suraphong Charoenrat/Anurat Srisura/ Kaival Klakhaeng

1200-1220 Farmer Participatory Research to Reduce Erosion in Cassava Production Systems – The case of Wang Nam Yen, Thailand – Sompong Katong/ Watana Watananonta/Kaival Klakhaeng

1220-1240 Future Plan of FPR approach in Thailand – Suttipun Brohmsubha

1240-1330 lunch

Chairman: Mr. Watana Watananonta

1330-1350 Evolution of FPR methodologies used and results obtained in Vietnam – Tran Ngoc Ngoan

1350-1410 FPR project and its impact in Thai Nguyen, Tuyen Quang and Phu Tho Provinces of North Vietnam – Nguyen The Dang

1410-1430 FPR project and its impact in Hai Tay, Hoa Bin and Thanh Hoa Provinces of North Vietnam – Trinh Phuong Loan/Thai Phien

1430-1450 FPR project and its impact in Thua Thien-Hue Province of Central Vietnam – Nguyen Thi Cach

1450-1510 FPR project in its Impact on the Use of Ensiled Cassava Roots and Leaves for On-farm Pig Feeding in Central Vietnam – Nguyen Thi Hoa Ly

1510-1530 coffee break

Chairman: Dr. Nguyen The Dang

1530-1550 FPR project in its impact in South Vietnam – Nguyen Huu Hy/Tran Thi Dung/Nguyen Thi Sam

1550-1610 Integration of Northern Upland Program with Farmer Participatory Research for Sustainable Cassava Production in North Vietnam – Le Quoc Doanh

1610-1630 Lessons learned, institutionalization of the FPR approach, and future plans in Vietnam – Hoang Kim/Tran Ngoc Ngoan

1630-1700 An impact assessment study of the Nippon Foundation project in Vietnam and Thailand – Tim Purcell/Nina Lilja

1720-1800 Achievements of the NF project and future plans – Reinhardt Howeler

1800-1830 General discussion

1830-1840 Final conclusions and closure – Pham Van Bien/Kentaro Ogiue

1900-2100 Closing dinner

Friday – Oct 31

Departure of participants

BACKGROUND AND GENERAL METHODOLOGY USED IN THE NIPPON FOUNDATION PROJECT[1]

Reinhardt H. Howeler[2]

ABSTRACT

The first phase of the Nippon Foundation cassava project in Asia was conducted from 1994 to 1998, and was followed by the second phase conducted from 1999 to 2003. The main objective was to develop, together with farmers, better cassava production practices that would enhance the sustainability of production, both in helping farmers increase their income and in protecting the soil resource base from degradation as a result of nutrient depletion and erosion. Both the first and second phase aimed at enhancing the adoption of more sustainable production practices by involving farmers directly in the development of site-specific most-appropriate practices through farmer participatory methods. The first phase of the project developed and tested mainly a farmer participatory research (FPR) methodology, while the second phase used this methodology, implemented in a simplified version in many more sites, and developed and used various farmer participatory extension (FPE) methods in order to disseminate the farmer-selected practices to as many other farmers as possible.

The second phase of the project was implemented by the CIAT Cassava Office for Asia in Bangkok in close collaboration with five institutions in Thailand, six in Vietnam and three in China. Researchers and extensionists in those institutions received training in farmer participatory methodologies and put this training into practice working directly with farmers, initially only in a few selected villages or pilot sites, but covering more sites year after year. In 2003 the project was working or had worked in 31 sites in China, 33 in Thailand and 34 in Vietnam, for a total of 99 project sites.

In general, the methodology developed started with the identification of suitable villages that might benefit from this project, discuss its implementation with officials at different levels, conduct a Rapid Rural Appraisal (RRA) with farmers in the village to obtain basic information and gauge their interest in participating. After analyzing the results, the most suitable villages were selected, based also on the willingness of local leaders to collaborate. Interested farmers from the selected pilot site(s) were then taken on a field trip to visit demonstration plots, or visit another village where farmers had already conducted FPR trials or had adopted some selected practices. At the demonstration plots, farmers evaluated and scored all the treatments and finally selected a few of most interest to try out in FPR trials on their own fields. Researchers and extensionists helped farmers to select appropriate treatments, stake-out plots and establish the selected treatments. Usually, FPR trials had 4-6 treatments, including the farmer's traditional practice, without replication. Plot size varied but normally ranged from about 10 x 10 m to 10 x 20 m. Although the emphasis was on the conducting of FPR erosion control trials, farmers could also test other technology components, such as new varieties, fertilization practices, intercropping, weed control and even pig feeding with cassava roots and leaves. At time of harvest, a field day was organized to let other farmers from the village and surrounding villages evaluate and discuss the results of the various treatments. From these results and discussions farmers then selected the best treatments for either further testing or for adoption in their production fields.

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[1] This paper is a modified and shortened version of part of the End-of-Project Report submitted to the Nippon Foundation in April 2004.

[2] CIAT Cassava Office for Asia, Department of Agriculture, Chatuchak, Bangkok, 10900 Thailand.

Usually, after 2-3 years of testing in FPR trials farmers had decided on the most suitable practices. Project staff then helped the farmers find the necessary varieties or other inputs like appropriate fertilizers to implement the selected technologies on their fields.

To enhance the further dissemination of those selected practices, the project used several FPE methodologies, such as organizing cross-visits of farmers from one village to another; field days, either during the crop cycle or at harvest; FPR training courses for farmers and local extension workers; and in some cases the setting up of community-based self-help groups, in Thailand called "Cassava Development Villages". The implementation of the project was greatly facilitated by working with these already organized groups rather than with individual farmers. In addition, the project made a video/CD about the FPR approach in Thailand and published several FPR manuals and extension booklets about erosion control and other improved practices in the various local languages.

1. INTRODUCTION

1.1 Cassava in Upland Farming Systems in Asia

During the past two decades, the standard of urban living in Southeast Asian countries has progressed rapidly, while that of the rural community has lagged behind. This is particularly true in areas that are marginal for crop production. These areas tend to have constraints, such as acid infertile soils, a long dry season, and steep slopes that exacerbate the problem of soil erosion. Under these conditions cassava is a popular crop because it will tolerate long periods of drought and produce reasonable yields on soils too acid or infertile to sustain the growth of other food crops. Moreover, in Asia cassava does not suffer from any serious diseases or insect pests and thus requires no pesticides or other purchased inputs with the possible exception of fertilizers. Cassava is an ideal crop for poor farmers because it can produce both human food and animal feed with the expenditure only of family labor. Thus, cassava can be an important food security crop, a source of income if fed to pigs or sold for the production of animal feed or starch.

In many countries in Asia, cassava has already been transformed from a subsistence to an industrial crop, a trend that is likely to continue. This change has benefited not only cassava farmers but also small-scale processors, traders and consumers. In some countries, particularly Thailand, cassava has become an important source of foreign exchange.

Cassava is seldom grown as the only crop in the farming system. It is mainly grown in monoculture in Thailand, but is usually intercropped with upland rice, maize and grain legumes in Indonesia, with maize or peanut in Vietnam, China, and the Philippines, or under coconut palms in India, Philippines and Indonesia. In northern Vietnam and southern China cassava roots are the principal ingredient for on-farm pig feeding, proceeds from which constitutes the farmer's main source of cash income. Manure from pigs can be returned to fields for maintaining soil productivity.

Governments in Asia recognize the important role cassava plays in food security and in the alleviation of poverty. Still, there remains a perception that the crop depletes soil nutrients and is a cause of erosion. Research has shown, however that cassava extracts less nutrients from the soil than most other food crops (Howeler, 1991). Nevertheless, when the crop is grown continuously on the same land without inputs of manure or fertilizers, soil nutrients will eventually be depleted and productivity will decline, as is true for all crops. In some areas the problem is alleviated by bush-fallow rotations, but where such rotations are not possible, farmers need to apply animal or green manures, or chemical fertilizers to maintain yields. Soils are mainly susceptible to erosion during the initial stage of the crop before the canopy closes and rain impacts directly on the soil (Putthacharoen *et al.*, 1998).

1.2 Institutional Support for Cassava Research and Development

CIAT holds the world's largest collection of cassava germplasm, which forms the basis for a comprehensive breeding program. New varieties with higher yield potential, higher starch content, improved plant type, and greater resistance to pests and diseases, have been developed. Since 1983, the CIAT Cassava program in Asia has worked with national cassava breeding programs selecting from clones and sexual seed transferred from CIAT, and crossing these for better local adaptation. Thirty eight cassava varieties containing genetic material from CIAT have now been released in Asia. These are grown on about 1,250,000 ha (35% of total cassava area). Similarly, there has been an active and collaborative research program on the crop's nutrient requirements, fertilization and soil management.

Most countries in Southeast Asia now have an active cassava research program with many of the staff having received training at CIAT in Colombia. These scientists formed an Asian Cassava Research Network, which organizes workshops, determines research priorities and distributes funds for collaborative research. In most countries research is not closely integrated with extension activities, except in Thailand which has an extension service for cassava and also a private sector organization, the Thai Tapioca Development Institute, which trains farmers in production practices and produces and distributes planting material of high-yielding varieties (Vankaew *et al.*, 2008).

1.3 Farmer Involvement in Developing Sustainable Cassava Production Systems

Research has shown that nutrient depletion and erosion can be serious problems when cassava is grown as a monocrop on infertile soils and on sloping land. Judicious application of manure or chemical fertilizers will permit continuous cassava production at high levels of yield without soil nutrient depletion (Howeler, 1996). Similarly, soil and crop management practices have been developed that will minimize erosion when cassava is grown on slopes (Howeler, 1987, 1994, 1995, 1998a, 1998b; Kawano and Howeler, 1997). These practices include minimal land preparation, contour ridging, fertilizer application, mulching, intercropping, and vegetative contour barriers to reduce runoff and enhance deposition of suspended soil behind these barriers. While most of these practices are effective in reducing erosion, they are not widely adopted by farmers because they require monetary or labor inputs and do not necessarily provide short-term benefits in terms of higher yields or incomes.

It was concluded that farmer adoption of soil conservation practices can only be achieved if technologies are developed and adapted together with farmers, taking into account farmers' specific needs and conditions, any short-term benefits to the farmer, and long-term benefits to society (Ashby *et al.*, 1987; Fujisaka, 1991). Thus, in 1994, a new approach to the development of sustainable cassava production practices was initiated through a farmer participatory research (FPR) project "Improving the Sustainability of Cassava-based Production Systems in Asia" funded by the Nippon Foundation in Japan.

The advantage of the FPR approach is that when farmers, researchers, and extension staff work together developing new varieties and production practices, they are more likely to do relevant research reflecting farmers' needs and priorities and develop successful technologies. Farmers benefit from better access to information and planting materials of new varieties. Other farmers benefit from new technologies disseminated directly by other farmers (farmer-to-farmer extension). When farmers are empowered to make their own decisions and do their own experiments, they will innovate to improve their conditions.

2. FIRST PHASE OF THE NIPPON FOUNDATION PROJECT (1994-1998)

2.1 Activities and Outputs

The first phase of the Nippon Foundation funded FPR project was conducted from 1994 to 1998 by CIAT in collaboration with national research and extension organizations in Thailand, Vietnam, Indonesia and China. Characteristics of the sites and details of trials conducted have been reported (CIAT, 1994, 1995, 1996 and 1997; Howeler, 1998c). Farmers in pilot sites selected and tested options for soil conservation that they had seen in demonstration plots. After 2-3 years of testing they generally selected one or two practices that were most effective in controlling erosion. They also selected and multiplied new cassava varieties, and tested new intercropping systems and fertilization practices. By 1997 participating farmers began adopting practices such as contour ridging or contour hedgerows of vetiver grass, *Tephrosia candida* or *Gliricidia sepium* in their fields. In 1998, more participating farmers as well as neighbors and neighboring communities were adopting these well-adapted and useful new technologies. Thus, a sound basis had been established to widely disseminate these technologies.

2.2 A Practical Model of Farmer Participatory Research (FPR)

The FPR approach was tested with various modifications in the four countries. The basic approach is that researchers and extension staff work with farmers at the village level to diagnose farmers' needs and plan research that addresses those needs. In Phase I, this research has usually been based on treatments farmers had seen in demonstration plots. Farmers decide on the types of trials and select the treatments of most interest to them. Farmers conduct the FPR trials with help from researchers or extension staff. The results are evaluated through participatory methods, discussed, and trials are continued or new trials planned until farmers have identified the best solutions to their needs. Farmers then extend these practices to the rest of their fields, making adjustments until the technologies are appropriate for larger areas. Incentives are kept to a minimum; farmers do the research for their own benefit and they themselves become the *owners* of the technology. In the future, these experienced farmers will become a valuable resource in the transfer of new technologies to other farmers and communities.

2.3 Training

An essential feature of FPR is that researchers and extension workers accept and feel comfortable with the approach. In 1994 an introductory course on FPR methodologies was held in Thailand for project researchers and extension staff of the four countries. In 1997 and 1998, in-country Training-of-Trainers courses in FPR were held in each of the four countries. A total of 127 researchers and extension staff were trained and given practice in FPR methodologies (Howeler, 2007a).

2.4 Production practices tested and selected by farmers

During the 1st phase of the project a total of 495 FPR trials were conducted by farmers in the four countries (Howeler, 2007a). Most farmers liked to test new varieties, resulting in 163 FPR variety trials; in addition, farmers conducted 191 erosion control trials, 106 fertilizer trials and 35 intercropping trials.

Usually, improved crop management practices evaluated in FPR trials resulted in clear economic and environmental benefits as illustrated by the example shown in **Table 1**.

Table 1. Effect of crop management on soil loss, yield of cassava and intercropped peanut, gross and net income and farmers preference. Trials conducted by six farmers in Kieu Tung village, Thanh Ba district, Phu Tho province, Vietnam, in 1997.

Treatments[1)]	Dry soil loss (t/ha)	Yield (t/ha) Cassava	Yield (t/ha) Peanut	Gross income[2)]	Product. costs	Net income	Farmers' ranking
				—(million dong/ha)—			
1. C monoculture, no fertilizers, no hedgerows (TP)	106	19	-	9.6	3.7	5.9	6
2. Cassava (C) + peanut (P), no fertilizers, no hedgerows	104	13	0.70	10.0	5.1	4.9	5
3. C+P, with fertilizers, no hedgerows	65	19	0.97	14.5	6.0	8.5	-
4. C+P, with fertilizers, *Tephrosia* hedgerows	40	15	0.85	11.6	6.0	5.6	3
5. C+P, with fertilizers, pineapple hedgerows	32	19	0.97	14.6	6.0	8.6	2
6. C+P, with fertilizers, vetiver hedgerows	32	24	0.85	16.1	6.0	10.1	1
7. C monoculture, with fertilizers, *Tephrosia* hedgerows	32	23	-	11.7	4.5	7.2	4

[1)] Fertilizers = 60 N+40 P_2O_5+120 K_2O; all plots received 10 t pig manure/ha; TP = farmer traditional practice
[2)] Prices: cassava: dong 500/kg fresh roots; peanut: dong 5000/kg dry pods (1US$ = approx. 13,000 dong)

Application of fertilizers, especially those high in N and K and low in P, with or without farmyard manure, produced high economic returns. The more vigorous growth obtained with fertilizer application also reduced erosion. In general, intercropping with peanut produced the highest net income, except in very dry areas of Thailand and East-Java of Indonesia, where mungbean or maize were the preferred intercrops, respectively. Intercropping with peanut was also effective in reducing erosion. However, the most effective practice in reducing erosion at most sites was the use of contour hedgerows of vetiver grass. Further, the grass did not compete much with nearby cassava plants.

The results of these FPR trials have been reported in more detail in the CIAT Annual Reports for 1994, 1995, 1996, 1997 and 1998; in the Progress Reports to the Nippon Foundation, as well as in various reports presented at the 6th Regional Cassava Workshop held in Ho Chi Minh city, Vietnam in February, 2000 (Howeler, 2001), and at the 7th Regional Workshop held in Bangkok, Thailand in October, 2002 (Howeler, 2007a).

The selection of soil conservation practices is highly site-specific and depends on particular local conditions and farmers' traditional practices. Practices modified by farmers to their own conditions are more likely to be adopted. Thus, at the end of the 1st phase of the project some farmers had started to adopt new varieties, improved fertilization, erosion control practices (where needed) and intercropping (Howeler, 2001).

3. SECOND PHASE OF THE NIPPON FOUNDATION PROJECT (1999-2003)

3.1 Project Goal and Purpose

The long-term goal is to increase the living standards of small farmers and to improve agricultural sustainability in less favored areas of Asia by improving the productivity and stability of farming systems where cassava is an important crop.

The project purpose is to develop, together with farmers, efficient and effective integrated crop and soil management practices that optimize farm productivity and contribute to the sustainability of cassava-based cropping systems.

3.2 Specific Objectives

i) To develop, with farmers, improved crop management practices that increase productivity and maintain the soil resource in smallholder farms where cassava is a principal crop,

ii) To disseminate new technologies at the local, provincial, national and international levels,

iii) To support national institutions in conducting strategic and applied research in cassava production that will overcome constraints identified at the farm level,

iv) To explore and test new and innovative FPR methodologies for technology development and dissemination that are suited to special needs and conditions in each location,

v) To strengthen the farmer participatory research capacity in national institutions and in selected farming communities, and

vi) To develop procedures for monitoring the impact of new technologies developed through FPR.

These objectives are inter-related and have been pursued concurrently.

3.3 Methodology and Principal Activities

The methodology used in Phase II of the project basically followed that used in Phase I, but with greater diversity of FPR approaches to match needs. As the project progressed, increasingly greater emphasis was given to the dissemination and adoption of improved soil management practices to other farmers, to strengthening of national institutions in participatory approaches to technology development, in order to achieve widespread adoption of improved varieties and production practices. This in turn would lead to increased yields and income, thus improving the living standards of farmers.

Partners

As in the first phase, the second phase of the project was coordinated by the CIAT-Bangkok office and implemented in collaboration with national research and extension institutions. The Nippon Foundation had suggested to limit the number of countries involved to Thailand and Vietnam – mainly because of their greater institutional capacity – but agreed to the more limited involvement of China. In Indonesia only a small number of long-term research trials were conducted in two locations, but no FPR activities were continued. **Table 2** shows the countries and institutions that participated in the first and second phase of the project. In the second phase this included three research institutes in Hainan (CATAS), Guangxi (GSCRI) and Yunnan (AHVSY) provinces of China; in Thailand this included three research (DOA and LDD) and extension (DOAE) institutes, one university (KU), and the semi-private Thai Tapioca Development Institute (TTDI). In Vietnam this included three universities (TNUAF, HUAF and AFU/TD) and three research organizations (VASI, NISF and IAS). **Appendix 1** shows the names of the principal collaborators in the project.

In China and Vietnam each institution conducted some research as well as FPR and FPE activities in an area not too far from their own institute; this was usually done in collaboration with district (county) or subdistrict officials and extensionists (in China, the Bureau of Science and Technology at provincial, district or county level).

Table 2. Institutions collaborating with CIAT in the first and second phase of the Nippon Foundation project.

Country-Province		Institution	1st Phase		2nd Phase		
			Research	FPR	Research	FPR	FPE
China	- Hainan	CATAS	✓	✓	✓	✓	✓
	- Guangxi	GSCRI	✓			✓	✓
	- Guangdong	UCRI	✓				
	- Yunnan	AHVSY				✓	✓
Indonesia	- E-Java	UNIBRAW	✓	✓			
	- E-Jave	RILET		✓			
	-W. Java	CRIFC	✓		✓		
Philippines	- Leyte	PRCRTC	✓				
	- Bohol	BES	✓				
Thailand	- Rayong	FCRI/DOA	✓	✓	✓	✓	✓
	- Bangkok	FCPD/DOAE		✓		✓	✓
	- Bangkok	Kasetsart Univ.	✓		✓		
	- Bangkok	SWCD/LDD				✓	✓
	- Korat	TTDI		✓		✓	✓
Vietnam	- Thai Nguyen	HUAF	✓	✓	✓	✓	✓
	- Hanoi	NISF		✓		✓	✓
	- Hanoi	VASI				✓	✓
	- Hue	HUAF			✓	✓	✓
	- Ho Chi Minh	IAS	✓		✓	✓	✓
	- Ho Chi Minh	AFU/TD				✓	✓

In Thailand, the research was generally conducted by the Department of Agriculture (DOA) and Kasetsart University (KU), while the FPR and FPE as well as the training courses were conducted mainly by the Department of Agric. Extension (DOAE) in collaboration with DOA and TTDI; the Land Development Department became actively involved in the project only in the last two years, conducting FPR trials in three sites; it was earlier involved in supplying vetiver grass plants to participating farmers and in teaching a special course for key farmers and extension workers on the multiplication and management of vetiver grass. Thus, each institution contributed according to their own mandate and expertise, but frequent interaction of researchers and extension workers from various institutions greatly enhanced interinstitutional collaboration.

Planning and implementation

Every year before the start of the rainy season, planning meetings were held in each of the three countries to review the previous year's results and decide how the project would be implemented, by which institution, where and when. Similarly, the training courses and field days would be planned whenever possible. These meetings were usually chaired by the country coordinators, i.e. Dr. Tran Ngoc Ngoan in Vietnam, and Mr. Preecha Suriyaphan (1999-2000) and Mr. Watana Watananonta (2001-2003) in Thailand; they coordinated the important activities among the various institutes in their country and organized the training courses. **Tables 3, 4** and **5** show the various activities and sites where the project was implemented from 1999 to 2003 in China, Thailand and Vietnam, respectively, while **Tables 6, 7** and **8** show the details and exact location of each project site, while **Figure 1** shows their location on a map. In general, the number of training courses and the number of sites where the project was implemented far exceeded those deemed possible at the beginning of the project. For instance, the total number of project sites planned in 1999, to be implemented by 2003, was 15 sites in Thailand and 16 sites in Vietnam (Tables 2 and 3 of 1st year's Activities Report), while in reality the project managed to extend to 33 sites in Thailand and 34 sites in Vietnam (**Tables 7** and **8**). This increased activity was possible because of the excellent collaboration of researchers and extensionists in the national institutions, as well as the active and enthusiastic involvement of officials and extensionists at provincial, district and subdistrict (or commune) levels. Moreover, local officials and farmers from neighboring villages or districts participating in the field days often requested to become involved in the project during the following year. Thus, the number of project sites snowballed way beyond what was originally considered possible. In many cases, the national government (in Thailand) and provincial or district governments (in China and Vietnam) provided additional funds to contribute to the implementation of specific parts of the project.

3.4 Development of Interinstitutional and Farmer Participatory Model.

The farmer participatory approach used in the first phase of the project, and with minor modifications continued in the second phase, can be visualized by the conceptual framework shown in **Figure 2**. It depicts how researchers, extensionist and farmers work together to develop new technologies, test these out with farmers to select the best practices to be adopted. However, the inputs of researchers diminish and those of farmers increase as one moves around the circle from strategic and applied research at the top right through farmer testing to adoption at the top left. The extensionist play a crucial bridging role between researchers and farmers which continues throughout the process, from problem identification, development of technical components, testing with farmers, selecting and scaling-up to dissemination and adoption. In most activities all actors play a role, but in different capacities and at different levels of involvement. Researchers tend to contribute their specialized knowledge about soils and crops, extensionists have special communication skills and can fit technology components into the local farming system, while farmers contribute mainly with their knowledge of farming practices and local conditions as well as their keen awareness of the economic consequences of various technology options. The knowledge and experience of all participants complement each other to work together towards achieving a common goal.

A more detailed model, specific to this project and developed during the first phase, is shown in **Figure 3**. It shows the various steps in the process. During the first phase, most activities centered around the right side of the circle, i.e. problem identification and Farmer Participatory Research (FPR). During the second phase of the project the emphasis gradually shifted from FPR to Farmer Participatory Extension (FPE) in order to reach more farmers and achieve widespread adoption of new varieties and improved practices. These two components, roughly corresponding to the right and the left side of the circle in **Figure 3**, are part of the same continuum, often called Farmer Participatory Technology Development and Dissemination (FPTDD). This model is particularly useful for testing new technologies such as varieties, fertilization, erosion control practices etc. While some technologies can be demonstrated and/or visually evaluated in the field (such as different varieties or pasture species) it seems that farmers are most convinced of the usefulness of a new technology when they actually do an FPR trial on their own fields, comparing various new options against their traditional practice. At time of harvest they can measure yields (and soil losses in erosion control trials) and calculate production costs, gross income and net income for each treatment. The informal testing and visual evaluation of various alternative options, used in 1998-2000 in several sites in Vietnam and Thailand, was found to be less effective in convincing farmers than the more formal testing in small plots in FPR trials. Thus, from 2000 to 2003 the methodology commonly used and found to be most effective more or less followed the model shown in **Figure 3;** it consists of the following steps:

Table 3. Implementation of the Nippon Foundation project in China, 1999-2003.

	1999	2000	2001	2002	2003
RRA in new sites	1	1	2	0	0
Demonstration plots	CATAS	CATAS	CATAS	CATAS	CATAS
FPR in pilot sites[1)]	Baisha	Baisha	Baisha	Danzhou	Danzhou
		Taiping	Qiongzhong	Baisha	Baisha
			Tunchang	Changjiang	Changjiang
			Taiping	Qiongzhong	Qiongzhong
			Ningwu	Tunchang	Tunchang
				Yongning	Chenmai
				Fangcheng	Wenchang
				Wuming	Yongning
				Pingguo	Wuming
				Hengxian	Binyang
				Lingchuang	Hengxian
				Qinzhou	Pingguo
				Binyang	Linzhou
				Liuzhou	Lingchuan
				Pingbian	Fangcheng
				Yuangyang	Qinzhou
					Pingbian
					Yuangyang
Adoption in pilot sites	1	2	8	15	18
FPE		✓	✓	✓	✓
Training of officials				✓	
Training of extensionists			✓		✓
Training of farmers			✓		✓
Workshops		Feb Ho Chi Minh		Nov. Bangkok	Oct Thai Nguyen

[1)] Total 32 pilot sites in 2003; only the counties shown.

Table 4. Implementation of the Nippon Foundation project in Thailand, 1999-2003.

	1999	2000	2001	2002	2003
RRA in new sites	2	7	5	2	0
Demonstration plots	TTDI+KHS	KHS	TTDI	TTDI	TTDI
FPR in pilot sites[1)]	Sahatsakhan Sanaam Chaikhet	Daan Khun Thot Theparak Sanaam Chaikhet Naadii	Daan Khun Thot Theparak Soeng Saang Naadii Kalasin Nong Kungsri Sahatsakhan Thaa Takiab Khanuwaralak-buri Thep Sathit Law Khwan	Daan Khun Thot Khonburi Naadii Naamon Don Chaan Huay Phueng Khanuwaralak -buri Thep Sathit Law Khwan	Huay Phueng Phoo Chai Khonburi Bo Thong Baan Poong Sai Yook
Adoption in pilot sites	2	12	20	23	26
FPE		✓	✓	✓	✓
Training of officials		✓		✓	
Training of extensionists		✓	✓	✓	
Training of farmers		✓	✓	✓	
Workshops		Feb. Ho Chi Minh		Nov. Bangkok	Oct Thai Nguyen

[1)] Total 33 pilot sites in 2003; only the districts shown.

1. Select suitable areas for new pilot sites
2. Discuss the project with local officials (often at the provincial, district and subdistrict levels) and village leaders
3. Conduct Rapid Rural Appraisals (RRA) to obtain information and select the most suitable site(s)
4. Discuss details of the project with farmers in the selected village
5. Take interested farmers to see demonstration plots and/or on a cross-site visit to a village that had already participated in the project and adopted some technologies
6. Discuss with interested farmers the technology components as well as specific treatments they want to test
7. Help farmers stake out the trials and establish the various treatments
8. Farmers maintain the trials, while project personnel visit regularly to solve problems, give encouragement, and take measurements
9. At time of harvest, organize a field day for participating and non-participating farmers and extension workers. Usually, on the day before the field day, participating farmers and project staff harvest the central part of each plot, leaving the harvested roots with a sign indicating the calculated yields in each plot. During the field day, farmers visit all trials and evaluate every treatment. Later in the day, the average results of each type of trial are presented and discussed, after which farmers indicate their preference for a particular treatment by the raising of hands
10. The preferred treatments may be retested in FPR trials the following year or tried out on small areas of their production fields

11. After making some adaptations, if necessary, the selected practice can be scaled up to larger areas, and the knowledge and experience with the new technology can be disseminated to others during field days, cross-visits or informal talks with neighbors
12. Once a new variety or improved practice is identified, local officials can help to obtain and distribute the necessary planting material of new cassava varieties or hedgerow species or help farmers obtain the most effective fertilizers.

Table 5. Implementation of the Nippon Foundation project in Vietnam, 1999-2003.

	1999	2000	2001	2002	2003
RRA in new sites	7	3	6	0	0
Demonstration plots	AFC/TNU Hung Loc	AFC/TNU Hung Loc	AFC/TNU	-	-
FPR in pilot sites[1)]	Pho Yen Luong Son Thanh Ba	Pho Yen Son Duong Luong Son Thanh Ba Phu Ninh Thach That Chuong My A Luoi Thong Nhat Phuoc Long Chau Duc	Pho Yen Son Duong Van Yen Luong Son Thanh Ba Phu Ninh Thach That Chuong My A Luoi Nam Dong Huong Tra Thong Nhat Phuoc Long Chau Duc	Pho Yen Son Duong Van Yen Luong Son Thanh Ba Phu Ninh Thach That Chuong My Nhu Xuan A Luoi Nam Dong Huong Tra Thong Nhat Phuoc Long Chau Duc	Pho Yen Phu Luong Na Ri Son Duong Luong Son Van Yen Yen Chau Thanh Ba Phu Ninh Thach That Chuong My Lac Son Nhu Xuan A Luoi Nam Dong Huong Tra Thong Nhat Dong Phu Chan Thanh Chau Duc
Adoption in pilot sites	4	14	21	25	28
FPE		✓	✓	✓	✓
Training of officials		✓			
Training of extensionists		✓	✓	✓	
Training of farmers		✓	✓	✓	
Workshops		Feb Ho Chi Minh		Nov Bangkok	Oct Thai Nguyen

[1)] Total 34 pilot sites in 2003; only the districts shown.

Table 6. Location of FPR sites of the Nippon Foundation cassava project in China in 2003.

	Province	City/District	County	Town	Village	Coordinates		Altitude
						N	E	(masl)
1.	Hainan	-	Wenchang	Fenglai	Shigou	19°31'30"	110°36'36"	112
2.			Chenmai		Bai Lian Ban	19°51'22"	110°08'40"	83
3.			Danzhou	Baodao	Xincun	19°30	108°30	
4.			Danzhou	Nada	Nada	19°30	108°30	
5.			Baisha	Qifang	Kongba	19°17'03"	109°14'12"	176
6.			Baisha	Qifang	Tapuling	19°17	109°14	
7.			Baisha	Fulong	Wentou			
8.			Baisha	Yuanmen	Yuanmen			
9.			Changjiang	Shiyetian	Shiyetian	19°17	108°55	
10.			Qiongzhong	Qiongtao	Laocun			
11.			Qiongzhong	Qiongtao	Lingtou			
12.			Qiongzhong	Songtao	new Songtao	19°22'45"	109°40'44"	153
13.			Tunchang	Nankun	Nanlao	19°15'49"	109°53'40"	192
14.			Tunchang	Nankun	Lingtao			
15.	Guangxi	Nanning city	Yongning	Shanxu	Shanyi	22°39'17"	108°13'35"	153
16.			Yongning	Suxu	Longed	22°39	108°13	
17.			Yongning		Tanluo	22°56'47"	107°50'31"	86
18.			Wuming		Qingle	23°09'02"	108°24'55"	132
19.			Wuming	Taiping	Xinglian	23°09	108°24	
20.			Wuming	Wuchuan	Xiawang	23°09	108°24	
21.			Binyang	Zouxu	Zouxu	23°21'52"	108°53'40"	92
22.			Binyang	Gula	Dahe	23°21	108°53	
23.			Binyang	Luxu	Luxu	23°21	108°53	
24.		Nanning district	Hengxian	Maling	Lintou	22°30	109°10	
25.		Bose district	Pingguo		Yalong	23°21'58"	107°33'37"	179
26.			Pingguo	Bangxu	Zhouxu	23°21	107°33	
27.		Liuzhou city	Liuzhou	Luorong	Luorong	24°29'58"	109°34'40"	224
28.		Guilin district	Lingchuan	Daxu	Wulin	25°30	110°25	
29.		Fangcheng city	Fangcheng	Pingwang	Hengguo	21°45	108°20	
30.		Qinzhou district	Qinzhou	Luwu	Pingtou	21°55	108°30	
31.	Yunnan	Mengzhi district	Pingbian	Beihe	Laha/Beisizai	22°56'55"	103°48'37"	532
32.		Mengzhi district	Yuangyang	Xincheng	Dafengya			

Some of these activities are described in more detail below:

a. Rapid Rural Appraisals (RRA)

These usually consisted of informal interviews of a group of farmers (or focus groups) about the local situation, current production and utilization practices as well as main problems, their causes and possible solutions. This was often supplemented with one-on-one interviews with farmers in their fields to confirm the information obtained in the focus groups.

Tables 9 and **10** show some of the information obtained in pilot sites in Thailand and Vietnam, respectively, while **Tables 11, 12** and **13** show more detailed data collected during RRAs in Thailand. Through these interviews the researchers and extension staff became more aware of the local production practices, the environmental and socio-economic conditions, as well as the problems and constraints farmers face.

Table 7. Location of FPR pilot sites of the Nippon Foundation cassava project in Thailand in 2003.

	Province	District	Subdistrict	Village	Coordinates N	Coordinates E	Altitude (masl)
1.	Kalasin	Mueang	Phuu Po	Noon Sawan	16° 37' 09"	103° 35' 17"	
2.		Mueang	Khamin	Khampla	16° 21' 02"	103° 30' 45"	
3.		Nongkungsri	Nong Bua	Khamsri	16° 41' 59"	103° 25' 26"	190
4.		Sahatsakhan	Noonburi	Noon Sawaat	16° 41' 51"	103° 29' 75"	191
5.		Sahatsakhan	Noon Nam Kliang	Huai Suea Ten	16° 40' 12"	103° 32' 27"	209
6.		Sahatsakhan	Noon Nam Kliang	Paa Kluai	16° 40' 05"	103° 32' 72"	
7.		Naamon	Naamon	Noon Thiang	16° 34' 02"	103° 46' 00"	231
8.		Huay Phueng	Nikhom	Huai Faa	16° 40' 85"	103° 52' 90"	
9.		Don Chaan	Dong Phayung	Noon Kokchik	16° 24' 27"	103° 51' 09"	
10.	Roy Et	Phoochai	Khampha-ung	Phuu Khaw Thong	16° 24' 19"	103° 51' 01"	224
11.	Khamphaengphet	Khanuwaralakburi	Bo Tham	Sii Yaek Ton sai	15° 56'	99° 41'	
12.	Chayaphum	Thep Sathit	Naayaang Klak	Khook Anu	15° 41'	101° 32'	
13.		Thep Sathit	Huai Yaay Yiew	Muu 17	15° 31' 20"	101° 25' 31"	302
14.	N. Ratchasima	Thepharak	Bueng Prue	Muu 8	15° 18' 41"	101° 23' 36"	129
15.		Thepharak	Bueng Prue	Muu 3, 6	15° 11' 34"	101° 40' 75"	
16.		Sii Khiiw	Paang Lako	Muu 1	15° 04' 49"	101° 30' 35"	337
17.		Daan Khun Thot	Baan Kaw	Khut Dook	15° 11' 34"	101° 40' 94"	337
18.		Soeng Saang	Noon Sombuun	Sapphongphoot	14° 26'	102° 21'	
19.		Soeng Saang	Sratakhian	Sratakhian	14° 23'	102° 28'	
20.		Khonburi	Tabaekbaan	Nong Phak Rai	14° 27' 83"	102° 20' 77"	
21.	Prachinburi	Naadi	Kaeng Dinso	Aang Thong	14° 03' 30"	101° 57' 54"	65
22.		Naadi	Kaeng Dinso	Khaw Khaat	14° 03'	101° 57'	
23.	Chachoengsao	Sanaam Chaikhet	Thung Phrayaa	Thaa Chiwit Mai			
24.		Thaa Takiap	Khlong Takraw	Nong Yai			
25.		Thaa Takiap	Khlong Takraw	Thung Saai			
26.		Thaa Takiap	Khlong Takraw	Sri Charoen Thong			
27.	Sra Kaew	Wang Sombuun	Wang Sombuun	Klong Ruam	13° 21' 51"	102° 09' 04"	164
28.	Chonburi	Bo Thong	Kaset Suwan	Khun Chamnaan	13° 22' 12"	101° 30' 35"	93
29.		Bo Thong	Kaset Suwan	Aang Kraphong			
30.		Bo Thong	Kaset Suwan	Khlong Pling			
31.	Ratchaburi	Baan Poong	Khaw Khalung	Poong Yo	13° 50' 52"	99° 41' 32"	52
32.	Kanchanaburi	Law Khwan	Thung Krabam	Nong Kae	14° 40'	99° 46'	
33.		Sai Yook	Sai Yook	Dauw Dueng	14° 28' 36"	98° 50' 11"	65
	Total 11	**22**	**26**	**33**			

b. Demonstration plots

Once the locations of the new project sites were decided, researchers would establish a demonstration trial in an experiment station or other suitable location not too far from these sites. Most of these trials showed many different production practices that may affect yield as well as erosion. The erosion control trials had to be laid out along the contour of a uniform slope. Along the lower side of each plot a trench was dug, about 40 cm wide and 40 cm deep, and covered with plastic as shown in **Figure 4**. Little holes made in the plastic allowed runoff water to seep away, while eroded soil sediments remained on the plastic at the bottom of the trench, and could be collected and weighed at 3-4 month intervals during the crop cycle. A sample of the wet sediments would be weighed, dried and weighed again to determine its water content and from that the amount of dry soil lossed by erosion could be calculated for each treatment.

Table 8. Location of FPR pilot sites of the Nippon Foundation cassava project in Vietnam in 2003.

	Province	District	Commune	Village	Coordinates		Altitude (masl)
					N	E	
1.	Thai Nguyen	Pho Yen	Tien Phong		21^0 24' 57''	105^0 54' 30''	21
2.		Pho Yen	Dac Son		21^0 24' 24''	105^0 51' 31''	18
3.		Pho Yen	Minh Duc		21^0 26' 19''	105^0 48' 37''	25
4.			Hong Tien		21^0 25' 55''	105^0 52' 33''	16
5.		Phu Luong	Yen Do		21^0 47' 46''	105^0 42' 47''	80
6.	Bac Can	Na Ri	Hao Nghia		22^0 06' 24''	106^0 05' 16''	314
7.	Tuyen Quang	Son Duong	Thuong Am	Am Thong	21^0 44' 44''	105^0 18' 46''	40
8.		Son Duong	Thuong Am	Hong Tien	21^0 43' 24''	105^0 19' 10''	75
9.	Yen Bai	Van Yen	Mau Dong		21^0 54' 44''	104^0 38' 45''	38
10.		Van Yen	Yen Hung				
11.		Van Yen	Mau A		21^0 52' 39''	104^0 41' 17''	49
12.		Van Yen	*An Binh*		22^0 00' 36''	104^0 34' 48''	143
13.	Son La	Yen Chau					
14.	Phu Tho	Thanh Ba	Phuong Linh	Kieu Tung	21^0 29' 05''	105^0 06' 55''	31
15.		Phu Ninh	Thong Nhat	Phu Ho	21^0 26' 28''	105^0 16' 32''	30
16.		Phu Ninh	Bao Thanh		21^0 27' 31''	105^0 17' 25''	35
17.	Ha Tay	Thach That	Thach Hoa		20^0 59' 08''	105^0 31' 34''	24
18.		Chuong My	Tran Phu		20^0 48' 42''	105^0 39' 40''	10
19.	Hoa Binh	Luong Son	Dong Rang		20^0 57' 31''	105^0 29' 46''	46
20.		Lac Son	Suat Hoa		21^0 29' 01''	105^0 24' 37''	19
21.		Lac Son	Lien Vu	Voi			
22.	Thanh Hoa	Nhu Xuan	Yen Cat		19^0 31' 59''	105^0 26' 48''	139
23.		Nhu Xuan	Bai Tranh		19^0 27' 54''	105^0 29' 30''	174
24.		Nhu Xuan	Hoa Quy		19^0 38' 22''	105^0 24' 20''	105
25.	Thua Thien-Hue	A Luoi	Huong Phuong		16^0 10' 02''	107^0 18' 53''	563
26.		A Luoi	Hong Ha		16^0 17' 59''	107^0 20' 04''	80
27.		Nam Dong	Thuong Long		16^0 06' 47''	107^0 38' 53''	121
28.		Nam Dong	Huong Hoa		16^0 09' 09''	107^0 41' 54''	88
29.		Huong Tra	Huong Van		16^0 30' 31''	107^0 26' 20''	9
30.	Dong Nai	Thong Nhat	An Vien		10^0 52' 46''	106^0 59' 24''	46
31.	Binh Phuoc	Dong Phu	Dong Tam		11^0 37' 17''	107^0 01' 40''	176
32.		Chan Thanh	Minh Lap		11^0 30' 34^{11}	106^0 45^1 48^{11}	54
33.	Baria-Vungtau	Chau Duc	Suoi Rao		10^0 35' 15^{11}	107^0 20^1 02^{11}	32
34.		Chau Duc	Son Binh		10^0 38' 10^{11}	107^0 21^1 10^{11}	58

c. Farmers evaluate and select most attractive options from demonstration plots

Farmers from a new pilot site would visit these demonstration plots to select some treatments that were considered suitable. Each farmer received a sheet with a lay-out of the trial and a brief discription of each treatment. The *pros* and *cons* of each treatment would be discussed in the field and each farmer could score each treatment. Finally, the scores of all farmers were added up and those treatments that received the highest scores were further discussed to reach a consensus about the 4-5 most suitable treatments to be tested in FPR trials in the village. **Tables 14** and **15** show examples of demonstration trials conducted in Thailand and Vietnam, respectively. The data in both tables show that contour hedgerows of vetiver grass is one of the most effective ways to reduce erosion, but that higher yields and income can often be obtained by intercropping or closer plant spacing. **Table 15** shows that fertilizer application can both increase yields and reduce erosion. Farmers visiting these plots often became aware of the seriousness of soil losses by erosion, and realized that many simple agronomic practices can effectively control erosion. Farmers, however, selected mainly those practices that are effective, require little labor or other inputs, and fit well in their current production system.

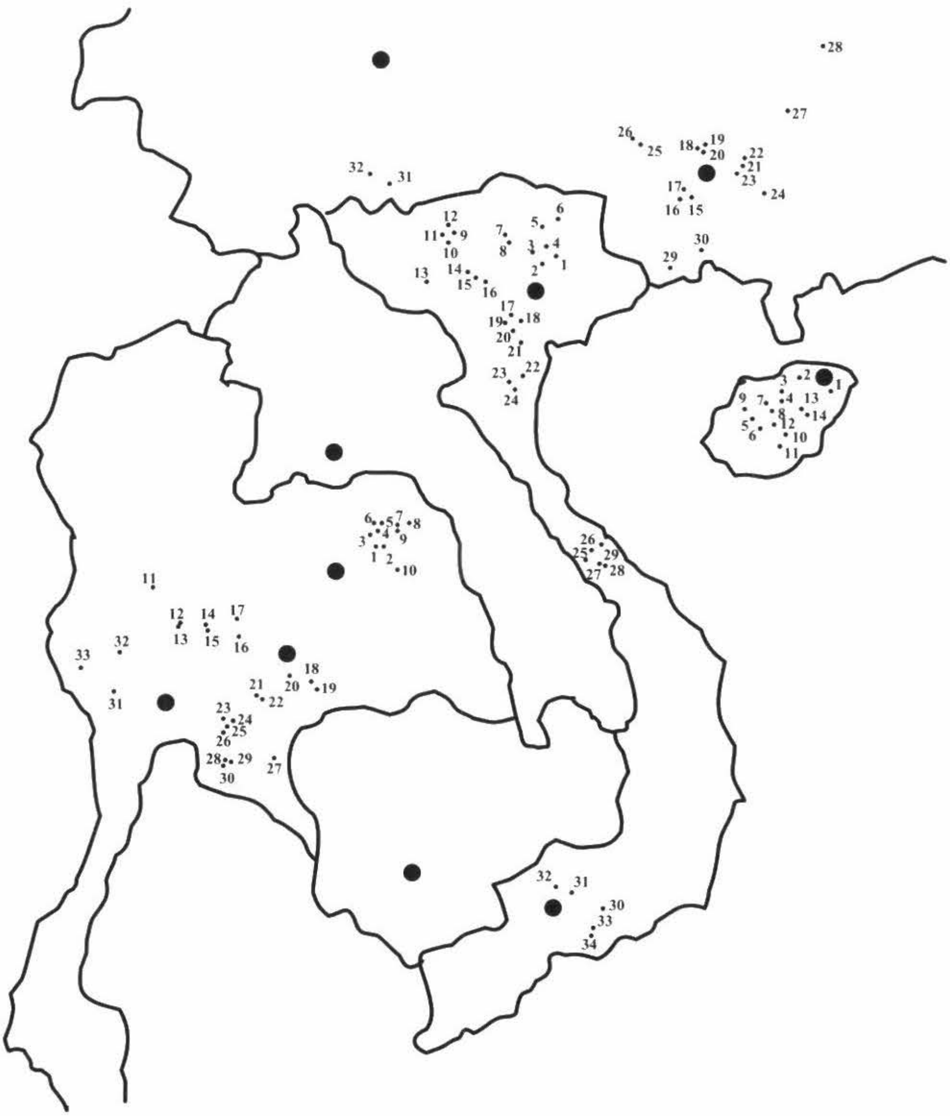


Figure 1. Location of FPR pilot sites in China, Thailand and Vietnam in the Nippon Foundation cassava project in 2003.

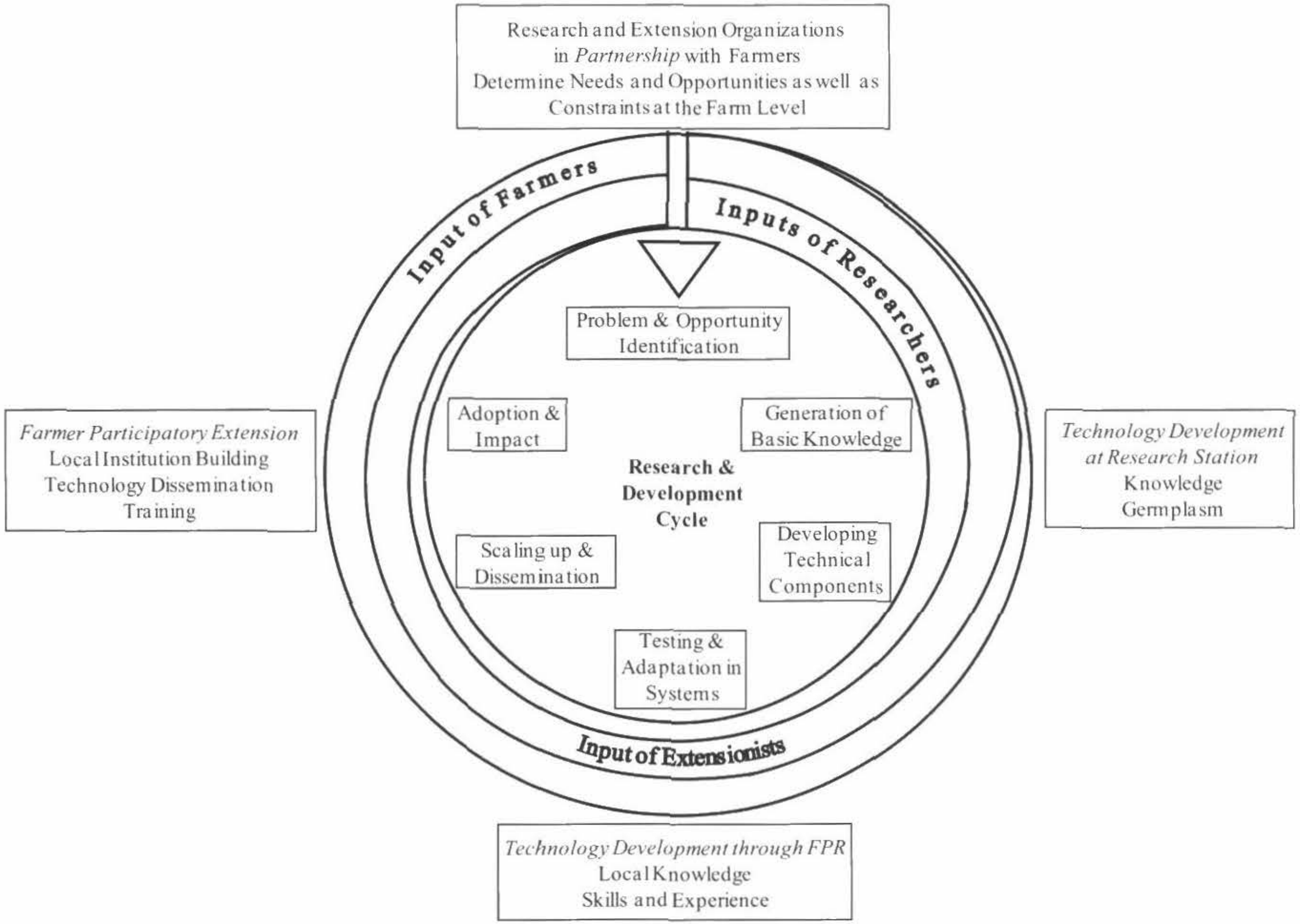


Figure 2. Conceptual framework for Farmer Participatory Technology Development and Dissemination (FPTDD)

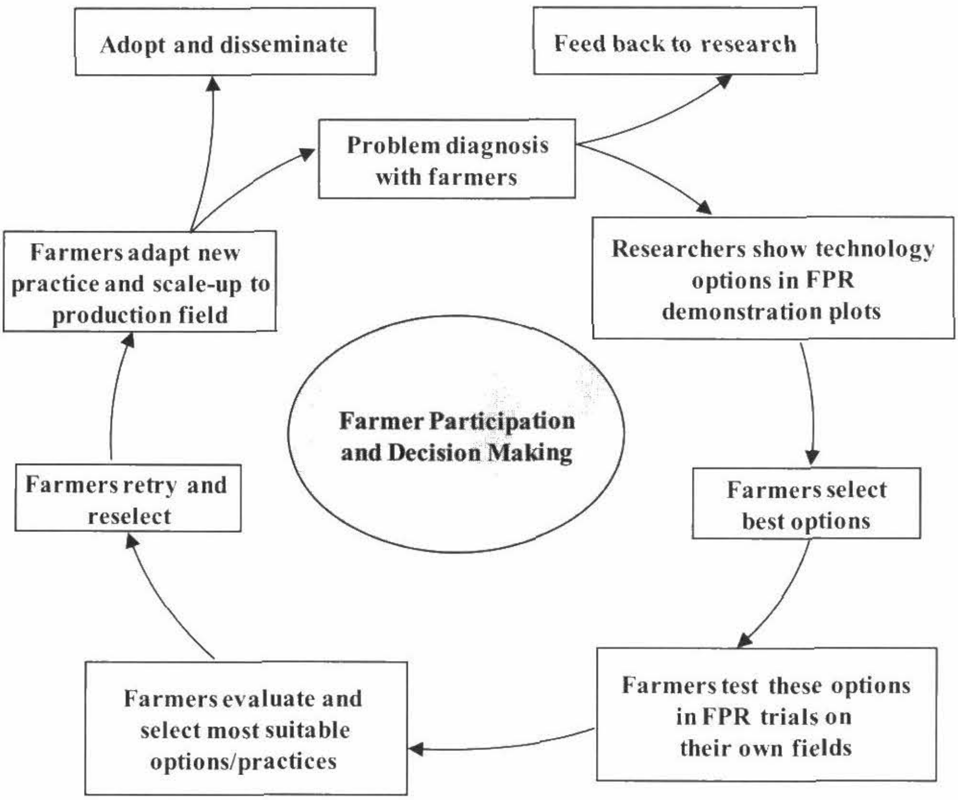


Figure 3. Farmer participatory model used for the development of sustainable cassava-based cropping systems in Asia.

3.5 Development of Sustainable Soil/Crop Management Practices

Once back in the village, the project staff asked who would be interested in conducting FPR trials and what technology components should be tested. Many farmers were interested in testing new varieties as a way of obtaining planting material; others may volunteer to do fertilizer, manure or green manuring trials, while those having sloping land may be interested in conducting erosion control trials. In addition, farmers in some sites liked to test different intercrops or different ways of intercropping, while in other sites they wanted to test plant spacing, weed control or even pig feeding with different rations of dry and ensiled cassava roots or leaves.

Besides choosing the technology components, farmers and project staff also discussed the specific treatments to be tested, usually 4-5 new technologies and the traditional farmer's practice. Without imposing their own ideas, project staff has to guide farmers towards the right selection of treatments; if farmers select treatments in which more than one factor changes between treatments the final results may be impossible to interpret as the change in yield can not be attributed to any one factor. This has been a weak point in many FPR trials where farmers selected their own treatments, or where they made changes during the crop cycle.

Table 9. Characteristics of selected pilot sites for conducting FPR in Thailand in 2000.

Village District	Kutdook Daan Khun Thod	Village 3, 6 Tepharak	Noon Sawaat Sahatsakhan	Noon Sawan Mueang	Khamsii Nong Kungsrii	Aang Thong Naadii
Province	Nakorn Rachasima	Nakorn Rachasima	Kalasin	Kalasin	Kalasin	Prachinburi
Latitude (°N)	15°	15°	17°	17°	17°	14°
Altitude (masl)	~200	~200	~200	~200	~180	~180
Rainfall (mm/yr)	1200	1200	1250	1320	1220	1300
Rainy season	Apr-Nov	Apr-Oct	Apr-Sept	March-Sept	March-Oct	May-Nov
Mean temperature (°C)	28-30	28-30	26-28	26-28	26-28	26-28
Landscape	rolling	rolling	rolling	rolling	rolling	rolling
Soils						
-color/texture	white sandy loam	white sandy loam	reddish sandy loam	white sandy loam	reddish sandy loam	white sandy loam
-fertility	low	low	low	low	low	low
Main crops	cassava rice maize fruit trees	cassava rice maize fruit trees	cassava (75%) rubber (19%) sugarcane (6%) rice	cassava (50%) rice (50%) sugarcane	cassava (95%) rice (5%)	cassava fruit trees rice vegetables
Farm size (ha)						
- total	-	-	5.8	5.9	2.3	3.2-4.8
- cassava	-	-	2.4	2.9	1.8	
Cropping system	C monocrop	C monocrop	C monocrop	C monocrop	C monocrop	C monocrop
Cassava yield (t/ha)	19	19	25	31	21	23
Cassava utilization	chips	chips	starch	starch	starch	chips
Varieties	Rayong 5 KU 50	KU 50 Rayong 5	Rayong 90 KU 50	Rayong 90 KU 50	Rayong 90 KU 50	KU 50 Ryong 90
Planting time	Febr+Nov	April+Nov	May+Oct-Nov	Aug-Oct	March-May+Oct	
Prod. costs ($/ha)	260	270	215	322	220	309

Table 10. Characteristics of selected pilot sites for conducting FPR in Vietnam in 2000.

Village District Province	Thach Hoa Thach That Ha Tay	Phu Ho Phu Ninh Phu Tho	Thuong Am Son Duong Tuyen Quang	Hong Ha A Luoi Thua Thien-Hue	Phu Rieng Phuoc Long Binh Phuoc	An Vien Thong Nhat Dong Nai
Latitude (°N)	21^0	22^0	22^0	17^0	12^0	11^0
Altitude (masl)	~50	~100	~100	~500	~30	~20
Rainfall (mm/yr)	2000	1800	~1800	2900	~2500	2000
Rainy season	Apr-Oct	Apr-Nov	Apr-Nov	Sept-Dec	May-Oct	May-Oct
Mean temperature (°C)	16-29	16-30	16-30	20-39	25-29	25-29
Landscape	hilly	hilly	hilly	mountainous	mountainous	rolling
Soils	clay loam	clay loam	clay loam	sandy clay loam	clay loam	sandy loam
Main crops	rice cassava tea peanut	rice cassava maize forest	rice cassava	cassava sugarcane rice maize	rubber cassava rice cassava	cashew cassava fruits
Farm size (ha)						
- total	0.90	-	0.43	0.63	-	-
- cassava	0.35	0.16	0.14	0.32	-	-
Cropping system	C monocrop	C monocrop	C monocrop	C monocrop	C monocrop	C monocrop
Cassava yield (t/ha)	13-19	11	10	10	20-25	15-20
Cassava utilization	pig feed/ starch	pig feed/ sale	pig feed/ sale	food	starch/ pig feed	starch/ pig feed

Table 11. Results of RRAs conducted in nine pilot sites in Thailand in 1997-2000: General conditions.

Village	Kutdook	Village 3 and 6	Noon Sawan	Noon Sawaat	Khamsii	Huay Lueaten	Paa Kluay	Village 7and 11	Thaa Chiwiit May
Subdistrict	Baan Kaw	Bueng Prue	Phuupo	Noon Burii	Nong Bua	Noon Naam Kliang	Noon Naam Kliang	Kaeng Dinso	Thung Phayaa
District	Daan Khun Thot	Thephaarak	Mueang	Sahatsakhan	Nong Kungsii	Sahatsakhan	Sahatsakhan	Naadii	Sanaam Chaikhet
Province	Nakorn Ratch.	Nakorn Ratch.	Kalasin	Kalasin	Kalasin	Kalasin	Kalasin	Prachinburii	Chachoengsao
Year	2000	2000	2000	2000	2000	Nov'97	March'98	2000	Nov'98
Land (%)									
-uplands	60	70	60	100		70	50-70	80	70
-lowlands	40	30	40	0		30	30-50	20	30
Upland soils									
-color/texture	white sand	white sand	sandy loam	sandy loam	sandy loam	sandy loam underlain by yellow clay	sandy loam underlain by yellow clay	sandy loam sandy+laterite	gray clay
-fertility				low	low	low	low	low	
Main crops (%)	cassava rice maize fruit trees	cassava rice maize fruit trees	cassava(51) rice (48) sugarcane(1)	cassava (75) rubber (19) sugarcane (6) rice	cassava (95) rice (5)	cassava sugarcane rice peanut	cassava rice	cassava fruit trees rice vegetables	cassava rice maize fruit trees
Animals	cattle buffalo pigs chickens	cattle buffalo pigs chickens	cattle pigs ducks chickens	cattle pigs ducks chickens/geese	cattle pigs chickens ducks	cattle buffalo ducks chickens	cattle pigs buffalo ducks/chickens	ducks chickens	cattle buffalo ducks/chickens pigs
Land ownership	mostly owned some rented	mostly owned some rented	mostly owned 8% rented		mostly owned some rented		land deed 50% user rights 50%		nun. 5
Farm size(ha)-total			5.9-6.3	2.4-3.2	2.3	1.6-3.2	3.2-4.8	3.2-4.8	4-8
-cassava			2.9-3.2	2.4	1.8			4.8	
Main problems	no money erosion lack knowledge on fertilizers low soil fertil.	erosion no money low yield need better variety	no money low yield low price erosion	erosion low price lack Rayong72 low soil fertil.	low price erosion acid soil termites			low price low soil fert. weeds not timely planting	no money lack good var. decreasing fertility fertilizers expensive
Area with erosion	56	61	60	85	71			40	

Table 12. Results of RRAs conducted in nine pilot sites in Thailand in 1997-2000: Cassava production practices and utilization.

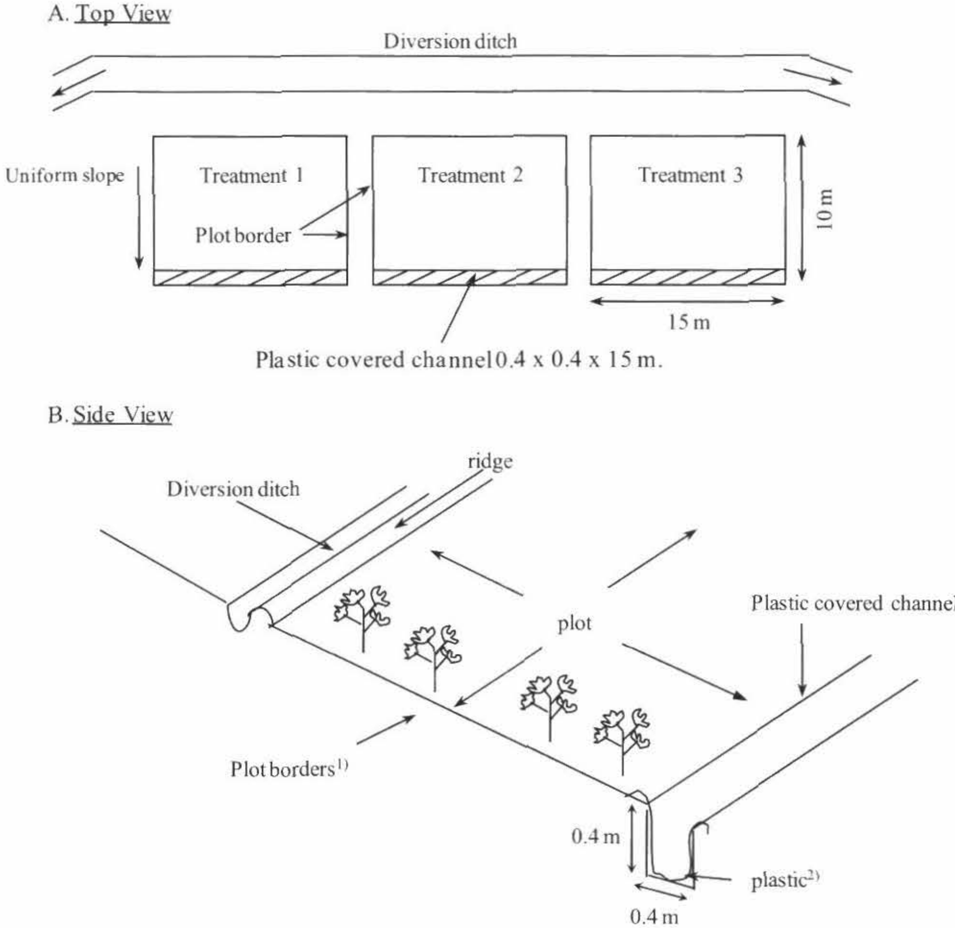
Village Subdistrict District Province Year	Kutdook Baan Kaw Daan Khun Thot Nakorn Ratch. 2000	Village 3 and 6 Bueng Prue Thephaarak Nakorn Ratch. 2000	Noon Sawan Phuupo Mueang Kalasin 2000	Noon Sawaat Noon Burii Sahatsakhan Kalasin 2000	Khamsii Nong Bua Nong Kungsii Kalasin 2000	Huay Lueaten Noon Naamk Kliang Sahatsakhan Kalasin Nov'97	Paa Kluay Noon Naam Kliang Sahatsakhan Kalasin March'98	Village 7and 11 Kaeng Dinso Naadii Prachinburii 2000	Thaa Chiwiit May Thung Phayaa Sanaam Chaikhet Chachoengsao Nov'98
Varieties (%)	Rayong 5 KU 50	KU 50 (80) Rayong 5 (20)							
Planting time	Feb+Nov	Apr-June+Nov	Aug-Oct	May+Oct-Nov	March-May+Oct	Nov-Jan	May-June+Oct-Nov	May-Nov	
Land preparation	tractor 3disc+ ridging	tractor 3disc+ ridging	tractor 3disc+7disc ridging	tractor 3disc+7disc ridging	tractor 3disc+7disc ridging	tractor 3disc+ ridging	tractor 3disc+7disc ridging	tractor 2x ridging	tractor 3disc+7disc 2x ridging
Plant distance(m)	0.6x0.7 0.7x0.8	0.7x0.8 0.8x0.9	0.75x1.0	0.75x1.0	0.75x1.0	0.75x1.0	0.40-0.7x1.0	0.6-0.8x 0.6x0.8	0.6x0.8
Planting method	vertical	slanted	slanted or vertical	slanted	vertical or slanted	slanted	vertical or slanted	vertical	slanted or vertical
Fertilization -chemical	15-15-15	15-15-15	15-15-15	15-15-15	16-8-8	15-15-15 13-13-21	15-15-15	Ami-Ami	15-15-15 13-13-13 16-20-20
-amount(kg/rai)	30-50	30-50	20	20	10-20	10-50	25-30		25-50
-time	before planting	at 1MAP			at 1-2 MAP		1-2x		
-organic	manure+compost	chicken manure	-	-	-	-	-	manure	-
Weeding	1x at 1-2MAP with tractor 1-2x by hoe	1x at 1-2MAP with tractor 1-2x by hoe	1x at 1-2MAP 1x at 3MAP by hoe or handplow	1x at 1MAP by hoe or handplow	1x at 1MAP 1x at 2MAP by hoe or handplow	1x with catlle 1-2x by hoe or handplow	1x at 1-2MAP 1x at 2-3MAP 1x at 4-5MAP by hoe or some herbicides	1x at 2MAP by hoe Gramoxone at 6 MAP Glyphosate at 8-9 MAP	1x by hoe or Gramoxone or Glyphosate 1x Gramoxone or Glyphosate 1x by hoe or knive or handplow
Harvest	digging loading transport	digging loading transport	contract	contract	contract	contract	contract		digging by hand or harvester
Utilization(%)	chips	chips starch	starch (90) chips (10)	starch (90) chips (10)	starch (90) chips (10)	starch(90) chips (10)	starch (80) chips (20)	chips (90) starch (10)	starch (90) chips (10)

1 ha = 6.25 rai

Table 13. Results of RRAs conducted in nine pilot sites inThailand in 1997-2000: Production costs and gross and net income (baht/rai)[1].

Village	Kutdook	Village 3 and 6	Noon Sawan	Noon Sawaat	Khamsii	Huay Lueaten	Paa Kluay	Village 7and 11	Thaa Chiwiit May
Subdistrict	Baan Kaw	Bueng Prue	Phuupo	Noon Burii	Nong Bua	Noon Naamk Kliang	Noon Naam Kliang	Kaeng Dinso	Thung Phayaa
District	Daan Khun Thot	Thephaarak	Mueang	Sahatsakhan	Nong Kungsii	Sahatsakhan	Sahatsakhan	Naadii	Sanaam Chaikhet
Province	Nakorn Ratch.	Nakorn Ratch.	Kalasin	Kalasin	Kalasin	Kalasin	Kalasin	Prachinburii	Chachoengsao
Year	2000	2000	2000	2000	2000	Nov'97	March'98	2000	Nov'98
Planting material	0	0	0	0	0	0	0	80	0
Land preparation									
-1st plowing	130	148	150	127	150	120	120-150	106	120-180
-2d plowing	-	-	130	120	120	120	120-150	106	120
-3d plowing	-	-	-	-	-	-	-	-	120
-ridging	130	145	120	-	-	100	100-120	100	100-120
Planting	100	177	183	116	80	200	300-500	118	120-180
Fertilization									
-fertil. 15-15-15	190	191	360	441	420	-	-	146	} 275
-application	100	85	100	140	70	118	80-140	20	}
-manure	60	90	-	-	-	-	-	-	-
Chemical appl.	-	-	240	-	130	-	-	89	-
Weeding									
-own labor	100	105	212	150	70	-	-		
-tractor for hillingup or contract labor	150	187	243	-	70	320-640	500-600	152	137-175
-herbicide	-	-	-	-	-	-	-	125	-
Harvest									
-harvester	-	-	-	-	-	-	-	-	130
-digging	180	145	185	180	197	150	200-500	554	} 250-300
-loading	170	133	100	100	100	100	100		} 150-200
-transport	-	-	-	-	-	-	-	380	100
Land rent	350	320	-	-	-	-	-	-	-
Total prod. cost.	1660	1726	2063	1374	1407	1228-1548	1520-2260	1976	1620-1900
Yield (t/rai)	3	3	5	4	3.4	1-5	2-5	3.7	2-4
Price (B/kg)	0.85	0.84	0.75	0.80	0.90	0.75	2.20	0.77	0.98-1.05
Gross income	2,550	2,520	3,750	3,200	3,060	750-3,750	4,400-11,000	2,849	1,960-4,200
Net income	890	794	1,687	1,826	1,653	0-2,202	2,680-9,280	873	340-2,300

[1] 1 US$ = 40 baht 1 ha = 6.25 rai



[1)] Plot borders of sheet metal, wood or soil ridge to prevent water entering or leaving plots.
[2)] Polyethylene or PVC plastic sheet with small holes in bottom to catch eroded soil sediments, but allow run-off water to seep away. Sediments are collected and weighed once a month or 3-4 times per year.

Figure 4. Experimental lay-out of simple trials to determine the effect of soil/crop management practices on soil erosion.

Table 14. Results of FPR demonstration plots laid out on 5% slope at TTDI Research and Development Center, Huay Bong, Daan Khun Thot, Nakhorn Ratchasima, Thailand in 2002/03.

Treatments[1)]	Dry soil loss (t/ha)	Cassava yield (t/ha)	Intercrop yield (t/ha)	Gross income[2)]	Product. costs	Net income
				--------('000B/ha)-------		
1. farmers' practice: no ridges, 25 kg/rai 15-15-15	5.88	28.80	-	37.44	16.40	21.04
2. up-down ridges; 25 kg/rai 15-15-15	7.96	21.25	-	27.63	14.99	12.64
3. contour ridges; 25 kg/rai 15-15-15	5.94	26.09	-	33.92	16.29	17.62
4. no ridges; 50 kg/rai 15-15-15	8.54	23.52	-	30.58	16.60	13.98
5. no ridges; 25 kg/rai 15-15-15+125 kg/rai chicken manure	9.06	26.28	-	34.16	16.78	17.38
6. no ridges; peanut intercrop	12.98	24.06	1.830	45.92	19.44	26.47
7. no ridges; pumpkin intercrop	8.84	23.67	3.242	50.22	19.01	31.21
8. no ridges; sweet corn intercrop	7.28	16.13	4.472	43.33	23.95	19.38
9. no ridges; mungbean intercrop (planted 2 WAP)	3.56	18.90	-	24.57	15.87	8.69
10. no ridges; *Canavalia* intercrop (planted 1.5 MAP)	17.08	11.77	-	15.30	13.13	2.17
11. no ridges; cowpea intercrop (planted 1.5 MAP)	4.70	16.25	-	21.13	15.51	5.61
12. no ridges; vetiver (from TTDI) hedgerows	1.48	19.94	-	25.92	14.51	11.42
13. no ridges; vetiver from Prachuap[3)] hedgerows	12.74	16.01	-	20.81	13.45	7.36
14. no ridges; vetiver from Vietnam hedgerows	1.98	23.12	-	30.06	15.37	14.69
15. no ridges; *Paspalum atratum* hedgerows	1.64	13.19	-	17.15	12.50	4.65
16. no ridges; *Tephrosia candida*[3)] hedgerows	8.56	20.07	-	26.09	14.37	11.73
17. no ridges; sugarcane (for chewing) hedgerows	7.20	23.72	1.250	34.59	17.03	17.56
18. no ridges; closer spacing (80x80cm)	8.96	31.45	-	40.89	18.06	22.83

[1)] All treatments except T_{18} were planted at 120x80 cm; all treatments except T_4 received 25 kg/rai of 15-15-15 fertilizers

[2)] Prices;

cassava	baht	1.30 /kg fresh roots
peanut		8.0 /kg dry pods
pumpkin		6.0 /kg fresh fruit
sweet corn		5.0 /kg fresh cobs
sugarcane		3.0 /stalk (1 kg)
15-15-15 fertilizers		10.4 /kg
chicken manure		920 /tonne (includes transport)

[3)] Needed to be replanted at 2 months

a. Test and evaluate most suitable options in FPR trials.

Once the treatments had been decided on by all participating farmers in the village, the same 4-6 treatments were established in all trials testing that particular technology component. Project staff would help farmers stake out the plots and establish the treatments. For erosion control trials it is absolutely essential that plots are laid-out side by side on a uniform slope and that runoff water from areas up-slope from the plots is diverted and does not enter the treatments. All rain falling on the plots must either infiltrate into the soil or runoff into the plastic-covered trenches, in order that eroded sediments are trapped and can be measured. Farmers, however, almost always want to lay out plots parallel to roads, footpaths or property boundaries so as not to waste land. This sometimes resulted in plots and sediment ditches not being on the contour, and runoff water leaving through side borders of plots, reducing the reliability of the soil loss data. Fortunately, most project staff were well-aware of this problem and helped farmers to lay out the plots correctly.

Table 15. Results of FPR demonstration plots at Thai Nguyen University, Thai Nguyen province in 2001 (3rd year).

Treatments[1]	Dry soil loss (t/ha)	Yield (t/ha) cassava	peanut dry pods	peanut biomass	hedgerow biomass	Gross income[2]	Product. costs[3]	Net income
						-----('000 dong/ha)-----		
1. no fert; no ridges, C monoculture; 1x0.8m; no hedgerows	67.75	2.75	-	-	-	1,375	2,800	-1,425
2. with fert; contour ridges, C mono-culture; 1x0.8m; no hedgerows	19.53	13.33	-	-	-	6,665	4,364	2,301
3. with fert; no ridges, C monoculture; 1x0.8m; *Paspalum* hedgerows	20.50	14.08	-	-	1.57	7,040	4,164	2,876
4. with fert; no ridges, C monoculture; 1x0.8m; vetiver+*Teph.* hedgerows	14.96	13.91	-	-	2.94	6,955	5,464	1,491
5. with fert; no ridges, C+P; 1x0.8m; *Tephrosia* hedgerows	16.35	15.83	0.50	4.23	1.34	10,415	5,464	4,951
6. with fert; no ridges, C+P; 1x0.8m; *Tephrosia*+pineapple hedgerows	15.95	15.41	0.41	4.02	1.00	9,755	5,464	4,291
7. with fert; no ridges, C+P; 1x0.8m; natural grass hedgerows	17.98	14.83	0.38	3.95	-	9,315	5,164	4,151
8. with fert; no ridges, C+P; 1x0.8m; vetiver grass hedgerows	13.98	16.91	0.33	3.42	1.63	10,105	5,464	4,641
9. with fert; no ridges, C+P; 1x0.8m; *Panicum max.* hedgerows	17.11	14.58	0.45	4.30	1.66	9,540	5,464	4,076
10. with fert; no ridges, C+P;0.6x0.8m; *Brach. brizantha* hedgerows	15.15	18.33	-	-	1.22	9,165	4,664	4,501

[1] Fertilizers = $60N+40P_2O_5+120K_2O$/ha
C+P = C+peanut; Variety = KM60
Distance between hedgerows: 5m
Intercropping: 2 rows of peanut

[2] Prices:

cassava	dong	500/kg
peanut		5,000/kg
urea (45% N)		2,100/kg
SSP (17% P_2O_5)		950/kg
KCl (60% K_2O)		2,300/kg
labor		10,000/manday

[3] Cost:

cassava cultivation	2.8 mil. dong/ha
fertilizers ($60N+40P_2O_5+120K_2O$)	0.964 mil. d/ha
fertilizer application	0.10 mil. d/ha
peanut seed	0.30 mil. d/ha
contour ridging	0.50 mil. d/ha
labor for intercropping	1.00 mil. d/ha
hedgerow seed, planting, maintenance	0.30 mil. d/ha

3.6 Farmer Participatory Extension (FPE)

As the project progressed, the emphasis shifted from FPR to FPE in order to reach more farmers and achieve widespread adoption. Nevertheless, both FPR and FPE are essential parts of a single and continuous process. Attempts to disseminate the knowledge solely through various FPE methodologies, such as cross visits, field days and training courses were not entirely successful. Farmers seem to be more convinced if they have actually tested the various options in their own fields through FPR trials. This is particularly true for very site-specific technologies such as erosion control and fertilization practices.

The Farmer Participatory Extension (FPE) methodologies used in the project included the following:

a. Cross-site visits

Farmers from a new pilot site visit an "old" village where the project has worked before, where farmers have already conducted FPR trials and have adopted some improved varieties and practices. In Thailand these cross visits were particularly effective in convincing farmers from new sites to either conduct their own FPR trials or start adopting those practices already selected by farmers in other communities. In one such cross visit to Huay Suea Ten village in Kalasin province, farmers from the new site were so impressed with the effectiveness of vetiver grass hedgerows in controlling erosion, that they all carried bundles of vetiver grass home to start multiplying for future use in their own cassava fields. In many cases, farmers feel more comfortable and are more easily convinced after talking to other farmers than they do talking to researchers or extensionists, who oftentimes promote a new practice without having had previous practical experience with it in the field.

b. Farmer field days at time of harvest

These are mostly for farmers from the village and neighboring villages to share the results of their FPR trials, to discuss the *pros* and *cons* of each treatment, and to select the best practices for further testing in FPR trials or for trying out in larger areas. These field days were particularly effective in Vietnam, where farmers from three nearby villages took turns hosting a field day to show *their* FPR trials to those of the other two villages. This allows for cross-site comparisons and stimulates pride in doing the trials well.

c. Large-scale field days during the cropping cycle

These large events, with participation of hundreds of farmers from the district and province, school children, local as well as provincial and national level government officials, TV crews and press, are a good way to disseminate new varieties and practices to many people. In one such event in Khut Dook village in Nakhon Ratchasima province, farmers visited different "stands" where farmers from the village, using charts and photos, explained the results of their FPR trials. This farmer-to-farmer extension is very effective. Afterwards, farmers could visit the fields where some new practices were being demonstrated.

d. Establish community-based self-help groups

These groups are similar to the "Landcare" groups in Australia and the Philippines, as well as the "CIALs" in Latin America. In Thailand these are called "Cassava Development Villages" and are set up by DOAE with financial support from the government. They are modeled on a "Soil Conservation Group" that had sprung up spontaneously in Sapphongphoot village where, after having seen the good results of vetiver in FPR trials in a neighboring village, farmers organized themselves to plant vetiver grass contour hedgerows in 320 ha of their cassava fields to control erosion. In a "Cassava Development Village", farmers are encouraged to become members of the group (need at least 40 members to get government support); they elect their own officers, usually consisting of a president, vice-president, treasurer, secretary and public relations officer; they meet biweekly or monthly to decide on their activities, such as conducting FPR trials, organizing field days, managing a vetiver grass or fruit tree nursery etc. They also manage a revolving credit fund, which is initiated from a one-time contribution of fertilizers from the Thai government. At the next time of harvest, farmers have to return the value of the fertilizers plus a small amount of interest to the revolving fund. Farmers can then borrow again from the fund for the purchase of production inputs such as fertilizers, but the fund can also be used for hospital emergencies or for educational purposes. Sofar, most farmers have been able to repay the money borrowed from the credit funds, and membership as well as the size of the funds have increased substantially over the past few years (Wilawan Vongkasem *et al.*, 2008).

e. Encouraging additional income generating activities

This is often part of the activities of the "Cassava Development Village" or commune and may include pig feeding with cassava roots and leaf silage; silk worm raising on fresh cassava leaves; duck, pig or cattle raising; planting of high-value crops such as fruit trees, sweet corn or vegetables; and the making of handicrafts from vetiver leaves.

f. Formation of "FPR teams"

These consist of 2-3 key farmers from each pilot site together with the local extension agent, who have participated in farmer/extensionist FPR training courses organized by the project. By inviting both extensionists and farmers from the same subdistrict to work together during the training course, they get to know each other and can form an "FPR team" that can teach others in the village about how to conduct trials or about new technologies learned during the training course.

g. Production and distribution of attractive pamphlets, booklets, posters and videos

These are discussed in Howeler (2008).

h. Newspaper articles and TV programs

During field days, press and TV crews are often invited to participate. They report about the project activities and interview participating farmers. The resulting articles and programs help to desseminate knowledge about the new technologies and the farmer participatory approach used in the project, while it gives farmers more self-confidence in their own abilities to contribute to technology development.

These various FPE methodologies were often used simultaneously, wherever and whenever appropriate.

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22 48 78

THE FPR PROJECT IN HAINAN PROVINCE OF CHINA

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ABSTRACT

The FPR project in China was funded by the Nippon Foundation in Japan. In Hainan province, the project has been implemented by CIAT and the Chinese Academy for Tropical Agric. Sciences (CATAS). This paper is divided into three main parts and covers the period from 1994 to 2003.

The FPR project was carried out in 12 counties of Hainan. More than 100 farmers participated in research trials and demonstrations. 742 farmers were trained and more than 1000 training materials were disseminated in yearly training courses.

65 farmers participated in 67 variety trials from 1995 to 2003. Four new varieties have been released during this period by the Chinese government. There was a marked increase in the area planted to new varieties, reaching about 3,000 ha or 11% of the total area planted to cassava in Hainan in 2002. The new varieties increased root yields by about 30% and had 6% higher root dry matter content (RMDC) than the traditional variety, SC 205.

15 farmers conducted 17 FPR fertilizer trials from 1995 to 1997. Application of No. 3 special fertilizer increased cassava yields by 33.3% and increased net income by 22.2%. Later, some participating farmers applied this special cassava fertilizer to their cassava fields as recommended by CATAS.

Soil erosion control experiments with 25 treatments of vegetative barriers and intercrops were conducted at CATAS from 1996 to 2001. *Clitoria ternatea, Chamaecrista rotundifolia, Tephrosia candida* and vetiver grass markedly reduced soil loss by erosion and maintained cassava yields over the years. These vegetative barriers were recommended to control erosion in cassava fields. Vetiver grass reduced soil loss 68.3% and increased root yield 2.7% on average over five years, from 1997 to 2001. Then, 12 selected grass barriers were tested at CATAS to determine their competition with cassava during 1998-2001. Vetiver grass was the best barrier because of its low competitiveness.

29 farmers participated in 17 FPR erosion control trials during 1995-1999. Practically all treatments reduced soil erosion. Vetiver grass was the best barrier. Vetiver grass hedgerows dramatically reduced soil loss by 72.0% and increased root yields 3.5% as compared to the check without hedgerows.

Since 1997, we have selected vetiver grass, sugarcane, *Tephrosia candida* and *Cajanus cajan* etc. for FPR demonstrative barriers. Later, some farmers only kept vetiver grass barriers in their cassava fields, interplanted between young rubber trees. Soil analysis indicate that soil collected above the barrier was soft and more fertile while below the barrier the soil was red and less fertile. Near the bottom of the field cassava yields were 50% higher than near the top of a field with 52% slope. Now, more than 50,000 bags of vetiver grass have been distributed and more than 2 km of vetiver grass barriers have been established from 2000 to 2002.

Some ideas about FPR are described in detail and discussed; for example, 1. Multilaterial cooperation among participants. 2. Cooperation between researchers and extension workers. 3. Some advantage of FPR, problems and solutions. The final part covers conclusions and future plans.

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INTRODUCTION

The Farmer Participatory Research (FPR) cassava project in Hainan is a collaborative project between CIAT and CATAS, and is financially supported by the Nippon Foundation of Japan.

At the start of the project, two CATAS researchers participated in an FPR training course held in Thailand in July 1994. Then a Rapid Rural Appraisal (RRA) was conducted in three provinces of China, including Hainan, in August 1994. During the RRA we visited eight villages and four cassava starch factories in five counties of Hainan. It gave us a better understanding of cassava production and utilization in Hainan, and we identified some major constraints and opportunities; lack of new varieties, fertilization and erosion control were the main constraints.

First, treatments were selected for an erosion control experiment and installed at CATAS; this experiment was used as a demonstration during the farmers training course. Second, 20 participating farmers were selected from two pilot sites in two counties; they participated in training at CATAS in January 1995. Third, the first FPR trials were established on the farmers' own fields in March-April of 1995. Those were the first of many FPR trials conducted in Hainan since then.

1. FPR Objective

The objective of the FPR project is to accelerate the development and extension of improved varieties and efficient cassava production practices through farmer participation, to reduce soil erosion, maintain soil productivity, sustain high yields and increase the income of cassava farmers in China.

2. FPR Methodology

Farmers selected the type of FPR trials by themselves. They were most interested in new varieties, fertilizer application and erosion control. CATAS provided technical assistance and supplied the basic planting materials. All farmer trials had only one replication, and usually had the same treatments in each type of trial in the village, so different farmers could be considered as replications. Not only the collaborating farmers but also other nearby farmers were invited to participate in the planting and harvests of the trials, so they could give their opinions about cassava yield, intercrop yield, dry soil loss etc. in the FPR trials. Farmers would then select the best improved varieties or other treatments to be included in next year's trials. Step by step, the best varieties and technologies would be selected and adopted by FPR participants.

3. FPR Processes

The FPR project started in 1995 by selecting two pilot sites in two counties. In the second phase in 1998-2000 we added five new sites (counties). Finally, we tried to expand the FPR to the whole cassava area in Hainan province. This process is shown schematically in **Figure 1**.

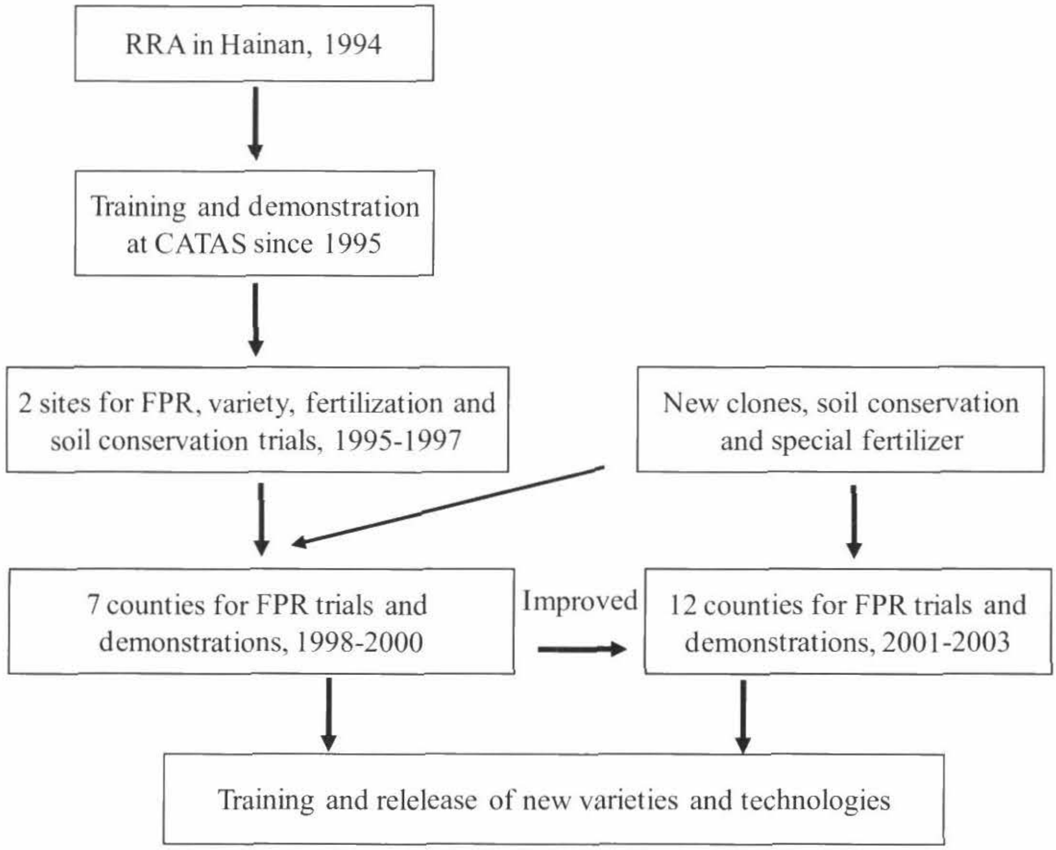

Figure 1. The evolution of the cassava FPR project in Hainan from 1994 to 2003.

4. FPR TRIALS AND TRAINING

The cassava FPR project has been conducted in Hainan for a decade, from 1994 to 2003. We started by establishing some demonstration plots at CATAS for farmer training and visiting. In total, more than one hundred farmers in 12 counties participated in conducting FPR trials that concentrated on three topics: varieties, fertilizer application and soil erosion control (**Table 1**). Data from the trials shown in **Table 1** were collected and analyzed. However, in some FPR trials no data were collected because some newly participating farmers did informal trials, which were affected by their casual cultivation. Both successful and failed trials and demonstrations are important for the FPR project, as we learned together from the earlier failures.

During the past ten years, CATAS organized four training courses in cooperation with CIAT; one of these, a training-of-trainers course was held in 1998. In addition, every year CATAS held training courses in cooperation with local governments or companies. A total of 742 farmers were trained and more than 1000 teaching materials were distributed. We prepared two publications, i.e. "Cassava breeding and cultural practices" and "FPR methodologies", which were used for training. Some students in the university also have been trained and participated in our FPR project. The 5th Asian Cassava Workshop was held at CATAS in November 1996, and all participants visited the FPR site in Kongba village, Baisha county, Hainan province.

Table 1. FPR trials and training in the FPR cassava project in Hainan from 1995 to 2003.

	Variety trials		Fertilizer trials		Soil conservation trials		No. of farmers trained
	Farmers	Clones	Farmers	Treatments	Farmers	Treatments	
1995	13	13	6	9	12	7	20[1]+40
1996	5	9	4	9	4	6	50
1997	8	11	4	9	4	5	80
1998	6	15			4	5	28[1]+60
1999	7	20			3	2	25[1]+60
2000	9	10			2	2	70
2001	5	16					80[1]+50
2002	6	15	1	5			80
2003	6	23					100
Total[2]	**65**	**67**	**15**	**17**	**29**	**17**	**742**

1) These training courses were held at CATAS in cooperation with CIAT; others were regional training course, conducted by CATAS.
2) Total number refers to different farmers, clones and treatments.

RESULTS OF FPR TRIALS

1. FPR Variety Trials

A total of 65 farmers participated in the testing of 67 varieties and breeding lines during 1995-2003. 13 new breeding lines were tested in the first year; each year some bad lines were eliminated and 6-12 new lines were added. Most lines were only tested by farmers for 1 or 2 years, while some lines were tested continuously because of their high yields and the farmers' interest. Those varieties and lines that were tested for more than three years are shown in **Table 2**.

SC 8013, SC 8002, SC 5 and SC 6 were released by the Chinese government during the FPR period. Some farmers liked to plant SC 124 and SC 8013 in the early years of the FPR project. At present, most farmers prefer SC 5 and SC 6 because of their high yield and easy harvest. According to the farmers' appraisal, these new varieties increase the root yield by about 30% and the root dry matter content by 6% above those of the check, SC 205.

2. FPR Fertilizer Trials and Special Fertilizers for Cassava

A total of 15 farmers conducted 17 FPR fertilizer trials from 1995 to 1997. In 1995 there was no responses to any fertilizer applications because the trials were conducted on fertile land which had just been cleared of luxuriant forest in the mountains. In 1996/97, there was a response to all fertilizer treatments (**Table 3**). No. 3 special fertilizer increased cassava yields by 33.3% and increased net income by 22.2%. Some farmers also applied either compound NPK or No. 3 special fertilizer on a larger scale in their production fields in 1997; these two types of fertilizers increased cassava yields by 51-54% and increased the net income by 35-37%. Naturally, farmers recognized the importance of fertilizer application on cassava fields.

Table 2. Main results of FPR variety trials conducted in Hainan during 1995-2002.

Varieties or clones[1]	Average years	RDMC[2] (%)	% CK RMDC	Average root yield (t/ha) New clone	Average root yield (t/ha) SC 205(CK)	% CK yield
SC 205		36.8	100.0			100.0
SC 124	4	37.6	102.2	29.9	25.9	115.4
SC 8013	4	39.2	106.5	28.6	27.0	105.9
SC 8002	4	36.7	99.7	24.0	23.4	102.6
SC 5	4	38.2	103.8	45.6	33.5	136.1
SC 6	7	39.3	106.8	30.5	23.3	130.9
SC 7	4	36.0	97.8	35.4	28.6	123.8
ZM 8641	5	38.4	104.3	25.1	27.2	92.3
ZM 9244	3	36.6	99.4	35.3	22.0	160.5
CMR 34-11-3	3	39.2	106.5	22.5	22.3	100.9
OMR 36-40-9	3	42.7	116.0	30.1	24.8	121.4

[1] South China (SC) is a new variety serial number; SC 5, SC 6 and SC 7 were previously known as ZM 9057, OMR 33-10-4 and ZM 8639, respectively.
[2] Root dry matter content (RDMC) was determined at CATAS.

Table 3. Results of FPR fertilizer trials conducted at Kongba village, Baisha county, Hainan, China in 1996/97.

Treatments[1]	Average root yield (t/ha)	Gross income (Yuan/ha)	Net income[2] (Yuan/ha)
Check	18.0	5,400	5,400
NPK	21.8	6,540	5,505
FYM	21.3	6,390	5,865
Compound fertilizer	21.6	6,480	5,640
No. 3. Fertilizer	24.0	7,200	6,600
No. 4 Fertilizer	21.4	6,420	5,820

[1] N = 225 kg/ha of urea (42% N); P = 225 kg/ha of SSP (16% P_2O_5); K = 225 kg/ha of KCl (60% K_2O); FYM = 15 t/ha of farm-yard manure; Compound = 300 kg/ha of 15-15-15; No. 3 Fertilizer = 300 kg/ha of special fertilizer consisting of 78% Compound 10:5:15, 1% Zn and 21% chicken manure; No. 4 Fertilizer = 300 kg/ha of special fertilizer consisting of 86% Compound 10:5:20, 1% Zn and 13% chicken manure.
[2] Net income is gross income minus fertilizer costs.

Later, the farmers considered that they didn't need to do more fertilizer trials. Based on their previous experience they liked to apply special fertilizers using CATAS' recommendation according to the soil analysis results in different areas. Moreover, some private farms or factories provided special cassava fertilizers to their farmers according to the CATAS recommendation.

3. Soil Conservation Demonstration at CATAS

We conducted for many years a soil erosion experiment at CATAS. The reason is that it is difficult for farmers to conduct an FPR erosion control trial, as it requires additional labor for digging ditches, collecting the eroded soil, to plant and maintain vegetative barriers while farmers couldn't see any direct economic benefits. Also, we liked to keep the experiment going as a useful long-term trial and demonstration, good for training and to show visitors the importance of erosion control. We also liked to explain the results of the erosion control treatments and promote their use in the future.

Previous research on soil conservation conducted in Hainan and other Asian countries during 1987-1994 showed that soil losses caused by erosion can be markedly reduced by zero tillage, contour ridging, closer plant spacing, intercropping and planting contour hedgerows of grasses, such as vetiver grass etc. As such, we selected 25 treatments, mainly concerning the use of contour barriers and intercrops, for our demonstration of erosion control at CATAS during 1996-2001 (**Table 4**). Most treatments were quite effective in reducing soil loss by erosion. As time went by, *Clitoria ternatea, Chamaecrista rotundifolia, Tephrosia candida* and vetiver grass markedly reduced soil losses by erosion and maintained or slightly increased cassava yields as compared to the check without erosion control measures. These results were used to recommend to plant contour barriers in cassava fields located on sloping land. Vetiver grass reduced dry soil loss by 68.3% and increased root yields by 2.7% on average during the five years from 1997-2001. Moreover, leguminous barrier and intercrops improved soil fertility, while some grasses or legumes were used for animal feed and intercrops to increase income.

Table 4. Main results of an experiment on soil erosion control conducted on 8% slope at CATAS from 1996 to 2001.

	Dry soil loss (t/ha)						Cassava root yield (t/ha)					
Treatment[1)]	1996	1997	1998	1999	2000	2001	1996	1997	1998	1999	2000	2001
Rainfall (mm)	2379	2168	1396	2484	2302	2367						
Check without barriers	106.5	85.2	85.6	97.8	31.2	12.2	24.2	30.8	25.3	19.9	21.7	21.6
Vertiver grass	129.9	52.2	18.9	20.2	5.7	1.9	15.5	29.2	24.1	25.4	21.4	22.4
Clitoria ternatea	83.3	28.5	15.2	14.6	10.8	5.4	10.5	30.4	26.4	28.7	25.7	20.8
Chamaecrista rotundifolia	107.6	38.1	45.4	17.3	8.9	6.5	23.0	27.8	23.1	23.1	22.4	23.6
Tephrosia candida	158.0	46.7	13.0	20.5	10.4	7.8	15.5	20.6	19.4	22.0	22.1	21.9

[1)] Check = cassava monoculture without any ridges, barriers or intercrops. Other treatments are cassava + contour hedgerows, and intercropped peanut, soybean or sesame in 1996-1999.

4. Experiment on the Competitie Effect of Grass Barriers on Cassava at CATAS

From 1998 to 2001, we conducted an experiment on the use of vegetative barriers for erosion control at CATAS. Twelve grass barriers were planted (**Table 5**), with the objective to determine the competitive effect, both above ground (for light) and underground (for water and nutrients) between cassava and the various barriers. Some grass barriers, such as King grass, grew very well leading to poorer growth of cassava. In contrast, in some cases, such as lemon grass, cassava grew well but the grass barriers grew poorly or even died. *Brachiaria decumbens* also had a strong competitive effect on cassava and *vice versa*. Ideal barriers will reduce erosion effectively and increase the sustainability of cassava production. As far as we are concerned, vetiver grass is currently the most effective erosion control barrier.

Vetiver grass is planted from vegetative material, but can not be planted from seed. Naturally, it is difficult and expensive to establish. Besides, vetiver grass has few other useful purposes such as for feed, which has limited its widespread use in Hainan. A barrier of *Paspalum atratum* may be better if we reduce the shading effect through a little wider planting distance with cassava. *Paspalum atratum* will not seriously compete with cassava, it is a good resource for animal feeding and is easy to establish, both from seed or from vegetative material.

Table 5. Main results of an experiment on the competition between various vegetative grass barriers and cassava conducted on 7% slope at CATAS during 1998-2001.

	Cassava root yield (t/ha)				Cassava	Dry grass yield (t/ha)				Barrier
Treatments[1)]	1998	1999	2000	2001	growing	1998	1999	2000	2001	growing
Vetiver grass	32.6	41.0	33.5	30.6	Well	3.5	7.3	14.5	4.3	Good
King grass	32.5	23.5	16.3	11.6	Bad	9.5	24.3	90.2	29.2	Well
Lemon grass	34.3	40.7	45.0	32.1	Well	0.6	6.0	0.5	0	Weak
Brachiaria decumbens	27.7	31.7	24.1	16.1	Good	3.5	8.3	23.8	11.9	Good
Paspalum atratum	29.7	34.1	32.6	28.7	Well	3.1	6.9	14.3	4.3	Weak

[1)] Total plot area is 7 x 10 m; there are 6 rows of cassava and 3 rows of grass barriers. Three rows of cassava are grown between two rows of grass, 1 meter space between two cassava rows and 0.5 meter between the cassava row and the grass row. The grass species are cut back at 30 cm above the soil whenever necessary.

5. FPR Erosion Control Trials

There were a total of 29 farmers participating in 17 FPR erosion control trials during 1995-1999 (**Table 6**). All treatments reduced soil erosion, which is similar to the results obtained in the experiment at CATAS. Vetiver grass contour hedgerows were the most effective. Vetiver grass barriers (without intercrops) remarkably reduced dry soil loss by 72.0% and increased root yield by 3.5% as compared to the check without hedgerows. But in the treatments with vetiver hedgerows and intercrops, cassava yields decreased slightly while soil loss increased in comparison with the same treatment without intercrop; this is due to the competition from the intercrop and the additional tillage required.

Table 6. Main results of some FPR erosion control trials conducted in Kongba and Dapulin villages, Baisha county, Hainan during 1995-1999.

	Root yield (t/ha)		Dry soil loss (t/ha)	
Treatments[1)]	Treatment	Check	Treatment	Check
C+vetiver grass+sesame	18.4	20.9	62.5	114.4
C+vetiver grass+peanut	20.0	21.7	55.6	79.2
C+vetiver grass	26.4	25.5	9.3	33.3

[1)] C = cassava. Check is cassava monoculture without any ridges, barriers or intercrops. Some intercrops were damaged by animals sometimes.

6. Demonstration of FPR Erosion Control

In 1997 we selected contour hedgerows of vetiver grass, sugarcane, *Tephrosia candida* and *Cajanus cajan* for FPR demonstrative barriers according to the farmers' preferences. Later, some farmers only kept and expanded vetiver grass in their cassava fields interplanted with young rubber trees, as contour barriers. After three years these had resulted in natural terraces with 30-40 cm high risers. Terraces not only help to control soil erosion in cassava fields but they also facilitate cultivation if farmers repair the terraces, especially for long-term crops like rubber or fruit trees. Now, more than 50,000 bags with vetiver grass plantlets have been transplanted, and more than 2 km of vetiver grass barriers have been established in 2000-2002.

In one of our FPR demonstrations, 13 rows of vetiver grass contour barriers were planted on a 1 ha mountain plot with 52% slope at Dapulin village, Hainan, in 1999. The soil analysis results indicate that the soil's nutrient content had changed between 1999 and 2003 (**Table 7**). The terrace risers in 2003 had a height of 50 cm; this markedly reduced soil erosion and runoff and conserved soil fertilizers and moisture. Between two barriers, the bottom section had collected soft fertile soil and had only 14.3% sand content, while the top part of the strip between barriers was eroded and revealed a red subsoil, which had 38.3% sand content. At harvest, the bottom section had 50% higher cassava yields than the mid or upper section. Planting contour barriers had an obvious effect on cassava yield and soil conservation on this steep slope. Vetiver grass barriers will hopefully expand in the future.

Table 7. Soil analysis between vetiver grass barriers at Dapulin villages, Baisha county, Hainan, in 1999 and 2003.

	Location between barriers[1)]	pH[2)]	> 2 mm sand (%)	OM (%)	Total N (%)	Available P (mg/kg)	Exchangeable K (mg/kg)
Dec. 1999	Top (7 m)	4.89	-	2.82	0.155	2.9	32.5
	Mid (4 m)	4.87	-	3.23	0.162	4.2	37.5
	Bottom (1 m)	4.75	-	3.40	0.185	1.6	44.0
Aug. 2003	Top (7 m)	3.93	38.3	2.83	0.133`	3.3	29.2
	Mid (4 m)	3.93	16.3	2.78	0.133	2.9	29.2
	Bottom (1 m)	3.75	14.3	3.34	0.156	3.8	41.7

[1)] 52% slope in 1999 and 45% slope in 2003; soil samples taken in contour strips at 1-, 4- and 7-meters above the lower vetiver grass barriers.

[2)] Soil analysis by CATAS, China.

7. Adoption of Soil Conservation Practices in Cassava Fields

From the FPR trials and demonstrations, many farmers realized the seriousness of soil erosion and the effectiveness of contour hedgerows to reduce soil losses. In fact, most farmers didn't like to plant barriers but liked to keep wide natural barriers for soil conservation. At the present, they don't need these barriers for animal feed, and they don't care about the land, because there are abundant weeds for feeding and large areas of waste land for exploitation in Hainan's mountains. It is now common practice to keep strips of natural bio-barriers, or to leave crop residues or weeds piled up along contour lines. But, previously farmers piled up crop residues haphazardly anywhere, which isn't good for soil conservation and makes tillage more difficult. Now, farmers participating in the FPR project adopted planting barriers and soil preparation along contour lines.

Besides, many farmers liked to combine zero tillage with chemical weed control, which is good for soil conservation on soft and fertile mountain soil; it resulted in higher yields and reduced hard work and costs. This technology has also been adopted by some large cassava plantations in Hainan to reduce crop management costs.

ACHIEVEMENTS OF FPR

Ten years ago in 1994 cassava yields in Hainan province were rather low as there were few new varieties and improved technologies. Much has changed since then as a result of the FPR project (**Table 8**). Up to now, more than 100 farmers have directly participated in cassava research, and thousands of farmers have adopted the results of the FPR project. Now, more than ten new varieties or clones selected by farmers are widely planted. In particular, 90% of the cassava area in the mountains of both Baisha and Tunchang counties are being planted with new varieties or clones. New varieties were multiplied and widely disseminated due to the successful demonstrative effect year after year. Many cassava farmers that had participated in the FPR project from the beginning are now well-off due to the high root yields and from the sale of stems of the new varieties.

Table 8. Achievements of FPR in Hainan (1993 and 2003).

	1993	2002
Total cassava area ('000 ha)	24.9	33.7
Average root yield (t/ha)	13.1	16.4
Average RDMC (%)	36.8	39.0
New variety or clone	Few	3,000 ha of new varieties or clones
Fertilizer application	Few	Partly by CATAS recommendation
Erosion control	No	Some, but most farmers realize its importance
Farmers' standard of living	Simple food and dress	Many "cassava" motor cycles and houses

At the same time, fertilization, erosion control, closer planting, zero tillage and chemical weed control are progressively being adopted through pilot demonstrations in cassava fields by CATAS' integrated extension programs. These new technologies are beneficial by both reducing production cost and increasing cassava yields.

The FPR project helped to develop the rural economy and make farmers richer, while stimulating the cassava industry in Hainan.

As a result of this close and effective cooperation in cassava research and FPR between CATAS and CIAT, Dr. Reinhardt Howeler and Dr. Kazuo Kawano were both awarded the "Friendship Prize of the P.R. of China" by the Chinese Central Government in 1998 and 1999, respectively.

DISCUSSION OF FPR

1. Multilateral Cooperation among Various Participants

FPR is a new research and extension methodology in China. Naturally, it needs multilateral science, technology and organization to solve a lot of new problems. But different participants have different objectives and responsibilities, for example:

1) Researchers: to conduct research and publish results; have a positive effect on society, the economy and ecology.
2) Extension officers: to follow government policies and write reports
3) Farmer extensionists: to make profit from selling agricultural materials
4) Cassava starch factory: to obtain sufficient cassava roots of high starch content
5) Farmer: to maximize crop growth and yield, marketing and income

We tried to work together so that every participant attained their objectives and received benefits. Some of these successful cooperations are shown in **Table 9**. At the same time, the FPR methodology has now been adopted in other crop areas through cooperation and study in China.

Table 9. Successful multilateral cooperation in conducting FPR in Hainan.

Partner	Contribution to the cooperation
CIAT	FPR methodology, international genetic resources and new technologies
Cassava project (CATAS))	New cassava varieties and improved technologies
Pasture researchers (CATAS)	Technology and planting material for contour barriers
Economist (CATAS)	Economic analysis
Nankun cassava starch factory	Wide dissemination of new variety, special fertilizer etc.
Qi Fang town government	Local management of the FPR project and transfer of selected technologies
Farmer technicians	Some group management of FPR trials and production of planting material
University students	Assistance and thesis research

2. Effect among FPR, Research and Extension

At the present, the Chinese government assesses about 6,000 agricultural achievements per year. There is still a low adoption rate (30-40%) of agricultural research achievements, due to a disjointed relation between researchers, extensionists and farmers. In contrast, in developed counties the adoption rate is about 70-80%.

The FPR methodology provides a close working relationship among three participants. It improves the transfer rate of science and technology; it also improves the agricultural knowledge of extensionists and farmers. For example, the best new clones and technologies from CATAS and CIAT were tested and selected by farmers in FPR trials. Participating farmers have quickly adopted these new varieties and technologies, and learned how to solve some problems by themselves by participating in research and study. For example, farmers developed by themselves a practical soil conservation method through FPR i.e. they maintained natural contour barriers of trees and weeds, which had never been included in the FPR trials or demonstrations.

3. Relationship between FPR, Research and Extension

The relationship between FPR, research and extension can best be explained as a triangular cooperation (**Figure 2**). It is a close joint relationship among participants. It is a reiterative process leading to continuous improvements for both participants and technologies.

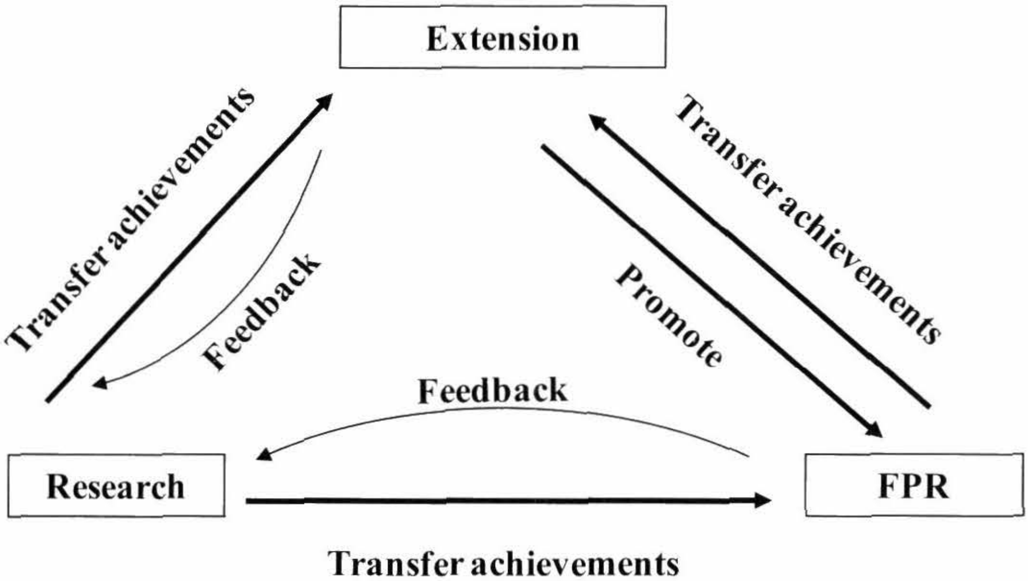

Figure 2. Schematic diagram of the relationship between FPR, research and extension

4. Advantage of FPR

The FPR approach has several advantages as compared with other extension methods. The main advantages of FPR are:

1) Equal communicative platform for all participants
2) Farmers are volunteers and are active partners
3) Researchers are directly involved in extension
4) Absorb and respect farmers' knowledge, evaluation and selection
5) New varieties and technologies are quickly adopted
6) Trials are direct and simple, clear and easy
7) Farmers contribute to the development and dissemination of practical technologies

5. Problems and Solutions

The main problem of FPR is the lack of an appropriate governmental organization and government support, which makes it difficult to do the FPR trials and obtain good data. The solution is to strengthen the links with government and other cooperators, keep long-term friendships and cooperation, stimulate their activity, simplify complicated technologies and conduct trials, after which simple and practical technologies are widely disseminated. In particular, the Chinese government has recognized the advantages of FPR and is now partly supporting this approach.

Generally, farmers are most interested in yield and income. FPR cassava farmers are mainly interested in improved varieties of high yield, and with drought and wind resistance because Hainan sometimes suffers from strong typhoons. Farmers have paid little attention to starch content, special fertilizers and vetiver grass barrier etc. because it is difficult for them to obtain direct economic benefits from these technologies. So, it is necessary to develop more profitable technologies that correspond to farmers' objectives and needs, and to demonstrate the effect on both yield and economic benefits. This requires improved skills in showing and explaining the experimental results and to let farmers draw their own conclusions and make their own selection of useful technologies.

In the future, the FPR project will concentrate on reducing costs, increasing yields and income, while maintaining sustainable production, in particular the conservation of sloping lands. It may be a good idea to develop contour barriers of multiple usage which will enhance farmer adoption.

We have made some successful attempts in above areas, and will try to do even better in the future.

CONCLUSIONS AND FUTURE PLAN

The FPR approach used for cassava in Hainan in collaboration with CIAT and other Asian countries is a successful extension methodology. At the same time, the FPR approach is now also being used for other crops. After having experienced some successes as well as failures during the past ten years we will try to develop this methodology further through various cooperations and through funding from both national and international sources. After that, we hope to expand the approach to other agricultural areas in China.

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THE FPR CASSAVA PROJECT IN GUANGXI PROVINCE OF CHINA

Tian Yinong and Li Jun[1]

INTRODUCTION

Guangxi province is located in the subtropics; the climate is warm in the summer and mildly cold in the winter with occasional frost; rainfall is quite good. The uplands account for more than 80% of the total land resources in the province, but many soils are too poor to grow crops like fruit trees, vegetables, maize, sugarcane, etc; however, they are reasonably good for cassava. Since the 1990s, Guangxi province has become the biggest cassava producing province, overtaking Guangdong province. The area and production of cassava is about 270,000 ha and 4,500,000 tonnes, respectively, accounting for about 70% of the national area and production. Moreover, Guangxi also has the largest cassava processing industry. There are now about 70 cassava starch factories and 20 ethanol factories which use cassava (fresh roots and dry chips) as raw materials. Every year about 500,000 tonnes of cassava starch and about 100,000 tonnes of ethanol are produced in the province, accounting for 70% and 80% of the national production, respectively. In recent years, the cassava industry of Guangxi has started to put more emphasis on further product development, which has resulted in the rapid development of the cassava industry, including the adoption of new technologies. The cassava processing industry is playing a more important role in the economic development in the province, both by increasing farmers' income and by paying more taxes to the government.

But we still face some problems in the cassava industry, such as:

1. Lack of good varieties and incorrect management in cassava cultivation

During the period from 1950 to about 1966, cassava yields were only around 4.5 t/ha, with the lowest yield of 1.7 t/ha in 1959. From 1966 to 1985 cassava yields varied from 4.9 t/ha to 8.1 t/ha. During the 1990s, cassava yields greatly improved, but were still less than 15 t/ha. There are two main reasons for this: one is a lack of suitable varieties being used. Since in Guangxi cassava is grown on many kinds of land and in different climates, different varieties are required that are adapted to different climates and land resources. At that time we had only two main varieties, SC201 and SC205; these still account for about 95% of the cassava planted area, which is far from optimum. The second one is poor management of cassava cultivation, including low inputs, simple land preparation, lack of weeding and other cultural practices.

2. Comparatively low value of the roots, unstable prices and low efficiency of land utilization if only cassava is grown

Most cassava was sold in the form of fresh roots or dry chips, so normally the income from cassava was not as high as from the other crops, like fruit trees, vegetables, maize, sugarcane, sisal etc. Moreover, cassava was normally cultivated on very poor land, and about 90% of cassava was planted in monoculture, while 10% was intercropped with

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watermelon, peanut, maize, beans, etc. This is the main reason why cassava produced little income. If farmers can do some intercropping in their cassava field during the first three months, they can not only get more income from these intercrops, but also increase the use-efficiency of their land. For instance, in the central part of Guangxi, those farmers that intercropped cassava with watermelon for seed had 5,000 RMB/ha more income than when cassava was grown in monoculture; in the southern part, intercropping with watermelon for seed produced nearly 10,000 RMB/ha more income than only from cassava. Of course, intercropping requires more inputs for fertilizer, irrigation, etc. and information about intercropping needs to be shared among farmers.

3. Serious soil erosion and rapid decrease of soil fertility

Most cassava in Guangxi is planted in the uplands and very little on flat land. The southern part of Guangxi, close to the sea, has a monsoon climate, so it receives a lot of rainfall which is concentrated in the five months of April, May, June, July and August. At this time cassava plants are still small, so the canopy of cassava is not yet completely closed, resulting in serious erosion. To reduce erosion, cassava should be intercropped or plants should be grown on contour ridges.

In general, considering the very limited land resources and the relatively poor economic conditions in rural areas, to develop the cassava industry and increase the income of farmers from cassava production, we need to do many things, like extending high yielding and high-starch cassava varieties, improving the efficiency of fertilization, protecting the soil from erosion and improving the management of the cultivation system.

Thus, in 1999, with support from the Nippon Foundation and some funding from the local governments of cities and counties, we started the Farmer Participatory Research (FPR) project in Guangxi province.

Project Objectives and Activities

The main objectives of the FPR project in Guangxi province are:

1. to extend new high yielding and high starch cassava varieties in rural areas
2. to extend better fertilization practices
3. to extend erosion control methodologies
4. to extend more efficient systems of cassava intercropping.

The main activities of the FPR project in Guangxi province are:

1. to select pilot sites for the project in the main cassava growing areas
2. to conduct problem diagnosis for cassava production with farmers
3. to identify the priority problems to be solved with the farmers
4. to establish a good cooperation between farmers and researchers that will best solve their problems
5. to provide technical support to farmers for improving their cassava production
6. to organize training courses in order to introduce the new cassava varieties and cultural practices and to share some publications with farmers.

The Farmer Participatory Research Methodology

The FPR approach in Guangxi included the following steps (**Figure 1**):

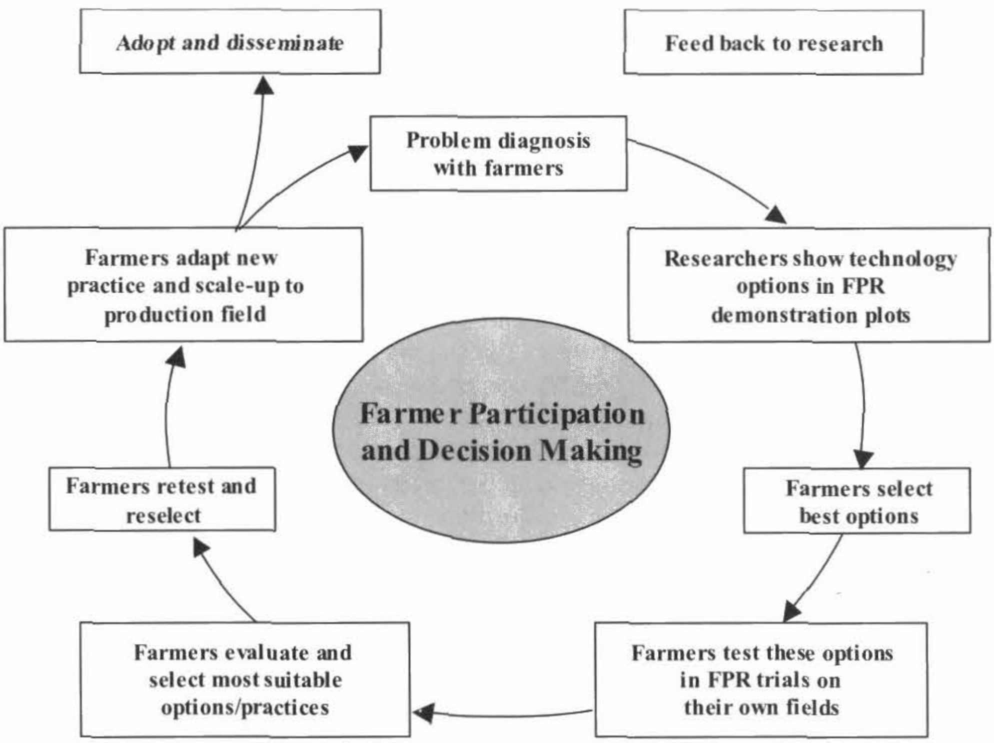

Figure 1. A schematic diagram of the FPR approach.

A. Problem diagnosis

This step is necessary to identify the main problems and to find possible solutions. From the problem diagnosis conducted in seven villages we see that the most important constraint in cassava production is low yield. Farmers ranked their priorities as follows: 1. High yielding varieties; 2. High starch varieties (because the factories like it); 3. Short duration varieties, and 4. Varieties that are easy to harvest. The others seems to be less important.

B. Conduct demonstration trials

Because new technologies spread slowly, we needed to do some trials to demonstrate mainly the new varieties, the importance of fertilization, erosion control and intercropping. Normally, in each village some innovating farmers were invited to do the demonstration trial. **Table 1** shows the results of three demonstration variety trials conducted in 2002.

Table 1. Results of a variety demonstration trial conducted in three sites in Guangxi province, *China in 2002.*

Variety	Wuming	Shanxu	Mingyang	**Average**	Ranking
SC201	-	61.60	24.72	**43.16**	11
SC205	-	58.33	41.82	**50.08**	4
SC5	36.26	25.83	54.54	**38.88**	16
ZM8639	45.52	53.33	52.04	**50.30**	3
ZM8803	46.06	41.67	45.10	**44.28**	10
ZM8316	44.94	-	53.20	**49.07**	6
SM1600	-	50.00	30.85	**40.43**	15
OMR36-31-1	53.00	54.85	39.58	**49.14**	5
OMR36-40-9	43.28	47.50	-	**45.39**	9
OMR36-34-4	28.85	-	55.20	**42.03**	12
CMR38-120-10	53.00	58.38	-	**55.69**	1
MBra 900	52.72	30.00	-	**41.36**	13
GR891	34.41	56.25	49.55	**46.74**	8
GR911	43.28	52.08	63.28	**52.88**	2
Nanzhi 199	38.00	-	43.35	**40.68**	14
Rayong 72	27.19	-	46.46	**36.63**	17
KU 50	56.63	41.25	-	**48.94**	7

C. Farmer evaluation and selection of best options from demonstration trials

Farmers select those options that they think will improve their production, first by observation (farmer trust their own eyes best); for instance, how is the germination, the growth, what is the resistance to drought, to pests etc. Then, by testing to determine the yield.

D. Farmers test the selected options in their own fields

Farmers conduct the FPR trials in their own field with or without help from the researchers. They conduct trials to test the options that they selected; some like to discuss these with researchers, while others don't. **Tables 2** and **3** show the number of sites and the number of different trials conducted, while **Tables 4** to **6** show some of the results.

Table 2 . Number of project sites and number of farmers who participated in the project in Guangxi province from 1999 to 2003.

	County	Village	Farmers
1999	1	1	5
2000	2	2	9
2001	2	2	32
2002	9	22	48
2003	10	18	120

Table 3. Number of each type of FPR trial conducted in farmers' fields and the number of training courses conducted in Guangxi from 1999 to 2003.

	1999	2000	2001	2002	2003	**Total**
Variety	2	4	7	12	15	**40**
Fertilizing	2	2	3	4	7	**18**
Intercropping		1	2	5	5	**13**
Erosion control	1	1	2	2	2	**8**
Training courses		2	3	8	10	**23**

Table 4. Results of an FPR fertilizer trial conducted by a farmer in Wu Xu town, Yong Ning county in 2002.

Variety	NPK treatment[1)]	Cassava yield (t/ha)			
					Average
SC 205	$N_3P_2K_1$	18.5	12.1	10.5	**13.7**
	$N_2P_1K_2$	15.9	13.7	11.1	**13.6**
	$N_3P_1K_3$	17.2	10.8	9.9	**12.6**
	$N_4P_1K_4$	19.1	14.3	10.2	**14.5**
	$N_2P_2K_2$	19.4	12.7	7.0	**13.0**
	N-P-K	17.5	8.0	11.1	**12.2**
Nanzhi 199	$N_3P_2K_1$	17.2	12.4	13.1	**14.2**
	$N_2P_1K_2$	19.7	12.1	10.2	**14.0**
	$N_3P_1K_3$	15.9	9.6	10.5	**12.0**
	$N_4P_1K_4$	16.2	11.8	8.0	**12.0**
	$N_2P_2K_2$	18.5	10.8	12.7	**14.0**
	N-P-K	17.2	10.2	10.2	**12.5**

[1)] N_1 = 140 kg N/ ha; P_1 = 140 kg P_2O_5/ha; K_1 = 160 kg K_2O/ha

N_2 = 280 kg N/ha; P_2 = 280 kg P_2O_5/ha; K_2 = 320 kg K_2O/ha

N_3 = 420 kg N/ha; K_3 = 480 kg K_2O/ha

N_4 = 560 kg N/ha; K_4 = 640 kg K_2O/ha

N-P-K = 375 kg/ha of compound fertilizer 15:15:15 = 56 kg N + 56 P_2O_5 + 56 K_2O/ha

Table 5. Effect of the use of plastic mulch on cassava yields (t/ha) in FPR trials conducted by three farmers in Qingle village , Taiping town ,Wuming county in 2003.

Treatments	Huang Yu	Huang Qun	Huang Meiying	**Average**
With plastic	36.2	33.2	30.2	**33.2**
Without plastic	34.4	31.7	29.7	**31.9**

Table 6. Effect of date of planting and the use of plastic mulch on cassava yields (t/ha) in an FPR trial conducted by a farmer in Tanluo town, Nanning city in 2002.

	Planted on March 27				Planted on April 7			
				Average				**Average**
With plastic	27.1	24.4	35.0	**28.8**	21.0	20.8	25.0	**22.3**
Without plastic	20.1	25.8	31.6	**25.8**	20.7	24.8	22.2	**22.6**

Note: plot area is 40 m^2, 50 plants; variety Nanzhi 199.

E. Farmer evaluation to select most suitable practices

Farmers evaluate the germination, growth, yield, whether or not it is easy to harvest, etc. and then they adopt those new options or practices that they think are most suitable for their own conditions. During the evaluation some comments may be required from researchers.

F. Farmers test again their selected options in a larger area

To get a better understanding of the new varieties and practices/methodologies they try them out on a larger area of their production field. They normally feed back their opinions to the researchers.

G. Extend the new technologies which have been tested and selected to other areas with similar conditions

After adoption farmers either give their planting materials to their neighbors, or share the results of their experiments with other farmers that live in the area. For people living in places far from the village, they sell the planting material to earn some money.

CONCLUSIONS

1. As a result of the implementation of the project, there are now more than 3,000 hectares of cassava planted with new promising varieties.
2. More and more farmers have adopted some new practices to improve their production, such as the use of plastic mulch to warm the soil and reduce weeding cost and erosion.
3. Cassava yields in the project sites have increased and farmers' income from cassava have also increased.
4. The FPR approach used in the project enhanced farmers' ability to make their own decisions, develop their own technologies and manage their own trials. Farmers have gained more self-confidence.
5. Through learning together and exchanging opinions, researchers and farmers established an equal partnership.

Experiences and Realizations

1. The flexible use of the participatory approach is the key to making the project successful
2. Effective organization is the key to success
3. Good support from local governments and technical agencies as well as from factories is very important

4. Researchers and government officials play a role as equal participants rather than being the main implementers
5. Get farmers to express their ideas freely
6. Farmer-to-farmer training is perhaps the most realistic way.

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ADOPTION OF NEW TECHNOLOGIES AND THEIR IMPACT ON CASSAVA PRODUCTION IN CHINA

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ABSTRACT

This paper mainly describes the situation of cassava production in China during the period when we conducted the FPR project, in cooperation with CIAT and supported by the Nippon Foundation of Japan.

The major constraints in cassava production in China were: a) lack of an effective organization and management system for developing cassava production; b) poor management resulting in low yield; and c) serious soil erosion and decline in soil fertility.

The recent increase in cassava yields can be attributed to the adoption of new technologies, especially that of improved varieties and good cultivation techniques. Cassava varietal improvement in China has focused on the following aspects: a) collection and introduction of cassava germplasm and establishment of a cassava germplasm bank for cross-breeding; b) establishing a national cassava trial network, forming an integrated breeding system of improved varieties, testing and demonstration, as well as extension of cassava; and c) multiplication and dissemination of improved varieties.

During 1993-2003, cassava agronomy research in China entered a new stage of development. Cassava agronomy in China placed major emphasis on fertility maintenance, erosion control, planting methods, time of planting and harvesting, etc. Compared with the traditional cultural practices, the adoption of improved practices in China mainly involved the use of more intensive production, better varieties, more fertilizer use, higher plant populations, better intercropping systems and the use of plastic film to cover the soil before planting. Some practices that are simple and highly profitable will be readily adopted by farmers, such as new high-yielding varieties. Also, controlling weeds by the use of herbicides was also widely adopted by farmers in Guangxi and Hainan provinces, because it reduces the labor needed for hand weeding.

On the other hand, erosion control practices are not readily adopted by farmers, because these generally require additional labor or investments without producing increases in yield or income in the short-term. The development of cassava-based products and improved market channels, as well as changes in government policy also affected the development of cassava production in China.

INTRODUCTION

In China, cassava can be cultivated in areas south of the Qinling mountains and Huaihe river, with mean annual temperatures above 18°C and a frost-free period of more than six months of the year. Therefore, there is a tremendous potential for further expansion of the cassava production area. Recently, the total cassava planted area in China is about 450,000 ha, with a total annual production of about 60 million tonnes of fresh roots. Cassava is mainly grown in Guangxi, Guangdong, Hainan and Yunnan provinces, and also in a limited area in the south of Fujian, Jiangxi and Sichuan provinces. Cassava processing and utilization have developed markedly in recent years, and the production of

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cassava-based products has increased from about 30 to 85%. The production of cassava has changed from being a scattered and backyard crop into one that is farmed intensively and grown mostly for industrial processing.

Unlike other tropical root and tuber crops, cassava has a high tolerance to drought and infertile soils. Having greater adaptability and more uses, cassava plays an increasingly more important role in upland farming, as well as in the utilization of land and labor resources. In China, cassava is an important economic crop for the uplands in both tropical and subtropical areas, and is one of the main sources of animal feed and raw material for the production of starch. It, therefore, has a major significance in the economics of the agricultural sector in certain parts of the country.

Cassava is the fifth most important crop in southern China, following rice, sweetpotato, sugarcane and maize. It is used mainly as animal feed and for starch manufacturing, which both play an important role in the upland agricultural economy. Cassava production makes full use of available land resources, especially in upland and hilly areas, as well as in marginal areas with poor soils. In recent years, cassava production and its economic value have increased due to the rapid development of the animal feed and starch industry, as well as to improvements in marketing channels for cassava products.

More and more attention has been paid to the release and planting of new varieties and the use of good cultivation technologies. From 1994 to 2003, considerable progress has been made in the adoption of new technologies of cassava in China, with CIAT's cooperation and supported by the Nippon Foundation of Japan.

MAJOR CONSTRAINTS IN CASSAVA PRODUCTION IN CHINA

1. Lack of an Effective Organization and Management System for Developing Cassava Production.

Due to the lack of interest in cassava by local governments and relevant agricultural authorities, there has been little coordination of cassava production, processing and marketing; instead, production and marketing was done mostly by the farmers themselves. Cassava technology transfer in China was carried out only by a few research institutes without any long-term budget from either the central or local governments. Moreover, there was no full-time personnel in the relevant departments of agriculture in charge of cassava demonstrations and variety release. Therefore, it was difficult to establish a stable long-term network of cassava technology transfer personnel, resulting in a lack of technical advice and training, and a slow release and adoption of advanced farming techniques and new cultivars.

2. Poor Crop Management Resulting in Low Yields.

New varieties have not yet been extended over a large area. Also, many good cultivation techniques have not yet been adopted by farmers. Most farmers are still not very concerned about obtaining high yields. Generally, the income of those farmers from cassava is not high, since their cassava planting area is small; therefore, they normally do not invest much in cassava production and don't care about the yield (Tian Yinong *et al.*, 2000).

3. Serious Soil Erosion and Decline in Soil Fertility.

In China, cassava is mainly planted on hillsides while flat and fertile land is used for other kinds of economic crops, like fruit trees. Cassava grown on sloping land without proper cultural practices can cause very serious erosion problems. Experimental data indicate that soil losses due to erosion caused by cassava planting on a 15% slope without any erosion control practices may be ten times higher than those obtained with good management practices.

WAYS TO INCREASE CASSAVA YIELDS

Cassava has been cultivated in China for over 180 years. Its production evolved from a small-scale backyard crop to large-scale commercial production; from a basic food crop to an upland cash crop used for animal feeding and industrial processing, while cropping systems gradually changed from predominantly monocropping to intercropping and crop rotations.

Before the 1950s cassava was grown by slash-and-burn cultivation or as a backyard crop. After the late 50s and in response to the call of the central government to make great efforts to develop agriculture, cassava was rapidly developed in south China, especially in Guangdong, Guangxi and Hainan provinces. For instance, from 1958 to 1964, cassava cultivation reached a peak with an annual growing area of about 500,000 ha. However, during the past two decades, the area under cassava production has been decreasing due to the development of highly intensive agriculture on flat land and a policy of reforestation in the mountainous areas. Therefore, it is very important to improve the extension of new cassava technologies so as to increase yields and the production value of cassava.

Cassava yields in China have increased rapidly in the last decade. This increase was mainly attributed to the increased use of improved cultivars and the adoption of good cultivation technologies, such as application of chemical fertilizers. Although higher yields can be obtained with fertilization, it may not always be profitable. Considering the fact that cassava is a low-value crop, only a limited amount of fertilizer can be applied economically. Therefore, adoption of new cassava varieties made probably the greatest contribution to increasing cassava yields.

1. Cassava Varietal Improvement in China

Cassava varietal improvement in China has historically been conducted by collecting and evaluating local varieties, introducing and testing of cassava germplasm, followed by cassava cross-breeding.

a) Collection and introduction of cassava germplasm and establishment of a cassava germplasm bank for cross-breeding

Over the years, China has introduced more than 60 accessions of cassava from CIAT/Colombia, the Thai-CIAT program or from other countries (**Table 1**) and a number of cross parents from CIAT's breeding materials have also been evaluated and are now being conserved. The cassava germplasm bank in China has been set up at CATAS, which presently has more than 200 accessions. Their major characteristics have been evaluated, and these are being documented and catalogued. Also, the genetic bankground of some cassava germplasm in China was studied using chromosome C-banding and RAPD techniques (Zeng, 2002). This fills in the gaps in the fields of cassava science and technology in China, forms the foundation for cassava breeding, and is a source of genetic diversity for selecting cross parents. From 1993 to 2002 the national cassava programs had produced more than 30,000 hybrid seeds from over 1,000 cross combinations, and had also evaluated 15,000 hybrid seeds from CIAT/Colombia and the Thai-CIAT breeding program.

Table 1. Foreign cassava germplasm introduced to CATAS from 1993 to 2002.

Accessions	Year of introduction	Origin	Utilization
MCub 32	1997	CIAT-Colombia	Propagation and testing
SG104-264	1997	CIAT-Colombia	Propagation and testing
MBra 900	1997	CIAT-Colombia	Propagation and testing
Rayong 60	1999	Rayong-Thailand	Propagation and testing
KU 50	1999	Rayong-Thailand	Propagation and testing
Rayong 72	1999	Rayong-Thailand	Propagation and testing
Rayong 90	2000	Rayong-Thailand	Propagation and testing
Rayong 5	2000	Rayong-Thailand	Propagation and testing
KM 94 (=KU 50)	2000	Vietnam	Propagation and testing
KM 98-1	2000	Vietnam	Propagation and testing
KM 98-5	2000	Vietnam	Propagation and testing
KM 98-6	2000	Vietnam	Propagation and testing
KM 99-6	2000	Vietnam	Propagation and testing
SM 1210-10	2001	CIAT-Colombia	Propagation and testing
CM 3555-6	2001	CIAT-Colombia	Propagation and testing
CM 837-3	2001	CIAT-Colombia	Propagation and testing
MCol 1505	2001	CIAT-Colombia	Propagation and testing
MBra 12	2001	CIAT-Colombia	Propagation and testing

b) Establishing a national cassava trial network, forming an integrated breeding system of improved varieties, testing and demonstration as well as extension of cassava

In China, a national cassava network has been set up, of which CATAS and GSCRI are mainly in charge of cassava science and technology research, such as cassava breeding, agronomic research and extension. Some representative experiment stations in Guangdong, Guangxi, Hainan and Yunnan provinces have been conducting regional trials and production tests. This forms the foundation of a new cassava technology transfer network in China.

c) Multiplication and dissemination of improved varieties

From 1993 to 2002, six improved varieties and breeding lines have been approved for release (**Tables 2** and **3**).

In 1994, two new improved varieties, SC 8002 and SC 8013, selected by CATAS, were released in south China. Of these, SC 8002 was mainly adopted in Guangdong province with an estimated planting area of about 10,000 ha, while SC 8013 was mainly adopted in the coastal regions of Hainan, Guangdong and Guangxi provinces with an estimated planting area of about 5,000 ha. Before 1999, SC 8013 was a major variety in those regions affected by typhoon, due to its good wind resistance. However, the planting area of SC 8013 has decreased in recent years due to the high fiber content of roots, which makes processing difficult.

Table 2. Performance of some new varieties in Regional Trials conducted in China in 2002.

	Fresh root yield (t/ha)									
	Guangxi		Hainan							
Variety	(1)[1)]	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
SC 205 (CK)	**36.33**	**58.33**	**23.25**	**41.37**	**24.06**	**26.88**	**22.37**		**12.50**	**30.00**
ZM 8639	45.52	53.33	28.75	39.06		25.68	52.60			50.00
GR 891	34.41	56.25								
KU 50	56.63	41.25				35.06				
GR 911	43.28	52.08								
SC 6		29.17	33.25	24.00			32.87	69.00	18.87	40.00
SC 201		61.67								

1) (1) Wuming county, Guangxi; (2) Shanxu county, Guangxi; (3) old Songtao village, Qiongzhong county, Hainan; (4) Lingtou factory, Quongzhong county, Hainan; (5) Nanlao village, Nankun town, Tunchang county, Hainan; (6) CATAS, Danzhou county, Hainan; (7) Qifang town, Baisha county, Hainan; (8) Yuanmen village, Baisha county, Hainan; (9) October Field farm, Changjiang county, Hainan; (10) Kongba village, Qi Fang town, Baisha county, Hainan.

Table 3. Yields of the new variety SC 5 as compared to the check variety SC 205 in five locations in Hainan and Guangxi provinces in 2002.

	Fresh root yield (t/ha)		
Places	SC 5	SC 205(CK)	Yield of SC 5 as % of SC 205
Tunchang, Hainan	81.25	24.06	337.7
Danzhou, Hainan	57.81	24.06	240.3
Qiongzhong, Hainan	27.50	23.25	118.3
Wuming, Guangxi	54.39	36.33	149.7
Shanxu, Guangxi	25.83	58.33	44.3
Average	**49.36**	**33.21**	**148.6**

In 1997 and 1998, another two new varieties with high yield and high starch content, named GR891 and GR911, selected from CIAT's breeding materials, were released by GSCRI. They were mainly adopted in Guangxi province with a total planting area of more than 3,000 ha.

In 2000, a cross made at CATAS between ZM 8625 and SC 8013, was selected by farmers in Kongba village from their FPR variety trials and released by CATAS as SC 5; this new variety is characterized by high yield and a high starch content, and is suitable for planting in mountainous areas.

In 2001, a Thai-CIAT material known as OMR 33-10-4 was similarly selected by farmers and released by CATAS as SC 6; it shows good performance in terms of high yield and high starch content, and also has good wind resistance.

All these new varieties have been released rapidly in China between 1999 and 2002, and the total planted area of these new varieties is now estimated at 80,000 ha, with an increased production of more than 1 million tonnes of fresh roots, resulting in added income of over 253 million Yuan RMB. (US$ 31 million).

d) Promising clones in the pipeline for further testing

From 1997 to 2002, 311 cross parents were introduced and/or produced in China, in the form of 11,888 true seeds, among which 60 cross parents from CIAT/Colombia and 16 from the Thai-CIAT breeding program. More than 10,000 F_1 seedlings were obtained. After a systemic evaluation and selection, many promising breeding lines have been identified, in addition to those improved varieties mentioned above. Of these, ZM 8639, CMR 38-120-10 and CMR 38-136-4 may soon be approved for release (**Tables 4, 5** and **6**).

Table 4. Yield characteristics of some promising clones at CATAS in 2000.

	Fresh root yield (t/ha)			Root dry matter content (%)		
Code of clones	Rep 1	Rep 2	Mean	Rep 1	Rep 2	Mean
SC 205			**20.5**			**35.3**
ZM 9710	30.4	31.1	30.8	39.8	40.1	40.0
ZM 9705	36.3	31.9	34.1	38.5	37.3	37.9
SM 2300-1	22.5	30.0	26.3	42.6	42.9	42.8
ZM 9605	27.9	31.3	29.6	37.3	36.8	37.1
CMR 38-136-4	29.6	37.7	33.7	40.6	41.2	40.9
SM 2323-6	29.6	25.4	27.5	39.1	37.3	38.2
CMR 38-120-10	32.1	39.0	35.6	38.1	37.9	38.0
ZM 96135	35.2	32.5	33.9	34.2	34.5	34.4
ZM 9690	32.9	27.9	30.4	36.9	36.0	36.5
ZM 9649	23.6	22.5	23.1	38.8	39.4	39.1

Table 5. Yield characteristics of some promising clones at CATAS in 2001.

	Fresh root yield (t/ha)					Root dry matter content (%)				
Code of clones	Rep1	Rep2	Rep3	Rep4	Mean	Rep1	Rep2	Rep3	Rep4	Mean
SC 205					**28.00**					**37.84**
ZM 98214	33.57	25.85			29.71	39.25	39.95			39.60
ZM 98246	29.61	32.53			31.07	42.64	41.03			41.84
MBra 900	30.86	33.57			32.22	35.12	31.97			33.55
KU 50	28.36	33.15			30.76	44.20	45.00			44.60
CMR 38-120-10	44.49	35.45	42.74	36.70	39.85	40.83	39.81	38.42	41.74	40.20
SC 5	30.73	26.69	26.69	23.77	26.97	39.28	37.50	36.51	38.85	38.04
ZM 9710	23.31	25.44	27.52	29.61	26.47	39.88	40.25	40.86	40.27	40.32
ZM 8641	30.07	27.94	26.27	30.02	28.58	40.03	40.17	42.08	39.35	40.41
ZM 8229	19.35	25.02	24.19	30.86	24.86	37.89	40.21	39.60	37.42	38.78

Table 6. Yield characteristics of some promising clones at CATAS in 2002.

	Fresh root yield (t/ha)					Root dry matter content (%)				
Code of clones	Rep1	Rep2	Rep3	Rep4	Mean	Rep1	Rep2	Rep3	Rep4	Mean
SC 205					**26.45**					**36.84**
ZM 98173	24.38	22.92			23.65	41.49	41.45			41.47
Rayong 90	27.71	15.83			21.77	42.17	45.46			43.82
ZM 98178	27.71	8.63			18.17	42.09	42.03			42.06
ZM 98214	32.54	18.54			25.54	38.80	34.41			36.61
KU 50	38.54	31.58			35.06	43.24	41.58			42.41
ZM 98246	31.67	23.54			27.60	35.07	31.41			33.24
ZM 96114	34.79	19.46			27.13	38.13	35.82			36.98
ZM 99229	26.25	32.08			29.17	37.75	38.39			38.07
ZM 9932	25.83	30.92			28.38	39.24	39.55			39.39
ZM 9936	29.17	33.50			31.33	40.75	41.90			41.33
ZM 99247	31.25	26.88			29.06	36.74	36.90			36.82
ZM 9710	18.83	31.13			24.98	39.36	40.84			40.10
ZM 9705	16.25	32.13			24.19	36.84	38.33			37.58
ZM 9605	26.25	26.63			26.44	34.99	35.90			35.44
ZM 9713	21.13	14.54			17.83	38.69	40.01			39.35
ZM 9781	27.29	30.83			29.06	40.45	41.61			41.03
ZM 8229	17.71	20.33	18.88	27.08	21.00	34.97	35.01	36.36	36.86	35.80
ZM 8639 = SC 7	20.50	32.42	25.63	24.17	25.68	32.54	33.69	32.13	33.61	32.99
CMR 38-136-4	19.92	34.67	33.33	27.38	28.82	40.56	41.09	40.16	39.66	40.37
CMR 38-120-10	25.00	37.71	30.21	28.13	30.26	37.82	37.65	38.39	36.31	37.54
SM 2300-1	22.08	26.04	22.71	28.92	24.94	43.20	44.38	44.80	34.21	41.65
ZM 8641	21.46	21.67	23.96	18.42	21.38	37.66	38.07	37.80	38.61	38.03
ZM 8803	26.46	24.42	26.04	30.96	26.97	33.89	34.82	34.84	35.91	34.86
CMR 38-136-1	26.88	23.75	27.08	31.63	27.33	39.76	40.56	39.18	40.60	40.02

e) Comparison of different sources of breeding materials

Evaluations and selections have been made at CATAS among three sources of hybrid materials, which included the locally generated seeds, the introduced seeds from CATAS/Colombia and those from the Thai-CIAT breeding program. Many high-yielding clones were identified from these three sources of seed materials, but the Thai-CIAT materials showed a clearly superior performance. The Thai-CIAT progenies gave the highest population mean (all entries from the same source in the trial) and the selection population mean (mean of all selected clones from the same sources) in terms of fresh yield and root dry matter content. It is therefore expected that the highest selection efficiency will be obtained from the Thai-CIAT hybrid seed material in comparison with the locally generated hybrid seeds or those from CIAT/Colombia.

From our experience we are convinced that it is impossible to make any major breakthrough in our breeding program by using only our native genetic resources. As such, the materials introduced from CIAT/Colombia or from the Thai-CIAT program, as well as the crosses made between introduced and local genetic materials are playing a very important role in cassava varietal improvement in China (**Table 7**).

Table 7. Comparison in yield parameters among clones of different origins in Advanced Yield Trials at CATAS, Hainan, China in 2000-2003.

Clones code	Origin		No. of clones	Average dry root yield (t/ha)	Average fresh root yield (t/ha)	Average root dry matter content (%)
CMR-OMR	Thai-CIAT	Total	9	10.96	27.90	39.28
		Those superior to SC 205	6	15.58	30.40	39.54
CM/SM	CIAT/Colombia	Total	5	7.65	20.27	37.76
		Those superior to SC 205	2	10.15	24.52	41.41
ZM	Local hybrids	Total	57	8.95	24.32	36.82
		Those superior to SC 205	22	10.35	26.98	38.37
SC205				9.16	24.98	36.66

f) Case studies of cassava varietal release

Case 1. Wuming county of Guangxi province

Wuming is the biggest cassava planting county in Guangxi province. Cassava is the third most important crop in this county, following rice and sugarcane. There are 39 cassava-based starch factories with an annual production capacity of 200,000 tonnes of starch. Of these, five factories also produce alcohol with a total annual capacity to produce 30,000 tonnes of industrial alcohol. In 2002, the harvested area of cassava in Wuming county was 15,146 ha, while the total production reached 377,100 tonnes of fresh roots. The production of cassava starch and alcohol were 130,000 tonnes and 10,800 tonnes, respectively. The annual output from cassava reached 360 million Yuan RMB (US$ 45 million) (including cassava production and processing)

The local government always paid much attention to cassava development in this county. Most farmers have changed their ideas about planting cassava, and they actively request new improved cassava technologies, especially new varieties and good cultivation techniques. So far, the new varieties, such as SC 5, GR 891, GR 911, Nanzhi 199 and SC 205 (introduced to this county in the last decade) are occupying more than 65% of the cassava planting area, and the yield increased substantially from 17.81 t/ha in 1995 to 24.90 t/ha in 2002 (**Table 8**). The average fresh root yield of 24.9 t/ha in Wuming county is about 10 t/ha higher than the average yield of less than 15.0 t/ha for the whole of Guangxi province. Many good cultivation techniques, such as intercropping, interplanting and covering the soil with plastic film (mulch) have also been adopted and are now recommended by farmers in this county.

Table 8. Past, present and expected future cassava production in Wuming county, Guangxi, China.

Year	Planted area (ha)	Fresh root yield (t/ha)	Production ('000 t)
1995	11,283	17.81	201.0
2000	14,083	22.80	321.1
2001	14,127	24.45	345.4
2002	15,145	24.90	377.1
2005	16,667	30.00 (expected)	500.0 (expected)
2008	20,000	37.50 (expected)	750.0 (expected)

Source: *Science and Technology Bureau of Wuming county, Guangxi, China.*

Case 2. Nankun town in Hainan province:

In Maling village of Nankun town, Tunchang county, Hainan province, more than 20 farmers have been better-off by planting new cassava varieties, mainly SC 5, since 2002. One farmer, named Li Zengde, harvested 1.3 ha of SC 5 with a total income of 14,000 Yuan RMB (about US$ 1,750); Li Zengwen received 9,000 Yuan (US$ 1,125) from harvesting 0.8 ha of new varieties. This greatly enhanced farmer's enthusiasm to plant the new variety and also helped the local officials to change their old concepts about planting cassava. The local government of Nankun town allocated 200,000 Yuan to the Nankun starch factory for it to organize planting materials of the new variety to distribute to the farmers. In 2003, the area planted to the new varieties was more than 50% of the total cassava planted area in the town. All farmers are very interested in accepting and trying to plant the new variety. It is estimated that the area of new varieties will reach more than 90% of the total cassava planted area of the town in 2004.

2. Cassava Agronomy Research and Adoption of Improved Practices in China

China has a very large population and limited land resources. Since farm land is quite limited and cassava is still a low-value crop, increasing cassava production can not be achieved by increasing the planted area to any great extent, but it must be done through increasing yields.

Besides releasing new varieties, better cultivation techniques, such as adequate fertilizer application, intercropping and interplanting, and better field management have also been gradually accepted by farmers recently.

a) Cassava agronomy research

From 1993 to 2003, in cooperation with CIAT, and supported by the Nippon Foundation of Japan, cassava agronomy research in China entered a new stage of development; many trials were conducted in Hainan, Guangxi, Guangdong and Yunnan provinces. This cassava agronomy research in China placed major emphasis on fertility maintenance, erosion control, planting methods, time of planting and harvesting etc. Long-term fertilization trials, conducted at CATAS, GSCRI and the Upland Crops Research Institute (UCRI) in Guangzhou, Guangdong province indicate that N was the most important nutrient for increasing cassava root yields during the early cropping cycles of cassava, but that K, and in some cases P, also became increasingly important. Results of soil erosion control trials conducted in Hainan and Guangxi provinces showed that contour ridging, intercropping with peanut or the planting of vetiver grass contour hedgerows were the most effective practices for reducing soil erosion when cassava was grown on slopes. Research on the effect of time of fertilizer application on cassava yield, conducted at CATAS, showed that a basal fertilizer application at 30 days after planting resulted in highest yields; there were no significant differences between a single application at 30 days and split applications at 30 and 60 days, or at 30, 60 and 90 days. The use of plastic film to cover the cassava fields is a new cultural method that has been recommended in China in recent years, especially in Guangxi province. Results of many of these experiments have been presented by Zhang Weite *et al.* (1998b) and Li Jun *et al.* (2001).

b) Adoption of improved agronomic practices

Due to the low profitability of cassava and the lack of recommendations for cultural practices in the past, farmers paid little attention to the cultivation of the crop. The recent expansion of cassava processing factories in China created greater demand for raw materials, resulting in an increase in the price of cassava roots. Farmers began to request information on new technologies and started to adopt some improved practices. Compared with the traditional cultural practices, the adoption of improved practices in China mainly involved the use of more intensive production, better varieties, more fertilizer use, higher plant populations, better intercropping systems, and the use of plastic film to cover the soil before planting. Some recommended practices, such as soil conservation and the optimum rate, time and method of fertilizer application, had a more limited impact on cassava yields while requiring additional labor or money; they were therefore difficult to be accepted by farmers and were rarely used to cultivate cassava on a large scale. But those practices which are simple and highly profitable will be readily adopted by farmers, such as new varieties. On the other hand, the use of herbicides to control weeds was widely adopted by farmers in Guangxi and Hainan provinces.

3. Development of Cassava-based Products

Due to the successful development of several cassava-based industrial products, like glucose, crystal glucose, esterified starch and hydroxyl-propyl starch, the demand for cassava has improved in recent years and many people have changed their ideas about cassava. The cassava planted area of China is expected to be maintained at its present level or to slightly increase. Even though the cassava planted area in Guangdong province has decreased a little, it is expected to increase in Yunnan and in some other parts of China, such as in Sichuan and Jiangxi provinces, while cassava root yields should increase substantially.

4. Policy Changes and Support of Cassava Projects

With the entry of China into the World Trade Organization (WTO), the government will attach more importance to research on cassava than ever before. After a long investigation, discussion and evaluation by a working group of experts, regarding the present situation and future potential of cassava in China, the Chinese central government has recognized that cassava production in China faces some difficulties but still has a bright future in the cassava-based industries. In recent years, the central government and many provincial governments have allocated some money to support cassava technology research, and the extension of new technologies. This policy change will markedly enhance the development of cassava production in China in the near future.

5. The FPR Approach as a Way to Enhance Adoption of New Technologies

The FPR project helped farmers to develop and then adopt many location-specific new cassava technologies in China. The FPR methodologies used offer a good approach to cassava technology transfer in China, i.e. to identify the needs of farmers and then help farmers to develop practical solutions to their problems; it offers a good communication platform for all participants.

6. Pilot Site's Contributions to the Extension of Improved Technologies

One of the pilot sites of the FPR project in Kongba village of Baisha county, Hainan province, was particularly successful. Many trials were conducted in this pilot site over the years. Many farmers, extensionists, officials and researchers visited those FPR trials and demonstration plots in farmers' own fields. They soon found out which practices or clones were the best to be tested in their own lands. So it was easy for them to adopt new technologies.

The annual planted area of improved cassava varieties in the village is about 133 ha, which occupied about 98% of the total harvested areas of cassava. During 2000-2002, more than 500 tonnes of planting material of new varieties were available for sale by those participants of the FPR project, and they made an added profit of 130,000 Yuan (US$ 16,000) from selling planting materials. It was a good way to promote the development of cassava production and an efficient way to propagate the new varieties for distribution to other cassava growing areas.

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22US81

FARMER PARTICIPATORY RESEARCH (FPR) AND EXTENSION (FPE) METHODOLOGIES USED IN THAILAND

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ABSTRACT

During the first phase (1994-1998) of the Nippon Foundation project on "Improving the Sustainability of Cassava-based Cropping Systems", two pilot sites were selected, namely Soeng Saang district, Nakhon Ratchasima province, and Wang Sombuun district, Sra Kaew province. Farmer Participatory Research (FPR) trials on methods to reduce soil erosion were conducted for three consecutive years. After narrowing down the number of suitable options, farmers in both sites finally selected and adopted the contour strip cropping of cassava with vetiver grass hedgerows. They also requested further support to extend the vetiver grass hedgerows on a larger scale to their cassava fields. In Soeng Saang district, farmers in Sapphong Phoot village got together to set up a Soil Conservation group. They agreed to plant vetiver grass hedgerows with a total length of 17 kilometers in the first year of 1998. Similarly, farmers in Wang Sombuun district planted vetiver grass hedgerows with a total length of about 10 kilometers. During the final year of the first phase, DOAE had extended the project to two other sites in Kalasin and Chachoengsao provinces.

At the end of the second phase of the project (1999-2003), a total of 33 villages in 21 districts, in 11 provinces had participated in the project. To be able to scale out to so many new sites, the project used and developed several Farmer Participatory Extension (FPE) methodologies, such as cross-visits, farmer evaluation of demonstration plots, FPR trials, training courses and field days. In addition, DOAE helped farmers in 21 sites to set up "Cassava Development Villages", i.e. community-based self-help groups that help each other to develop better cassava production practices and protect the natural resources in the community. The final result is that farmers in all villages adopted vetiver grass hedgerows as the most suitable system to reduce erosion. At the end of 2003, 865 farmers were participating in the project and the total length of the vetiver grass hedgerows had grown to 145 kilometers, covering 940 ha of cassava fields. In addition, farmers also adopted new cassava varieties, such as Rayong 5, Rayong 72, Rayong 90 and Kasetsart 50, and they are using more chemical fertilizers as well as animal manures. Recently, farmers have shown a new interest in trying out the use of green manures in their FPR trials; as a result of these trials they have now adopted the planting of *Canavalia ensiformis* as a green manure between cassava rows.

INTRODUCTION

Cassava can grow well even in low fertility soils and under low rainfall conditions. However, the rate of soil erosion in cassava fields is quite high, particularly in sandy soils with a low organic matter content. This is due to the wide plant spacing used and the slow growth of cassava during the first three months (Putthacharoen, 1992). Joint research between the Centro Internacional de Agricultura Tropical (CIAT), the Department of Agriculture (DOA), and Kasetsart University (KU) revealed that adjustments in planting methods or planting systems could markedly reduce soil erosion. At least 24 ways to reduce soil erosion were included in demonstration trials; for instance, intercropping with

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various field crops, such as maize, groundnut, mungbean, pumpkin and watermelon; the use of various chemical fertilizers, manures or green manures to stimulate early growth; or contour strip cropping with some grasses, such as ruzie grass, elephant grass, vetiver grass and lemon grass. Each method has its advantages and disadvantages. Some methods give extra income, but some need more management or more investment. The problem is still whether or not the farmers would adopt any of these methods. In 1994, CIAT, in cooperation with DOAE and DOA, started on-farm trials using Farmer Participatory Research (FPR) techniques. This methodology will enhance the farmers' awareness of soil erosion problems. This approach also encouraged farmers to decide for themselves which method of soil erosion protection is suitable and practical for their communities. The farmers conducted the trials by themselves under supervision of DOAE and DOA staff. Eventually, the farmers were the ones who selected the soil conservation method that was most suitable and efficient for them.

In the first phase of the FPR project (1994-1998), two pilot sites were selected, namely Soeng Saang district in Nakhon Ratchasima province, and Wang Sombuun district in Sra Kaew province. FPR trials on soil erosion control methods were conducted continuously for three years. Finally, the farmers in both sites chose and adopted the contour strip cropping with vetiver grass. They also requested further support to extend the vetiver contour hedgerows on a larger scale of their cassava fields. In Sapphong Phoot village of Soeng Saang district, the farmers decided to form a group for soil and environmental conservation. They agreed to plant vetiver grass in contour hedgerows for a total length of 17 km in the first year, 1998. Similarly, farmers in Wang Sombuun district planted vetiver grass hedgerows totaling about 10 kilometers. In the final year of the first phase, DOAE extended the project to two additional sites in Kalasin and Chachoengsao provinces.

In the second phase (1999-2003), 33 villages in 21 districts in 11 provinces participated in the Project. This promoted the learning and understanding of soil and water conservation by more officers and farmers. The implementation still followed the farmer participatory research approach but added more extension activities.

THE FARMER PARTICIPATORY RESEARCH (FPR) AND EXTENSION (FPE) PROJECT

1. Objectives

1. To make cassava growers aware of the importance of soil conservation and the need to reduce soil erosion, and to encourage direct farmer participation in decision making and in the selection of suitable soil conservation practices.
2. To scale-up the adoption of selected methods to more farmers and over a wider area.

2. Responsible Organizations

Table 1 shows the responsibilities and activities conducted by the six institutions involved in the second phase of the FPR project in Thailand.

Table 1. Institutions collaborating in the second phase of the Nippon Foundation Cassava Project in Thailand, and their main activities and responsibilities.

Organization	Responsibility/Activity
Centro Internacional de Agricultura Tropical (CIAT)	-Provide budget -Staff training and workshops -Monitoring and evaluation
Department of Agricultural Extension (DOAE)	-Facilitate project activities in the villages -Organize farmers meetings (using farmer participatory methods) -Provide budget -Training/lectures -Monitoring and evaluation
Department of Agriculture (DOA)	-Support technical knowledge -Conduct demonstration trials and take part in field trials -Take part in monitoring and evaluation -Training/lecturers
Land Development Department (LDD)	-Support knowledge on vetiver grass growing and the use of green manures -Provide vetiver tillers and green manure seeds -Survey and set out contour lines for vetiver strips -Take part in monitoring and evaluation
Thai Tapioca Development Institute (TTDI)	-Conduct demonstration trials -Training/lectures -Provide training facilities -Take part in monitoring and evaluation
Kasetsart University	-Conduct research on effective and suitable soil conservation practices -Conduct demonstration trials

3. Farmer Participatory Research (FPR) and *Extension* (FPE) Activities

This process consisted of the following steps:

1. Select pilot sites and conduct RRAs
2. Conduct demonstration plots
3. Organize cross-site visits
4. Conduct FPR trials with farmers
5. Training
6. Farmer meetings
7. Field days

8. Establish community-based self-help groups
9. Media productions
10. Additional activities

1. Select pilot sites and conduct Rapid Rural Appraisals (RRAs)

The criteria for selection of project sites were:

- Cassava is the main crop in the area, it is grown on slopes and soil erosion is a serious problem
- Farmers and extensionists must be eager to work together to solve various problems.

After a preliminary selection of suitable sites the agro- and socio-economic conditions of these potential sites were further explored by conducting Rapid Rural Appraisals (RRAs) in every site. The problems of cassava production were also discussed with the farmers.

2. Install demonstration plots

Demonstration plots showing many options to control erosion were laid out in different research centers as well as on some farmers' fields. Farmers from every new pilot site came to visit these demonstration plots, to evaluate the treatments and discuss and select the most suitable practices to control erosion.

3. Organize farmers' meetings and cross-site visits

Farmers' meetings were held in the selected villages to discuss the objectives, principles and procedures of the project. Ways to improve their soil's fertility by the use of animal or green manures or chemical fertilizers were also discussed. The farmers then discussed and decided for themselves whether or not they wanted to participate in the project. In case farmers were not interested, the project would look for other sites.

Farmers who wanted to participate in the project were invited to join the study tour to observe the demonstration plots on soil erosion control methods as described above. After this, farmers from a new site would visit an "older" site, either Sapphong Phoot village in Nakhon Ratchasima province, or the farmers group of Khlong Ruam village in Sra Kaew province. Farmers in both these sites had already adopted the planting of vetiver grass contour hedgerows. This was an opportunity to exchange experiences between the visitors and the hosts. The idea of establishing a village credit fund and the administration of this fund were also discussed.

At the end of the study tour, farmers were asked whether they were interested in either conducting their own FPR trials on various topics, including erosion control, or to adopt any of the observed soil erosion control practices right away. In most cases, farmers preferred to adopt the planting of vetiver grass hedgerows, because they had already observed the efficiency of these hedgerows for soil erosion control under farming conditions.

4. Conduct FPR trials on ways to increase cassava yields

In case farmers wanted to conduct their own FPR trails, they were provided with some extra inputs, such as seeds of intercrops, seeds or tillers of hedgerow species, plastic sheets to cover the sediment collection ditches, and they were reimbursed for the cost of digging the ditches. Officials from DOA and DOAE helped farmers lay out the field trials. Alternatively, if farmers wanted to adopt the planting of vetiver grass hedgerows, they would receive the necessary vetiver slips and help from LDD in setting out contour lines.

Usually, DOAE staff would suggest farmers to conduct additional FPR trials on new cassava varieties, chemical and organic fertilizers, or green manures. These trials provided farmers with information on how to increase cassava production efficiency and also helped to stimulate their interest in participating in the project.

5. Training of staff

Training workshops were organized by CIAT to train the project staff of the three departments, namely DOA, DOAE, and LDD in both the central and regional offices, in the use of farmer participatory research and extension methodologies. Furthermore, CIAT provided additional training of the main trainers by sending them to courses abroad.

6. Technology transfer through Farmer Participatory Extension (FPE)

In order to transfer technologies with farmers' participation, a budget was allocated to support 4-6 farmers' meetings annually. The topics included discussion on project implementation and the possible solutions for both project management and crop production. The local extension agents acted as coordinators to invite the experts or lecturers from outside according to the farmers' needs.

7. Field days

The project organized three levels of farmer field days:

7.1 *Village level.* This was the harvesting field day. After the trial plots were harvested, all data were recorded and the results were analyzed together with the farmers. In this way, the farmers learned and obtained information to make decisions about which technologies were most suitable for their village conditions. They then discussed and planned for action in the following year.

7.2 *District level.* The purpose of these field days was to disseminate the technologies selected from FPR trials to nearby villages and sub-districts. On the field day, the farmers shared their knowledge with other farmers. Staff from DOA, DOAE and LDD also discussed how to increase cassava yields, increase soil fertility by planting green manures, and to control erosion by planting contour strips of vetiver grass. These field days took place in the project village so that farmers would be able to study the real situation. This technique was quite effective as the visiting farmers were interested in duplicating the practices of soil erosion control in their own areas.

7.3 *Provincial level.* At this level, approximately 1,000-1,500 farmers and officials from nearby provinces were invited to visit the field day. Farmers of the host village presented the results of their FPR trials to the visiting farmers and officials. Reporters from newspapers and television stations were also invited in order to report the project activities through the wider mass media.

8. Media production

In order to disseminate the project activities and information to a larger audience, a video showing how to operate development work through farmers' participation was produced and distributed to many provincial offices and agencies. The Office of the Royal

Development Projects Board also supported the Project by providing a booklet series, "The Factual Tips about Vetiver", for distribution to the farmers who participated in the project.

9. Additional Activities

The following additional activities were organized:

9.1 Training course for making handicrafts from vetiver leaves: The training course was aimed at offering a choice to generate income from vetiver grass leaves. So far, the farmers from three villages: Sapphong Phoot village in Soeng Saang district, Khut Dook village in Daan Khun Thot district of Nakhon Ratchasima province, and Huai Suea Ten village in Sahatsakhan district of Kalasin province were trained. The trainers of the courses were provided by the Department of Industrial Promotion.

9.2 Setting up Cassava Development Villages: Since the year 2000, DOAE has adjusted the project implementation by setting up the so-called "Cassava Development Villages". The farmers in the target villages were trained to have more knowledge and be able to develop a clear understanding of the benefits and the need to conserve soil resources for generating higher yields. The planting of vetiver grass hedgerows across the slope and the use of green manures to increase soil fertility were discussed. DOAE provided the farmers with planting material of good varieties of cassava, chemical fertilizer, and vetiver slips on condition that they return the value of these materials to the village-revolving fund after the harvest. The rate of interest charged was agreed upon among the villagers themselves. Futhermore, the members voted to elect the "Fund Administration Committee", which comprised a chairman, a vice-chairman, a treasurer, and a secretary as the minimum number. Rules and regulations were defined according to the members' resolution.

FINAL RESULTS AND DISCUSSION

The implementation of the FPR Cassava Project over the past ten years has had a great impact on the farmers' awareness of the importance of soil erosion prevention. After testing various options to reduce soil loss by erosion they selected the planting of vetiver grass hedgerows across the slope as the most suitable and effective erosion control practice. Presently, this practice has been adopted in 20 villages located in nine provinces. Altogether, 866 farmers participated in planting vetiver hedgerows with a total length of 145 km in their cassava fields, using a total of 1.6 million vetiver slips. Furthermore, farmers in a few villages adopted the planting of *Canavalia ensiformis* (jack bean) as a green manure. In addition, 21 "Cassava Development Villages' were established. At present, members of these farmers' groups have access to a revolving fund, which range in size from Baht 40,000 to 380,000 per group, with a total of Baht 1,745,922, to be used for the development of these communities **(Table 5).** The establishment of these groups is a way to strengthen rural communities in the future. Besides, DOAE tries to make use of the project sites for field visits by farmers from nearby villages, sub-districts, districts and provinces in order to encourage further scaling-up of the project results.

Table 5. Location of pilot sites for the project "Enahancing the Adoption of Soil Erosion Control Practices in Cassva Fields", the extent of adoption of vetiver grass *hedgerows, and the status of the village revolving credit funds at the end of 2003.*

Province	District	Subdistrict	Village	No. of farmers	Cassava area (rai)[1]	No. of vetiver plants	Length hedgerows (km)	Credit fund (baht)
1. Kalasin	Mueang	Phuu Po	Noon Sawan }	61	306	85,500	8.6	40,000
2.		Khamin	Khamplaafaa }	-	-	-	-	-
3.	Nongkungsri	Nong Bua	Khamsri	67	690	111,600	11.2	85,850
4.	Sahatsakhan	Noonburi	Noon Sawaat	63	370	86,170	8.6	75,000
5.		Noon Nankliang	Huay Suea Ten }	42	254	128,330	12.8	141,180
6.			Paa Kluay }	-	-	-	-	-
7.	Naamon	Naamon	Noon Thiang	50	150	200,000	20.0	31,500
8.	Huay Phueng	Nikhom	Huay Faa	65	150	40,000	4.0	50,300
9.	Don Chaan	Dong Phayung	Noon Kokchik	58	150	55,000	5.5	55,000
10. Roy Et	Phoochai	Kham Pha-ung	Phuu Khaw Thong	30	18	2,000	0	0
11. Kamphaengphet	Khanuwaralakburi	Bo Tham	*Siiyaek-Ton Thoo*	42	170	68,000	3.0	126,193
12. Chayaphum	Thepsathit	Naayaang Klak	Khook Anu	42	170	68,000	4.0	126,400
15. Nakhon Ratchasima	Thepharak	Bueng Prue	3 and 6	26	214	80,000	11.0	54,000
17.	Daan Khun Thot	Baan Kaw	Khut Dook	53	309	130,000	15.0	132,000
18.	Soeng Saang	Noon Sombuun	Sapphong Phoot	60	828	80,000	10.0	73,300
19.		Sra Takhian	Sra Takhian	0	30	20,000	2.0	0
20.	Khonburi	Tabaekbaan	Nong Phak Rai	27	150	50,000	0.0	20,000
21. Prachinburi	Naadii	Kaeng Dinso	Aang Thong }	42	170	60,000	4.5	84,800
22.			Khaw Khaat }	-	-	-	-	-
23. Chachoengsao	Sanaam Chaykhet	Thung Phraya	Thaa Chiwit May	40	45	50,000	2.0	101,900
24.	Thaa Takiab	Khlong Takraw	Nong Yai	42	170	100,000	5.3	108,500
27. Sra Kaew	Wang Sombuun	Wang Sombuun	Khlong Ruam	42	1380	90,000	9.0	380,000
28. Chonburi	Bo Thong	Kaset Suwan	Thammarat+6 others	60	15	30,000	3.0	0
31. Ratchaburi	Baan Poong	Khaw Khalung	Poong Yo	42	20	0	0	0
32. Kanchanaburi	Law Khwan	Thung Krabam	Nong Kae	42	170	80,000	3.0	60,000
33.	Say Yook	Say Yook	Dauw Dueng	42	20	20,000	2.0	0
Total 11	**21**	**24**	**33**	**1,038**	**5,896**	**1,634,600**	**145**	**1,745,922**

1 ha = 6.25 rai

LESSONS LEARNED

The following lessons have been learned from the project:

1. The implementation of a project that has as its objective to conserve soil, water and the environment, must involve the people of the whole community, or at least, it must start with some parts of the community that participate in the project. The villagers must be aware of the seriousness of the problems that need to be solved by sharing their opinions and by making decisions together.
2. The technologies offered to the farmers must have a direct positive effect on yield and must be adapted to their way of life. For example, the adoption of vetiver grass hedgerows to control erosion and intercropping cassava with jack bean as a green manure is likely to improve soil fertility, which in turn may result in increased cassava yields.
3. The duration of a project is also another significant factor for its success, because the soil erosion problem does not have an immediate impact on the daily lives of the farmers. Thus, farmers need some time to become aware of the problem, to test several treatments and to confirm the results before they decide to adopt soil conservation practices. In this case, the project was able to continue for at least ten years.
4. Agricultural extensionists need to change their role, from recommending certain practices to being a facilitator, to encourage members of the community to participate in analyzing their problems and searching for solutions. In many cases, they can act as the coordinator to seek help and knowledge from outside. Nevertheless, the needs must be identified by the community.
5. Some incentives or subsidies of some production inputs are necessary, particularly for the conducting of field trials, to provide vetiver slips and to help set out contour lines after farmers have decided to adopt the use of vetiver grass contour hedgerow planting.
6. Farmers should be given freedom to select and modify the soil erosion prevention treatments to be tried on their own field. For example, they can test the use of other grasses or other crops as contour hedgerows, such as sugarcane for chewing or upland rice.
7. The forming of farmers' self-help groups will provide opportunities for members of the community to express their opinions and find the best ways for future development. Support from outsiders in terms of supplying planting materials, fertilizer, seeds, etc., with the condition that the users of the inputs return these to start the village revolving funds, may be a way of strengthening their development.

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THE USE OF A FARMER PARTICIPATORY APPROACH IN CASSAVA TECHNOLOGY TRANSFER IN THAILAND

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ABSTRACT

The Thai Tapioca Development Institute (TTDI) was establish at the end of 1993 with the main objective to transfer technologies to improve the cassava cultivation systems used by Thai farmers through the multiplication and distribution of planting material of high-yielding cassava varieties, and by conducting demonstrations and training programs (Charae Chutharatkul, 2008).

Since 1993 several new cassava varieties have been released, such as Rayong 5, Kasetsart 50 and Rayong 72. Between 1995 and 2001 TTDI has trained more than 30,000 farmers and farmers' leaders, and distributed 40 million stems of new varieties to the farmers. Although the training program used one-way technology transfer methods, farmers adopted some of the new technologies, mostly the planting of new varieties.

From Jan 17 to 21, 2000, CIAT organized a training-of-trainers course on farmer participatory research (FPR) for researchers an extensionists in Thailand. The training program on FPR encouraged a new attitude and the use of new methodologies for Thai researchers. Six researchers from TTDI participated in this training program.

From 2002 to 2003 TTDI trained 465 farmers' leaders from 21 provinces of Thailand who had planted cassava. TTDI adopted a new way of training using FPR methodologies with farmers' leaders, such as brainstorming with cards, problem diagnosis, demonstration of new varieties, erosion control, etc.

After training farmers adopted new technologies by themselves. Researchers also changed their attitude and instead of using a one way technology transfer they adopted a two-way "bottom-up" approach. Especially after researchers conducted a problem diagnosis with farmers using these FPR methodologies farmers had more activities to concentrate on their own problems.

Furthermore, TTDI started a new project to transfer new technologies to farmers by joining together with farmers on their farms in order to multiply and distribute new varieties and new cassava planting systems, to reduce production costs and increase cassava root yields and starch contents. This new project will use a farmer participatory research approach and use various FPR methodologies.

INTRODUCTION

The original TTDI farmer training program conducted from 1993 to 2001 covered the following topics: recently released cassava varieties, land preparation, planting systems, soil improvement and erosion control, and marketing aspects. More than 30,000 farmers participated in these 2-day training courses. In addition, from 2002 to 2003 TTDI trained 465 farmers' leaders to improve farmers' technologies for cassava cultivation in order to increase cassava yields and starch contents, and transferred effective technologies to

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control erosion. The training program was free of charge and included transport from their homes in 21 provinces in Thailand to TTDI's research station located in Huay Bong, Dan Khun Thod, Nakhon Ratchasima. Farmers' leaders received training in five separate groups between November 8, 2002 and August 16, 2003 on the topic "How to increase cassava yields to 31 tonnes/hectare (5 tonnes/rai). During the training many FPR methodologies were used such as problem diagnosis. Field problems experienced by farmers in cassava production were studied and discussed. Farmers participated actively in the problem diagnosis.

RESULTS AND DISCUSSION

The farmers who participated in this training project are farmers' leaders from many parts of Thailand (**Table 1**). These cover almost all cassava planting areas except some from the Eastern part of Thailand, such as Chonburi, Rayong, Chanthaburi, Chachoengsoa and Srakeaw which are also important cassava areas. All the farmers' leaders who participated in this training had previously participated in the basic courses on cassava cultivation conducted by TTDI from 1993 to 2001, and had already received planting material of new varieties such as KU 50 or Rayong 5 from TTDI.

Table 1. Number and origin of farmers' leaders participating in the FPR training courses in 2002 and 2003.

	Number of farmers' in each group					
Province	Group 1	Group 2	Group 3	Group 4	Group 5	Total
Nakhon Ratchasima	62	18	28	-	-	108
Chayaphum	13	12	-	-	-	25
Buriram	-	9	2	-	-	11
Kalasin	-	-	56	-	-	56
Khon Kaen	-	-	14	-	-	14
Mahasarakham	-	-	2	-	-	2
UdonThani	-	-	-	24	-	24
Loei	-	-	-	12	-	12
Nong Bua Lamphu	-	-	-	10	-	10
Sakhon Nakhon	-	-	-	9	-	9
Nakhon Sawan	-	18	-	-	7	25
Kamphaengphet	-	-	12	-	52	64
Pitsanulook	-	-	-	-	18	18
Utaradit	-	-	-	-	31	31
Uthai Thani	-	-	-	-	12	12
Ratchaburi	-	-	-	-	10	10
Kanchanaburi	-	-	-	-	8	8
Suphanburi	-	-	-	-	5	5
Chainat	-	-	-	-	10	10
Lopburi	-	10	-	-	-	10
Prachinburi	-	1	-	-	-	1
Total	**75**	**68**	**114**	**55**	**153**	**465**

The FPR training program used various participatory methodologies such as problem diagnosis. The farmers were asked to identify and prioritize their problems. This information can be useful for researchers so they can focus their research on the real needs of the farmers.

The relative importance of each of the cassava cultivation problems are shown in **Table 2**. The first group of farmers came from Nakhon Ratchasima and Chayaphum. For these farmers the main problem was lack of capital, the deterioration of soil fertility and soil compaction. These problems received scores of 35.48, 24.58 and 22.73%, respectively.

Table 2. Results of farmer participatory problem diagnosis using brainstorming with cards to identify the problems, followed by a matrix ranking[1)] of these problems by five different groups of farmers from various parts of Thailand.

	Matrix ranging (%)					
Field problems for cassava production	Group 1	Group 2	Group 3	Group 4	Group 5	**Average**
1. Deterioration of soil fertility	24.58	21.18	34.77	32.80	45.26	**31.72**
2. Diseases and insect pests	3.10	24.39	13.77	21.23	10.11	**14.52**
3. Lack of capital	35.48	8.82	1.36	4.27	-	**9.99**
4. Lack of know-how	1.92	8.02	9.09	14.89	14.81	**9.75**
5. Lack of new varieties	4.69	12.19	12.75	3.01	5.05	**7.54**
6. Soil compaction	22.73	-	-	-	-	**4.55**
7. Lack of rain	5.03	3.37	9.09	5.86	1.10	**4.89**
8. Weeds	-	11.07	5.61	5.54	-	**4.44**
9. Lack of organic materials for soil improvement	2.43	5.54	2.38	12.36	-	**4.54**
10. Soil erosion	-	1.28	-	-	11.40	**2.54**
11. Lack of government support	-	-	-	-	8.64	**1.73**
12. Low land potential	-	-	3.99	-	3.58	**1.51**
13. Low price of cassava	-	4.17	3.48	-	-	**1.53**
14. Chemical fertilizer of poor quality	-	-	3.65	-	-	**0.73**

[1)] Each group of farmers received the same number of beans to distribute among the various problems previously identified, to indicate their relative importance.
Source: *Chareinsuk Rojanaridpiched, 2004.*

The second group of farmers came from Nakhon Ratchasima, Chayaphum, Buriram, Nakhon Sawan and Lopburi. The most important problems for this groups are diseases and insect pests followed by the deterioration of soil fertility and lack of new varieties. These problems received score of 24.39, 21.18 and 12.19%, respectively.

The third group came from Nakhon Ratchasima, Kalasin, Khon Kaen, Mahasarakharm and Kamphaengpet. The main problems identified by this group are almost the same as those of the second group, starting from the deterioration of soil fertility, diseases and insect pests and lack of new varieties. These received scores of 34.77, 13.77 and 12.75%, respectively.

The 4th group came from the Northeast of Thailand, mainly from Udon Thani, Loei, Nong Bua Lamphu and Sakhon Nakhon. The main problems for this group are the deterioration of soil fertility, diseases and insect pests and lack of know-how about good cultivation methods. These received scores of 32.8, 21.23 and 14.89%, respectively.

The 5th group came from Nakhon Sawan, Kamphaengpet, Pitsanulook, Utaradit, Uthai Thani, Ratchaburi, Kanchanaburi, Suphanburi and Chainat. The most important problems for this group are deterioration of soil fertility, lack of know-how for good cultivation methods and soil loss by erosion. These problems received score of 45.26, 14.81 and 11.40%, respectively.

CONCLUSIONS

FPR is an effective methodology to transfer technologies to farmers. Farmers had more understanding and a good interaction with researchers. Also, farmers were more interested to learn new things than before. Especially when researchers would like to quantify their observations about something, they can use various FPR methodologies to learn about farmers' opinions. In a Rapid Rural Appraisal (RRA) the questions need to be clear as farmers are sometimes afraid to speak out.

Finally, this report indicates the most important problems of cassava field production as perceived by the farmers. The results show that the main problems are the deterioration of soil fertility, diseases and insect pests, lack of capital, lack of know-how and lack of new varieties; of secondary importance are soil erosion, the low price of cassava etc. Cassava researchers and extensionists of the government or the private sector need to improve farmers' know-how and try to solve farmers' problems in order to increase the sustainability of cassava production in Thailand.

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ADOPTION OF NEW TECHNOLOGIES AND THEIR IMPACT ON CASSAVA PRODUCTION IN THAILAND

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ABSTRACT

During the first 2-3 months after cassava planting, the rate of canopy establishment is rather slow. As such, part of the soil remains exposed to the direct impact of rainfall which can cause serious erosion. Complete canopy cover in a cassava crop takes a rather long time, normally 3-4 months. If farmers do not apply much fertilizers to cassava, soil fertility may decline while plant nutrients in the soil may be lost due to erosion when the crop is grown on slopes. Although nutrient extraction and removal by cassava tends to be less compared with many other crops, soil loss due to erosion may be higher because of the crop's slow initial development. Past research has shown that fertilizer application, reduced tillage, contour ridging, mulching, intercropping and the planting of contour hedgerows can greatly reduce erosion, Nevertheless, farmers seldom adopt such soil conservation practices, mainly because the recommended practices are not suitable for the local conditions, they may be too costly or require too much labor, or they may be ineffective. Moreover, farmers are not aware of the amount of soil lost by erosion.

The farmer participatory research (FPR) cassava project, conducted over the past ten years in more than 30 pilot sites in Thailand, shows that farmers can make their own decisions, and that they are willing to adopt new technologies, such as new cassava varieties, improved fertilization, use of animal or green manure, and herbicides, especially when the use of these practices lead to a higher net income. The FPR erosion control trials showed farmers that the planting of contour hedgerows of vetiver grass, or other grasses or legumes, was very effective in reducing erosion. The use of a farmer participatory approach was very effective in developing more suitable varieties and production practices, which farmers could readily adopt and then disseminate to other farmers in neighboring communities. The widespread adoption of new varieties and improved agronomic practices, including soil conservation, has resulted in marked increases in cassava yields in Thailand over the past ten years. The additional gross income of farmers due to the increased yields obtained today as compared to those in 1994, is estimated to be about US$147 million annually.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is usually grown by smallholders in upland areas on poor soil with low or unpredictable rainfall. In the northeastern and eastern regions of Thailand, cassava is grown on almost flat or slightly undulating terrain. But due to the very light texture of the soil and the very low levels of soil organic matter (OM), soil erosion can still be very serious. Since most cassava farmers are poor, they tend not to apply sufficient fertilizers to cassava; this can lead to a decline in soil fertility and low yields, and this further exacerbates soil erosion. Past research by Kasetsart University in Thailand, has shown that cassava cultivation caused twice as much soil erosion as

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[3] CIAT, Cassava Office for Asia, Dept. of Agriculture, Chatuchak, Bangkok, 10900 Thailand.

mungbean, and three times as much as maize, sorghum and peanut (Puttacharoen *et al.*, 1998) grown during the same 4-year period.

Research on erosion control practices indicates that soil losses due to erosion can be markedly reduced by various agronomic practices combined with simple soil conservation practices, including agronomic practices such as minimum or zero tillage, mulching, contour ridging, intercropping, fertilizer or manure application, and closer plant spacing. Soil conservation practices include terracing, hillside ditches and planting contour hedgerows of grasses or legumes. Unfortunately, farmers seldom adopt such soil conservation measures because they may not be appropriate for the specific circumstances of the farmers, either from an agronomic or a socio-economic standpoint (Howeler, 2001).

Since 1994, the Nippon Foundation in Tokyo, Japan has supported the project "Integrated Cassava–based Cropping Systems in Asia: Farming Practices to Enhance Sustainability." This project has developed and used farmer participatory research (FPR) and extension (FPE) methodologies.

MATERIALS AND METHODS

Project Sites

***First Phase* (1994-1998)**

To implement the project, cassava growing areas were selected that had at least 5% slope and where the farmers and local extension personnel were enthusiastic and willing to collaborate. Rapid Rural Appraisals (RRAs) were conducted in each area to obtain baseline information and to select the most suitable pilot sites (Howeler, 2001; Vongkasem *et al.*, 1998; Watananonta *et al.*, 2002). The project initially worked in only two sites (villages), one in Soeng Saang district of Nakhon Ratchasima province, and one in Wang Nam Yen district in Sra Kaew province. In 1998 this was extended to another two sites, one in Sahatsakhan district of Kalasin province and one in Sanaam Chaikhet district of Chachoengsao province.

***Second Phase* (1999–2003)**

During the 2nd phase the project expanded rapidly to include over 33 sites in the following eleven provinces :

1. Nakhon Ratchasima province in the lower Northeast region
2. Kalasin province in the upper Northeast region
3. Prachinburi province in the Eastern region
4. Chachoengsao province in the Eastern region
5. Chaiyaphum province in the Northeast region
6. Kamphaengpet province in the lower Northern region
7. Kanchanaburi province in the Western region
8. Roi-Et province in the upper Northeast region
9. Ratchaburi province in the Western region
10. Chonburi province in the Eastern region
11. Srakaew province in the Eastern region

Collaborating Organizations

During the 2nd phase the following institutions collaborated in the project :

1. Field Crops Research Institute of the Dept. of Agriculture (DOA)
2. Rice and Field Crops Promotion Division of the Dept. of Agricultural Extension (DOAE)
3. Soil and Water Conservation Division of the Land Development Dept. (LDD)
4. Kasetsart University (KU)
5. Thai Tapioca Development Institute (TTDI)
6. The Centro Internacional de Agricultura Tropical (CIAT)

Activities

1. Selection of project areas

The criteria of selection were the same as in Phase 1. Each year the project expanded to 1-2 new provinces by selecting appropriate pilot sites in one or more districts.

2. Training

Field staff of new sites were trained in cassava production practices and FPR and RRA methodologies.

3. Farmers meetings

Farmers from the new sites that were interested in participating in the project took part in a one-day training course which had the objective of increasing the farmers' knowledge and understanding of soil conservation in cassava growing areas, and to discuss with farmers how to conduct, with help of researchers and extensionists, FPR trials on their own fields. These farmers then visited demonstration plots with various management practices to reduce soil erosion. Farmers were asked to score the various soil erosion control treatments, considering their effect on soil loss by erosion, cassava yield and net income. Farmers then selected the most suitable 4–5 soil erosion control treatments to test in FPR trials on their own fields.

4. Demonstration plots

Each year demonstration plots were established by DOA, KU or TTDI at their research stations. These demonstrations had a large (18-24) number of treatments, including the application of chemical fertilizer or manures, green manures, closer plant spacing, intercropping with different crops and contour hedgerows of different grasses or legumes. These treatments tended to reduce soil erosion and gave farmers some ideas about alternative ways of solving erosion problems. The demonstration plots were laid out along the contour of a uniform slope; ditches were dug along the lower ends of each plot and covered with plastic to catch the soil sediments eroded from each plot. Farmers from new sites visited these demonstration plots, scored the treatments and selected those they would like to try out in FPR erosion control trials on their own fields.

5. FPR trials

After farmers decided to conduct FPR trials, researchers and extensionists helped them to decide on the best treatments, provided the necessary materials and helped them to set out the trials. During the crop season, researchers and extensionists visited the trials 1-2 times to discuss with the farmers and solve any problems.

At time of harvest, collaborating farmers and project staff harvested all the trials in the plot site, recorded all data and calculated average results of each type of trial. Data on soil loss from every treatment was also presented to the participating farmers and others interested. The meeting then discussed the results of each trial and selected again the best treatments for next year's trials (Howeler, 2001; Watananonta *et al.*, 2002).

6. Scaling-up and adoption

After two years of conducting FPR trials, farmers had usually selected the most suitable treatments to try in larger size plots (approximately 1,500-3,000 m^2) on their fields. Project staff tried to help them, for instance, in setting out contour lines to plant hedgerows for erosion control, or to obtain seed or vegetative planting material of the selected hedgerow species, intercrops or new cassava varieties.

RESULTS AND DISCUSSION

Farmer Participatory Research in the Second Phase

1. Demonstration plots

The data in **Table 1** show that most of the hedgerows treatments (T_{12}-T_{18}) as well as contour ridging (T_3) and closer plant spacing (T_8) were very effective in reducing soil loss by erosion. Some of the intercrops (T_9 and T_{11}) and one of the vetiver grass varieties (T_{16}) competed strongly with nearby cassava, causing a reduction in yield. Farmers from several new sites have visited these plots. Farmers evaluated the treatments and selected 3–4 treatments that they considered most effective and wanted to try out in FPR erosion control trials on their own fields. Most farmers selected vetiver grass hedgerows as the most suitable practice, followed by closer spacing, the combined application of fertilizers and chicken manure, contour ridging, and intercropping with pumpkin.

2. FPR Trials

Many results of the FPR trials conducted by farmers in Thailand have already been published (Howeler, 2001; Howeler *et al.*, 2002; Watananonta *et al.*, 2002). **Tables 2** and **3** are a few examples of FPR trials conducted by farmers in Chayaphum and Nakhon Ratchasima provinces. **Table 2** shows that both vetiver grass and lemon grass hedgerows were very effective in reducing soil loss by erosion, in some (but not all) cases they also increased yields and net income. Most farmers selected vetiver grass over lemon grass hedgerows because of the former's tolerance to drought and poor soils, and for its ease of planting and maintenance. In addition, farmers observed that contour plowing and ridging, closer plant spacing and adequate fertilization also contributed to reduced erosion and generally increased yields. Intercropping practices are not widely adopted in Thailand because of the high cost of labor. Similar results were obtained in many other sites. Once farmers saw the benefits of the various soil conservation practices, they adopted closer plant spacing, more balanced fertilization and the planting of contour hedgerows of vetiver grass; the latter in turn led to contour plowing and ridging in some areas. The FPR variety trial was similar to those conducted by farmers in various provinces. After conducting trials for two years farmers adopted Rayong 90, which produced the highest yield and net income, followed by Kasetsart 50 (**Table 3**).

Table 1. Results of the FPR demonstration plots at TTDI, Huay Bong, Nakhon Ratchasima, Thailand, in 2001/02.

Treatments[1]	Dry soil loss (t/ha)	Cassava yield (t/ha)	Intercrop yield (t/ha)	Starch content (%)	Gross income[2]	Prod. costs ('000 B/ha)	Net income
1. farmers' practice: up/down ridges, no fertilizers	10.50	44.12	-	25.4	53.74	17.59	36.15
2. up/down ridges; 50 kg/rai 15-15-15 fertilizers	37.68	43.51	-	30.9	57.78	20.93	36.85
3. contour ridges; 50 kg/rai 15-15-15 fertilizers	5.86	40.28	-	28.0	51.16	20.06	13.10
4. no ridges; 50 kg/rai 15-15-15 fertilizers	12.06	48.68	-	25.5	59.39	21.51	37.88
5. no ridges; 25 kg/rai 15-15-15 fertilizers	12.70	46.96	-	28.7	60.30	19.42	40.88
6. no ridges; 25 kg/rai fertilizer+125 kg/rai chicken manure	10.83	45.36	-	24.5	54.43	19.85	34.58
7. no ridges; 25 kg/rai fertilizer+1,000 kg/rai compost	13.09	45.63	-	29.0	58.86	20.16	38.70
8. no ridges; closer spacing (0.8 x 0.8 m)	4.52	49.27	-	31.6	66.12	21.98	44.14
9. no ridges; peanut intercrop	11.70	27.00	2.00	26.1	53.26	18.66	34.60
10. no ridges; pumpkin intercrop	5.53	40.41	3.80	23.5	85.68	23.28	62.40
11. no ridges; sweet corn intercrop	16.70	17.80[3]	7.10	25.7	57.29	18.18	39.11
12. no ridges; *Leucaena leucocephela* hedgerows	5.28	33.80	-	25.4	41.17	18.50	22.67
13. no ridges; sugarcane (for chewing) hedgerows	7.51	44.01	-	23.0	51.49	21.25	30.24
14. no ridges; lemon grass hedgerows	6.51	42.09	0.65	27.2	52.78	20.73	32.05
15. no ridges; *Paspalum atratum* hedgerows	14.24	39.09	-	23.3	45.97	19.92	26.05
16. no ridges; vetiver (from TTDI) hedgerows	4.69	25.46[4]	-	22.0	29.28	16.24	13.04
17. no ridges; vetiver Songkla-3 hedgerows	6.24	46.10	-	26.0	56.70	21.82	34.88
18. no ridges; vetiver from Vietnam hedgerows	8.25	41.68	-	24.6	50.10	20.62	29.48

[1] Variety KU-50; treatments 8-18 were all fertilized with 50kg/rai of 15-15-15 fertilizers, and all treatments except T_8 were planted at 0.8 x 1.25 m spacing; 1 ha = 6.25 rai

[2] Prices: cassava baht 1.31/ kg fresh roots at 30% starch; 0.02 baht reduction for every 1% lower starch content

peanut	10.0/ kg dry pods	sweet corn	5.0/ kg
pumpkin	10.0/ kg	lemon grass	5.0/ kg

[3] Low yield due to strong intercrop competition and poor drainage

[4] Low yield due to competition from very vigorous vetiver grass hedgerow

[5] 1 US$ = 44 baht

Table 2. Average results of two FPR erosion control trials conducted by farmers in Khook Anu village, Thep Sathit district of Chayaphum province, Thailand, in 2001/02.

Treatments	Dry soil loss (t/ha)	Yield (t/ha) Cassava	Intercrop	Root starch content (%)	Gross income	Product. costs[2]	Net income	Farmers' preference (%)
					(baht/ha)			
1. farmer's practice	14.0	12.61	-	20.3	12,736	12,018	718	0
2. contour plowing	10.2	8.41	-	20.0	8,410	11,471	-3,061	100
3. up/down plowing	31.1	12.34	-	18.3	11,970	11,974	-4	0
4. mungbean intercrop	10.3	8.70	0.306	24.0	15,516	15,392	124	82
5. lemon grass hedgerows	4.5	15.94	-	21.0	16,259	13,550	2,709	0 [3]
6. vetiver hedgerows	8.0	13.02	-	22.3	13,619	13,083	536	100

[1] Prices: cassava baht 1.20/kg fresh roots at 30% starch
mungbean 20/kg dry grain
[2] Cost of cassava production without harvest 10,000/ha
Cost of C+mungbean production 14,000/ha
Extra cost of contour plowing 125/ha
Cost hedgerow planting + maintenance 1,000/ha
Harvest + transport 160/tonne
[3] Although lemon grass hedgerows produced the highest net income, farmers do not like this practice because lemon grass does not tolerate drought and it is difficult to sell in large quantities

Table 3. Results of a FPR variety trial conducted by farmers in Kut Dook village, Baan Kaw subdistrict of Daan Khun Thot district, Nakhon Ratchasima province of Thailand in 2001/02.

Varieties	Cassava yield (t/ha)	Starch content (%)	Gross income[1]	Production costs[2]	Net income
				(US$/ha)	
Kasetsart 50	29.6	26.5	705.6	433.8	271.8
Rayong 5	28.3	26.5	674.2	426.4	247.8
Rayong 90	32.7	26.0	779.0	451.5	327.5
Rayong 72	28.4	23.2	676.6	427.0	249.6

[1] Prices: cassava US$ 23.84/tonne fresh roots
[2] Productions cost are based on data from the Office of Agricultural Economics in 2000.

Table 4 shows the total number and area of the different types of FPR trials conducted by farmers in the project pilot sites during the second phase of the project (1998-2003)

3. Adoption

After conducting their own FPR trials, or after a cross-visit to another village where trails were being conducted, farmers often decided to adopt one or more technologies on their production fields with the hope of increasing their yields or income and protecting the soil from further degradation.

In Thailand, practically all the cassava area is now planted with new varieties and about 75 per cent of farmers apply some chemical fertilizers (TTDI, 2000), although usually not enough nor in the right proportion. As a result of the FPR fertilizer trials,

Table 4. Number of various types of FPR trials conducted by farmers in the pilot sites of the Nippon Foundation project in Thailand in 2002/03.

					Types of FPR trials						
Province	District	Subdistrict	Village[1)]	No. of farmers	Varie-ties	Org. manures	Chem. fertile.	Chem.+org. manures	Herbi-cides	Green manures	Inter-crops
Nakhon Ratchasima	Daan Khum Thot	Baan Kaw	Khut Dook	53	1	1	1	-	-	-	1
	Thephaarak	Bueng Prue	Village 3 and 6	-	-	-	-	-	-	-	-
	Soeng Saang	Noon Sombujn	Sapphong Phoot	-	-	-	-	-	-	-	-
		Sra Takhian	Sra Takhian	-	-	-	-	-	-	-	-
	Khonburi	Tabaekbaan	Nong Phak Rai	27	1	1	1	-	-	-	1
Prachinburi	Naadii	Kaeng Dinso	Aang Thong Khaw Khaat	34	1	-	-	-	1	-	-
Kalasin	Mueang	Phuu Po	Noon Sawan	-	-	-	-	-	-	-	-
		Khamin	Khamplaafaa	-	-	-	-	-	-	-	-
	Nong Kungsri	Nong Bua	Khamsri	-	-	-	-	-	-	-	-
	Sahatsakhan	Noonburi	Noon Sawaat	-	-	-	-	-	-	-	-
		Noon Namkliang	Huay Suea Ten Paa Kluay	-	-	-	-	-	-	-	-
	Naamon	Naamon	Noon Thiang*	50	4	-	3	2	-	3	-
	Don Chaan	Dong Phayung	Noon Thiang*	50	4	-	4	-	-	3	-
	Huay Phueng	Nikhom	Huay Faa*	50	4	-	4	-	-	3	-
Chachoengsao	Sanaam Chaikhet	Thung Phrayaa	Thaa Chiwit Mai	-	-	-	-	-	-	-	-
	Thaa Takiab	Khlong Takraw	Nong Yai	-	-	-	-	-	-	-	-
Kamphaengphet	Khanuwaralakburi	Bo Tham	Siiyaek-Ton Thoo	30	-	-	1	5	-	-	1
Chaiyaphuum	Thep Sathit	Naayaang Klak	Khook Anu	50	2	-	2	-	4	-	3
Kanchanaburi	Law Khwan	Thung Krabam	Nong Kae	42	2	2	2	-	-	2	2
Sra Kaew	Wang Sombuun	Wang Sombuun	Khlong Ruam	-	-	-	-	-	-	-	-
Total: 6	**9**	**9**	**9**	**386**	**19**	**4**	**18**	**7**	**5**	**11**	**8**

[1)] * = initiated in 2002

Total no. of FPR trials =72

farmers started to apply more K, due to the official fertilizer recommendation for cassava being changed from an $N\text{-}P_2O_5\text{-}K_2O$ ratio of 1 : 1 : 1 to 2 : 1 : 2. After trying various ways of controlling erosion, most farmers selected the planting of vetiver grass contour hedgerows as the most suitable. By the end of 2003, about 1,038 farmers had planted a total of 1.63 million vetiver plants, corresponding to about 145 km of hedgerows (Wilawan Vongkasem *et al.*, 2008).

In August 2002 a participatory monitoring and evaluation (PM & E) was conducted in four pilot sites in Thailand where the project had been initiated at least four years previously.

Using focus group discussions and participatory evaluation methodologies, data were collected on the extent of adoption of the various technologies and the reasons for the adoption or non-adoption. **Table 5** shows that new varieties had been adopted in 100% of the cassava growing areas at all four sites. The application of chemical fertilizers varied from 79-100%, vetiver grass hedgerows were planted on 20-55% of the cassava area, green manures on 0-50%, and intercropping was not adopted at all, mainly due to a lack of labor to manage the intercropping (Howeler *et al.*, 2003; Vongkasem *et al.*, 2003; Watananonta *et al.*, 2003).

Table 5. Extent of adoption[1)] of various cassava technology components in four pilot sites in Thailand in 2002.

	Baan Khlong Ruam Sra Kaew		Thaa Chiwit Mai Chachoengsao		Sapphong Phoot Nakhon Ratchasima		Huay Suea Ten Kalasin	
Technology component	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)
Varieties	480	100	469	100	396	100	228	100
Chemical fertilizers	480	100	469	100	364	92	180	79
Vetiver grass hedgerows	139	29	94	20	218	55	89	39
Green manures	72	15	0	0	0	0	114	50
Intercropping	0	0	0	0	0	0	0	0

[1)] Estimated by farmers in each site during Participatory Monitoring and Evaluation (PM&E) in Aug 2002.

4. Impact assessment

In order to determine more precisely the effect of this project on the adoption of new technologies, an impact assessment was performed by an independent consultant. **Figure 1** shows the cassava yields that farmers reported before and after the project corresponding more or less to the second phase of the project, or from 1999 to 2003. In Thailand the yields of participating farmers increased from 19.4 to 25.8 t/ha (33%).

Table 6 shows that during the past ten years the average cassava yields in Thailand increased from 13.81 to 19.43 t/ha or an increase of 5.62 t/ha, and in Asia as a whole 3.71 t/ha. These increases in yields correspond to annual increases in gross income received by Thai farmers of about US$ 147 million, and by all cassava farmers in Asia of about US$ 325 million. In addition, farmers in Thailand received higher prices due to the higher starch content of the new varieties.

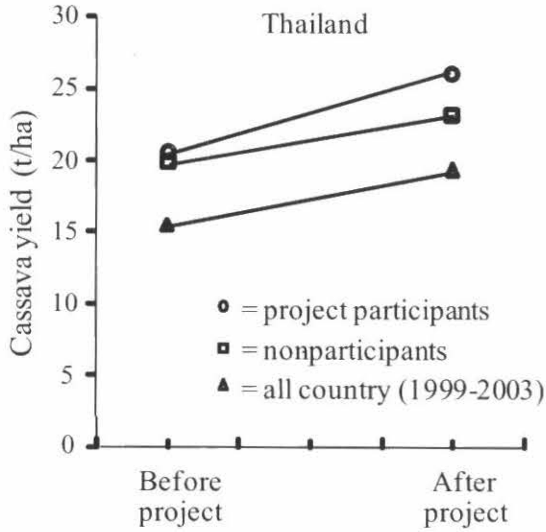

Figure 1. *Average cassava yields of Thai farmers participating in the Nippon Foundation project, as well as of nearby but non-participating farmers, before the project started and at the end of the project. Data originates from PRRA census forms collected from 417 households in Thailand. For comparison the national average cassava yields in 1999 (before) and 2003 (after) are also shown.*
Source: *Howeler, 2004.*

Table 6. Estimation of the annual increase in gross income due to higher cassava yields in 2004 resulting from the adoption of new cassava varieties and improved practices in Thailand as well as in Asia as a whole as compared to 1994.

Country	Total cassava area (ha)[1]	Cassava yield (t/ha)[1]		Yield increase (t/ha)	Cassava price ($/tons)	Increased gross income due to higher yield (million US$)
		1994	2004			
Thailand	1,050,000	13.81	19.43	5.62	25	147.5[2]
Total Asia	3,508,103	12.93	16.64	3.71	25	324.4

[1] Data from FAOSTAT for 2004.
[2] In addition, farmers also benefited from higher prices due to a higher starch content in Thailand.
Source: *Howeler et al., 2005.*

CONCLUSIONS

The use of a farmer participatory approach for technology development and dissemination was very effective in enhancing the adoption of soil conservation practices. Participating farmer were enthusiastic to test and select the most suitable varieties and cultural practices. They not only selected vetiver grass hedgerows as the best way to control soil erosion but they also increased their cassava yields and net income by selecting the most suitable cassava varieties and cultural practices. The adoption of more sustainable cassava production is likely to improve Thai farmers' living standards.

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WORKING TOGETHER FOR SUCCESS IN THAILAND: A CASE STUDY OF KHUT DOOK "CASSAVA DEVELOPMENT VILLAGE"

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INTRODUCTION

Cassava, *Manihot esculenta* Crantz, belongs to the family Euphorbiaceae, which includes rubber (*Hevea brasilensis*) and castor bean (*Ricinuts communis*). There are two main centers of diversity – a major one in Brazil and a secondary one in Central America. Dutch traders introduced cassava from Mexico to Southeast Asia during the 17 th century. The Thai agricultural historical record indicates that in 1786 cassava was introduced to Thailand from Malaysia. In 1937, Mr. Tun Komkrit, an agricultural researcher of the Department of Agriculture, DOA, suggested that cassava be planted in more than 450 hectares as an intercrop in rubber plantations in Songkla province in the southern part of Thailand, for producing starch and sago. At the end of the Second World War, due to increasing demand on the world starch market, many cassava plantations and their starch factories were established in Chonburi province in the eastern part of Thailand.

Thailand has been exporting cassava products for more than 50 years. In 1950, 18,915 tonnes of cassava starch, 14,934 tonnes of sago, and 34 tonnes of cassava chips were exported, with a total value of 33 million baht. The export of cassava chips and pellets increased rapidly during the 1970s due to increasing demand for animal feed in the EEC. Cassava actually became the principal export products of the country in 1978, with a value of 10,891 million baht. At that time, more than 50% of the cassava roots produced was used in the pellets and chips industries. The highest value of exported cassava products was 23,974 million baht in 1989 corresponding to a volume of 9,826,220 tonnes of pellets, starch and chips. The EU was the major importer of cassava products for the animal feed industries (Tiraporn, 1994).

Cassava Area, Yield and Production

The agricultural statistics for Thailand indicate that in 2000/01 the cassava planting area was 995,818 ha and the harvesting area was 988,220 ha. Total production in 2001 was about 16.87 million tonnes of fresh roots. The average root yield was 17.06 t/ha. The northeastern region accounted for 54% of the total planting area, followed by the eastern region at 32 %, and the northern region at 14%.

Besides the high efficiency of the Thai cassava industry in developing various products required by the market, there are also good roads and modern seaports available for exporting cassava products. When we compare the world average yields of various field crops, such as rice, maize, sugarcane, soybean and cassava, to the average crop yields in

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Thailand, we see that the average yield of other field crops is generally lower than the world average, but the average yield of cassava in Thailand is always considerably above the average yield in the world (Office of Agric. Economics, 2002).

Cassava Soil Management

The objective of the research was to develop general recommendations for all cassava growing areas. In the high-rainfall and high-temperature tropical environment, continuous cultivation changes soil properties drastically, nutrients leach out of the root zone and the soil becomes compacted. This may lead to widespread deterioration of the soil's productive capacity. From about 1985 to 2000, our research focussed on soil fertility maintenance, erosion control, intercropping, crop rotation and land preparation, in collaboration with CIAT and Kasetsart University.

Many people in Thailand incorrectly believe that the cultivation of cassava inevitably leads to a deterioration of the soil. This is partly because cassava can be grown in areas with low soil fertility where other crops can not be grown productively. Even without growing any crop in such areas, the soil fertility will naturally decline by nutrient leaching and erosion due to the sandy soil texture. In fact, cassava extracts and removes nutrients from soil less than many other crops such as sugarcane.

Farmers of the northeast and eastern regions generally grow cassava on loamy Paleustults and sandy Quartzipsamment soils. The general characteristics of these soils are a sandy loam texture, fast draining, and a medium to low organic matter and phosphorus content. But, they are also very low in potassium. They are considered low soil fertility soils. Other economic crops such as maize, sorghum, cotton or beans can not be grown productively.

To reduce soil erosion in cassava fields, farmers should use good soil management and soil conservation practices. Application of chemical fertilizers high in N and K, are generally required, while application of some micronutrients may be necessary in some soils. Animal manure and green manure applications will improve the soil's physical properties. Contour plowing and planting contour hedgerows of vetiver grass are effective in reducing erosion (Tongglum *et al.*, 1996).

Farmer Participatory Research (FPR) and Extension (FPE)

There are many effective ways to improve the cassava cropping system, in order to enhance plant nutrient conservation and reduce erosion. Each management practice has its advantages and disadvantages, which makes it difficult for researchers to make decisions on the most appropriate technologies to transfer. Therefore, from 1994 to 2003, CIAT, DOAE, DOA and the Thai Tapioca Development Institute have had a collaborative project to work with farmers using a farmer participatory research approach.

KHUT DOOK "CASSAVA DEVELOPMENT VILLAGE"

Located in the lower Northeastern region, Khut Dook village in Daan Khun Thot district of Nakhon Ratchasima province is not favored agriculturally with its poor soils and erratic rainfall. The village is part of the arid Khorat Plateau and is characterized by a rolling topography. Sixty per cent of the village's agricultural land has gentle slopes with sandy soils. Harsh climatic conditions – a short monsoon season and a long dry season – often result in this region being subjected to both floods and droughts. The Northeastern region is a slightly elevated plateau of 17 million ha located at 100-300 masl. Rainfall varies from 900 to 2,000 mm, with an average of 1,250 mm per year; 85% of this rain falls from mid-April to mid-October. Average monthly high temperatures range from 30°C in December to 36°C in April. Principal crops in the region are rainfed paddy rice, upland field crops, forest and grazing lands. A typical Northeastern household cultivates 1-4 ha of upland crops (cassava, sugarcane, maize, horticultural crops) and raises one to three buffalos for use as draft animals. Many households also own a few head of cattle for draft and/or commercial sale.

Khut Dook village occupies 1,013 ha and has a population of 432. Sixty six per cent of the households have grown cassava for more than 30 years. Rayong 5 and Kasetsart 50 are now the most popular cassava varieties. Generally, land preparation in Khut Dook village is done by contract tractor plowing using 3- and 7-disk plows. Plant spacing of 60 x 70 or 70 x 80 cm is commonly used. Normally two times hand weeding is practiced for weed control. About 130-190 kg/ha of 15-15-15 complete chemical fertilizer is applied to each crop. The average root yield was 18.78 t/ha in 2001.

The main problems of cassava growers in Khut Dook are a lack of investment money, serious soil erosion, low soil fertility, and roots being damaged by white grubs.

The Khut Dook "Cassava Development Village" was established on August 8, 2000 with 23 members and a US$ 750 revolving fund. After participating in the FPR project for about two years, this cassava development village now has 53 members with a US$ 3,300 revolving fund.

In 2001 and 2002, four FPR trials were conducted, i.e. a variety trial, fertilizer trial, weed control trial and erosion control trial. Some results for 2001/02 were reported by Watana *et al.* (2007). Results from the cassava variety trial indicate that some of the high-yielding new cassava varieties can provide more net income for the farmers. For erosion control, the farmer preferences were 100% for contour plowing and planting contour hedgerows of vetiver grass; this was followed by intercropping between the rows of cassava with mungbean (82%).

In the same year, the district and provincial extension staff organized two farmer participatory extension activities: several cross-site visits and a provincial field day. These activities help other villagers to improve their cassava production and to establishe their own "Cassava Development Village". Vetiver grass was planted for erosion control in Khut Dook village in about 49.4 ha, equivalent to about 15 km of vetiver hedgerows. The key factor for success was the working together of the FPR and FPE teams as partners with the farmers, and using a bottom-up instead of top-down approach.

CONCLUSION

The best way to control soil erosion in cassava fields is to use good agronomic practices, such as high-yielding varieties, timely weed control and adequate fertilization, combined with soil conservation practices such as contour plowing and planting vetiver grass contour hedgerows. The principal problems of cassava growers at Khut Dook are a lack of investment money, crops damage by erosion, low soil fertility and root damage by white grubs. Results from farmer participatory trials indicate that the planting of new high-yielding cassava varieties in combination with suitable agronomic practices can provide more net income, while contour plowing with vetiver grass hedgerows can markedly reduce erosion and improve root yields. The key factor for success was working together of the FPR and FPE teams as partners with the farmers and applying a bottom-up instead of top-down approach.

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EVOLUTION OF FPR METHODOLOGIES USED AND RESULTS OBTAINED IN VIETNAM

Tran Ngoc Ngoan[1]

ABSTRACT

In recent years cassava has become the third most important food crop in Vietnam, after rice and maize. Its production, processed mainly into starch, is partially used for export. So, cassava has steadily developed in Vietnam. During the last ten years (1994-2003) the Nippon Foundation Project, entitled "Enhancing the Sustainability of Cassava-based Cropping Systems in Asia", was implemented in four countries, including Vietnam. The main objective of the project is to encourage researchers, extension workers and farmers to participate in identifying new ways to improve cassava production by testing and selecting suitable technologies to apply in farmers' fields, so as to increase the living standards of small farmers and to contribute to the sustainability of cassava-based cropping systems.

Phase 1 of the project (1994-1998) was used mainly to introduce and learn about the participatory approach by researchers, extensionists and farmers, and to develop an effective FPR methodology by the conducting of FPR trials. The second phase (1999-2003) aimed at disseminating widely the new selected technologies, in order to enhance adoption by farmers on a large scale. Various aspects of this phase of the project were quite successful. First, in 2003, the number of FPR sites in Vietnam reached more than 30 while more than 22,898 farmers adopted new technologies on about 9,228 ha, while 3,370 pigs were raised using cassava-based diets. The estimated increase in gross income was about 34,082 mil. dong or US$ 2.20 million. The most important contribution of the Nippon Foundation project was to show farmers, extension workers and local leaders the potential for higher cassava yields when using the right combination of varieties, fertilizers and intercropping, and to enhance soil conservation through different ways of reducing soil erosion when growing cassava on sloping land. Secondly, another contribution of the project was to introduce the participatory approach in doing research for development, and to encourage the working together of researchers, extension workers, local governments and farmers, in order to find the best way to solve farmers' problems. This approach is a good methodology for capacity building as well.

INTRODUCTION

During the last ten years (1993-2002) cassava cultivation in Vietnam has changed very much, both in terms of cassava area and cassava yield. Initially the cassava area decreased from 278,000 ha in 1993 to 226,800 ha in 1999 while the fresh root yield also decreased from 8.81 t/ha to 7.96 t/ha. But, subsequently the cassava area increased to 329.900 ha, while yields increased to 13.5 t/ha in 2002. The main reasons for this change are: 1) Cassava has changed from being a food crop to being mainly an industrial crop, used for animal feeding and production of starch; and 2) the increasing demand for cassava products in neighboring China.

PROJECT OBJECTIVES

The overall objective of the project is to increase the living standards of smallholder farmers and to improve the agricultural sustainability in less-favored areas of Vietnam by improving the productivity and stability of cassava-based cropping systems.

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The specific objectives are:

1) To work with farmers in identifying their constraints, to conduct trials and to evaluate and then select the most suitable technologies for the farmers' conditions
2) To develop and disseminate new technologies on a large scale that are best suited to farmers' needs and adapted to local conditions
3) To increase cassava production and maintain the soil resources of small farmers living in less favored areas of Vietnam
4) To strengthen the capacity of scientists, extensionists, local authorities and farmers in selecting the best options for development.

METHODOLOGIES

The first Phase (1994-1998) of the project focused on the following activities:

- To conduct participatory problem diagnosis and select potential solutions for testing in FPR trials at selected pilot sites.
- To conduct FPR trials in a limited number of sites for learning and training
- To organize training courses on FPR methodologies for researchers and extension workers

The second Phase (1999-2003) of the project focused on the following activities:

- To use various farmer participatory methodologies, such as participatory diagnosis of problems and the conducting of FPR trials in a number of pilot sites. In 2003, the project was working in a total of 31 sites in different regions of Vietnam.
- To organize training courses on FPR methodologies for extension workers and farmers.
- To organize field days (on-farm workshops), and cross-visits at the time the trials were harvested.
- To facilitate the adoption of new technologies which had been selected by farmers.
- To analyze and evaluate the results, as well as the impacts of the project on farmers' income and on soil conservation, as well as the ability of researchers, extension workers and farmers to adopt a more participatory approach in research for development.

The various steps in the process used in this project are shown in **Figure 1** and include the following activities: Participatory diagnosis→Participatory selection of potential solutions → Participatory trials→Participatory evaluation and selection of new technologies→ Participatory extension and adoption of new technologies.

RESULTS AND DISCUSSION

1. Characterization of Cassava Production and Utilization in Pilot Sites

The project has conducted Rapid Rural Appraisals (RRA) with farmer participation in 25 pilot sites; this helped farmers to diagnose their problems and to select several component technologies to be tested in FPR trials to solve those problems. The results of these RRAs indicate the main features of cassava production in selected pilot sites (**Table 1)** as follows:

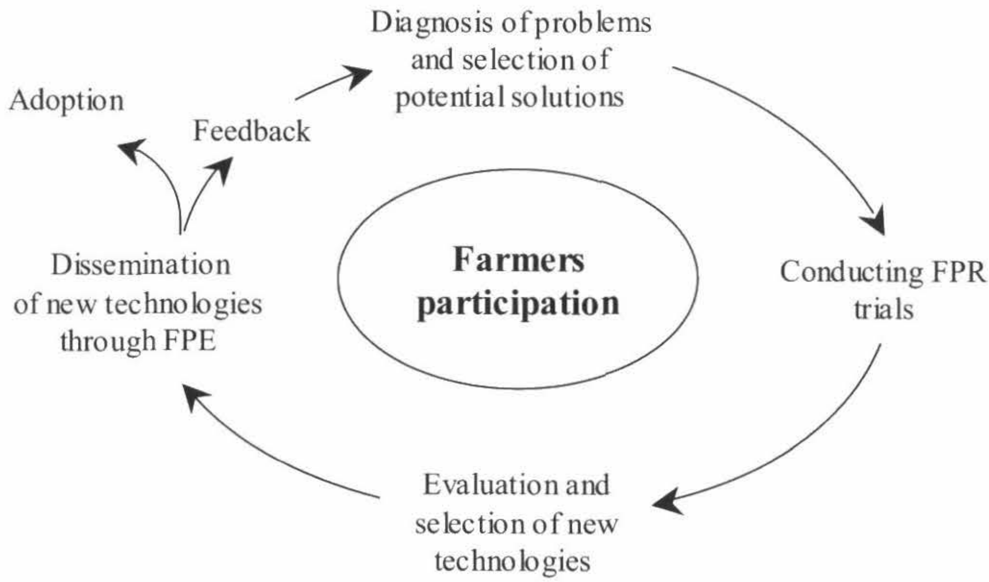

Figure 1. Steps in the farmer participatory research and extension activities.

Table 1. Main features of cassava production in Vietnam in selected FPR pilot sites, based on information obtained through RRAs conducted before starting the project in each site.

Location			Cassava			
Village or commune	Province	Topography	yield (t/ha)	Utilization (%)	Main variety	Inputs used[1)]
Tien Phong	Thai Nguyen	hilly	8.5	30%[2)];70%[3)]	Vinh Phu	A; A+B
Dong Rang	Hoa Binh	steep slope	11.0-12.0	30%; 70%	Vinh Phu	A; B; C
Kieu Tung	Phu Tho	steep slope	8.0-15.0	60%; 40%	Vinh Phu	A; C
Thuong Am	Tuyen Quang	steep slope	10.2	40%; 60%	SC 205; V. Phu	None
Thong Nhat	Phu Tho	steep slope	8.0	30%; 70%	SC 205; V. Phu	A; B; A+B
Tran Phu	Ha Tay	flat	11.0	30%, 70%	SC 205; V. Phu	A; B; A+B
Hong Ha	Thua Thien-Hue	steep slope	7.0	Human food	Nep[4)]	None
Dong Tam	Binh Phuoc	steep slope	15.0	Feed, starch Human food	Local; KM60 KM94	C
Suoi Rao	Baria Vungtau	hilly	15.0	70%; 30%	Local; KM60 KM94	B
Average			**10.8**			

[1)] A = pig manure; B = unbalanced NPK fertilizers; C = urea
[2)] for sale; [3)] for animal feeding; [4)] local variety

In Vietnam cassava is grown mainly on steep slopes with very low inputs. In some areas farmers did not apply any fertilizers. In most areas farmers grow local varieties, but in other areas, farmers started to grow new varieties (Dong Tam in Binh Phuoc and Suoi Rao in Baria-Vungtau). Therefore, cassava fresh root yields were still very low, ranging from 7.0 to 15.0 t/ha . About 70% of cassava roots were used for animal feeding and 30% for human consumption.

The results of RRAs indicate that the main constraints to obtaining high cassava yields can be ranked in priority order as indicated in **Table 2**.

Table 2. Main constraints to cassava production in Vietnam according to participatory diagnoses with farmers.

1. Low yield and low starch content of local varieties
2. Without, low levels, or unbalanced NPK fertilizers applied
3. Serious soil erosion
4. Lack of knowledge on cultural practices
5. Unstable prices
6. Weed competition
7. Lack of good varieties for fresh consumption

2. FPR Trials

Based on the needs of farmers and the constraints identified through discussion and the use of various participatory diagnosis methodologies, seven different technology components were selected for the FPR trials (**Table 3**).

Table 3. Number of FPR pilot sites and type and number of FPR trials conducted in Vietnam from 1995 to 2003.

No. of FPR sites	Phase 1				Phase 2					
Type of trials	1995	1996	1997	1998	1999	2000	2001	2002	2003	**Total**
No. of FPR sites	***3***	***3***	***3***	***3***	***3***	***16***	***21***	***25***	***31***	***31***
Soil erosion control	16	15	15	15	15	25	29	30	23	**183**
New varieties	7	17	25	22	22	26	36	47	34	**236**
Fertilization	5	13	13	15	15	25	36	24	24	**170**
Intercropping	8	11	8	8	8	13	32	31	26	**145**
Plant spacing	-	-	-	-	-	-	7	19	8	**34**
Silage making	-	-	-	-	-	15	11	16	13	**55**
Weed control	-	-	-	-	-	-	-	2	-	**2**
Leaf harvest	-	-	-	-	-	-	2	-	3	**5**
Total	**36**	**56**	**61**	**60**	**60**	**104**	**153**	**169**	**131**	**830**

The number of FPR sites increased from three sites in 1995 up to 31 sites in 2003. The number of FPR trials also increased from 36 trials in 1995 to 169 in 2002 and then decreased to 131 in 2003. Among these trials, those on new varieties were considered of highest priority by farmers (total of 236 trials), followed by trials on soil erosion control, fertilization and intercropping (total of 183, 170 and 145 trials, respectively). Some other trials were conducted for specific needs, such as those on cassava leaf and root silage making, plant spacing, and cassava leaf production.

Through their participation in FPR trials farmers have learned not only how to manage FPR trials, but they also evaluated and then selected the most suitable technologies for adoption (**Table 4**). To reduce soil erosion, farmers have adopted and disseminated the following types of hedgerows: planting contour lines of *Tephrosia candida*, *Paspalum atratum*, vetiver grass and pineapple. They have selected and applied some fertilizer formulas for cassava as follows: 40 kg N+ 40 kg P_20_5 +40 kg K_20/ha; 80 kg N + 40 kg P_20_5 + 80 kg K_20/ha; or pig manure + 40 kg N + 40 kg P_20_5 + 80 kg K_20/ha. New high-yielding cassava varieties were of particular interest to farmers, and after testing and evaluation they selected and adopted the following new varieties: KM 94, KM 98-7, KM 98-1, SM 937-26 and KM 98-5; these were quickly disseminated on a large scale. Cassava intercropping with different kinds of leguminous species and other crops was also rapidly adopted by farmers, as the intercrops can help control weeds and reduce soil loss by erosion, while also giving a higher income compared to monocropping. Especially, after testing cassava root and leaf silage for pig raising at Huong Van commune in Huong Tra district of Hue, farmers have adopted and applied this technology in pig raising to replace some of their traditional technologies .

The positive effects of applying these new technologies during implementation of the project are very encouraging (**Table 5**), and they have already caught the attention of both farmers and local leaders. In many areas, the leaders have reconsidered their development policies. Cassava is now being considered as a commercial crop, effectively contributing to the elimination of hunger and poverty, and to contribute to rural development and modernization through agro-industry. Van Yen district in Yen Bai province is a good example. Starting from the intercropping trials in 2001 and 2002, the area under cassava intercropped with peanut was enlarged to 6 ha in 2003. Similarly, the initial FPR variety trials were soon expanded to an area of 20 ha of new cassava varieties of high yield and starch content, such as KM 60 and KM 94. After the field days evaluating the results, the district and provincial officials decided to concentrate their efforts on enlarging the area under new cassava varieties; this reached a total area of 2,500 ha in 2003. Van Yen district is a good example of how cassava production suddenly expanded in North Vietnam with the adoption of new varieties and improved agronomic practices.

Having knowledge and understanding of the technologies, analyze the problems, determine the type of FPR trials to find solutions that would meet the farmers' needs, and evaluate and disseminate adopted technologies are very important to extension workers and farmers. So, training and farmer field days have always been important activities of the project, and these activities are combined with the trial process. Field days were also organized at FPR sites at the time of harvesting the trials. Farmers and their neighbors participated in the harvest and evaluated the various treatments in each trial; they finally discussed, analyzed and selected the most appropriate technologies for the local conditions. Up to 2003, six farmer training courses had been organized in three regions of Vietnam with a total of 186 extension workers and farmers participating (**Table 6**).

Farmer field days and cross-site visits were organized yearly by all six collaborating institutions; a total of 1,055 farmers and local officials participated in these activities. This was a very effective extension method since farmers were directly involved and participated in the evaluation and the selection of those technologies that they preferred.

Table 4. Types of cassava technologies adopted and disseminated by farmers in various Nippon Foundation project sites in Vietnam between 1999 and 2003.

Technology component	Type of technology	District (province)
1. Soil conservation practices	Contour hedgerows of *Tephrosia candida, Paspalum atratum,* vetiver grass and pineapple	Van Yen (Yen Bai); Son Duong (Tuyen Quang), Phu Ninh (Phu Tho); Luong Son (Hoa Binh)
2. Improved fertilizer practices	40 N-40 P_2O_5-40 K_2O 80 N-40 P_2O_5-80 K_2O pig manure + 40-40-80	Van Yen; Son Duong; Pho Yen (Thai Nguyen); Thong Nhat (Dong Nai); Chau Duc (Baria-Vungtau)
3. New varieties	KM 94	Van Yen; Son Duong; Phu Ninh; Thach That and Chuong My (Ha Tay); Lac Son (Hoa Binh); Nhu Xuan (Thanh Hoa); Phuoc Long (Binh Phuoc); Thong Nhat; Chau Duc
	KM 98-7	Pho Yen; Thanh Ba (Phu Tho)
	KM 98-1	A Luoi, Nam Dong and Huong Tra (Hue)
	SM 937-26, KM 98-5	Phuoc Long
4. Intercropping	Peanut (1-2 rows)	Pho Yen; Van Yen; Thanh Ba; Chuong My; Lac Son; Huong Tra ; Chau Duc
	Black bean	Pho Yen; Thanh Ba
	Maize	Chau Duc
5. Ensiling	Cassava root and leaf silage for pig feeding	Huong Tra, A Luoi and Nam Dong

Table 5. Estimated increase in cassava fresh root yields due to the adoption of various new technology components in Vietnam in 2002/03[1].

Technology component	Cassava yield (t/ha) Farmers' practice[2]	Cassava yield (t/ha) With adoption of new technology component	New practice as % of farmers' practice[2]
1. New varieties	17.61	29.93	170
2. Improved fertilization	21.37	30.50	143
3. Soil conservation practices	20.60	25.48	124
4. Intercropping	29.95	28.94	97

[1] Based on results from 15 FPR sites where new technologies have been adopted by farmers
[2] Farmers' practice usually includes most new technologies except the technology being tested

Table 6. Type and number of participants in FPR training courses, field days and cross-visits of the Nipon Foundation project in Vietnam (1995-2003).

Type of FPR training course	Phase 1	Phase 2
For researchers and extensionists	30	103
For farmers and extensionists	-	186
Farmers in cross-site visits	-	305
Farmers in field days	56	694

3. Adoption of Soil Erosion Control Practices

Most cassava in Vietnam is planted on sloping land. With the rainy season being concentrated during the summer time this may result in serious soil erosion in cassava fields. Soil loss due to erosion may be as high as 50-110 t of dry soil/ha. Therefore, soil erosion control is a very important practice that contributes to more sustainable cassava production. One of the ways to reduce erosion is to plant hedgerows along the contours with a distance between rows of 6 to 10 m, depending on the slope. Hedgerow species tested in this project were *Tephrosia candida,* vetiver grass, *Paspalum atratum*, *Panicum maximum* and pineapple.

Depending on local conditions, farmers in each region selected the most appropriate hedgerow species. Farmers in the South liked vetiver grass or *Paspalum atratum*, farmers in the Central Coast preferred pineapple, while farmers in the North generally preferred *Tephrosia candida* and *Paspalum atratum*

By the end of the project, these hedgerow technologies had been adopted by households in an area of 612 ha in the FPR pilot sites. By applying soil conservation practices fresh root yields also increased, ranging from 13.5% to 23.7% as compared to areas with no hedgerows; the gross income from cassava was estimated to be about 1,208.146 million VND (US$ 80,000) higher than that in areas using traditional practices without erosion control (**Table 7**).

Table 7. Extent of adoption of soil conservation practices and the estimated increase in yield and gross income of farmers in the FPR pilot sites in Vietnam from 2000 to 2003 as a result of the Nippon Foundation project.

Year	Number of farmers	Area with soil conser. (ha)	Cassava yield (t/ha) Farmers' practice[1)]	With soil conservation	Percent yield increase	Increase in gross income[2)] (mil. VND) Per ha	Total	Per household
2000	62	21.12	12.11	13.75	13.5	0.574	12.123	0.196
2001	200	59.87	16.50	19.95	20.9	1.112	66.596	0.333
2002	222	88.85	20.60	25.48	23.7	1.952	173.728	0.782
2003	831	612.00	20.60[3)]	25.48[3)]	23.7	1.561	955.699	1.150
Total	831	612.00					1,208.146	

[1)] Farmers' practice includes most new technologies except soil conservation
[2)] Fresh root price: in 2000 350 VND/kg
in 2001 350 VND/kg in north, 300 in central and 290 in south
in 2002 400 VND/kg
in 2003 320 VND/kg
[3)] Yields estimated from 2002

4. Adoption of Improved Fertilization Practices

Results of RRAs conducted before the project started in each new site indicate that farmers were growing cassava either without or with very few inputs. Farmers generally apply only nitrogen fertilizers, while phosphorus and especially potassium are almost never applied to cassava. After testing various new fertilizer technologies the number of households that had adopted the use of balanced fertilizer application to cassava increased up to 1,710 with fertilizers being applied in a total area of 607 ha. Use of a more balanced fertilizer application to cassava doubled cassava yields in many places. The average yield increase ranged from 25.47 to 30.50%. The value of additional income per ha ranged from 2.228 to 3.398 million VND as compared to the farmer's traditional practice of no fertilizer application. Therefore, total gross income increased 1,909 mil VND by the adoption of improved fertilization practices in the pilot sites over four years **(Table 8).**

Table 8. Extent of adoption of improved fertilization practices and the estimated increase in yield and gross income of farmers in the FPR pilot sites in Vietnam from 2000 to 2003 as a result of the Nippon Foundation project.

Year	Number of farmers	Area with balanced fertilization (ha)	Cassava yield (t/ha) Farmers' practice	Improved fertilization	Increase in gross income[1)] (mil VND) Per ha	Total	Per household
2000	64	10.85	15.76	25.47	3.398	36.87	0.576
2001	123	15.30	22.49	29.19	2.228	34.09	0.277
2002	157	26.00	22.24	28.49	2.500	65.00	0.414
2003	1,710	607.00	21.37	30.50	2.922	1,773.65	1.037
Total	1,710	607.00				1,909.01	

[1)] Prices: see footnote Table 7.

5. Adoption of Intercropping Practices

In some areas farmers have traditionally intercropped cassava with short-duration crops like legumes or taro in between rows of cassava. Through the FPR intercropping trials, farmers in the north and the central part of Vietnam selected intercropping with peanut, usually two rows of peanut in between rows of cassava. The use of this intercropping pattern did not decrease cassava yields very much, but produced an additional 0.8-1.2 tonnes of dry peanut pods/ha. Moreover, about ten tonnes of residue were returned to the soil as green manure. In the Southeastern region, farmers preferred intercropping cassava with maize or mungbean.

Since the advantages of intercropping are remarkable, 4,250 households applied the intercropping technology in 2003. Cassava yields were slightly reduced in 2002 and 2003, but on average they harvested 1.18 tonnes of dry peanut pods/ha. Therefore, the gross income/ha increased by 0.29 to 1.977 million VND. The total additional gross income over four years from cassava and the intercrops was 497.702 million VND as compared to the farmer's traditional practice of planting cassava in monoculture (**Table 9**).

Table 9. Extent of adoption of intercropping and the estimated increase in yield and gross income of farmers in the FPR pilot sites in Vietnam from 2000 to 2003 as a result of the Nippon Foundation project.

Year	Number of farmers	Area with intercropping (ha)	Cassava yield (t/ha) Farmers' practice	With intercropping	Increase in gross income[1] (mil. VND) Per ha	Total	Per household
2000	127	11.75	7.14-29.03	8.8-31.9	0.29-1.974	39.212	0.309
2001	360	27.77	5.0-29.4	9.8-31.9	0.385-1.977	91.693	0.255
2002	689	42.20	29.95	28.94	0.385-1.977	142.797	0.207
2003	4,250	160.00	29.95	28.94	1.400[2]	224.000	0.053
Total	4,250	160.00				497.702	

[1] Prices: see footnote Table 7.
[2] Additional value of the intercrops per ha = 1,720.000 VND

6. Adoption of New Cassava Varieties

In Vietnam, most local cassava varieties have previously been imported from other countries and most of these were sweet varieties for human consumption. These varieties normally have low fresh root yields and low starch contents. They are, therefore, not suitable for starch processing. Farmers normally are mainly interested in selecting the most appropriate varieties. New high-yield varieties are usually more readily accepted than other new technologies as adopting these other technologies normally require additional investments. By changing the variety, production can be increased without much additional costs. Moreover, higher investment for obtaining higher yields through the adoption of other technologies can be more easily accepted when using new varieties. Farmers will more readily accept to apply balanced fertilizers if they already use new cassava varieties.

Therefore, after four years of conducting the project's activities, the number of households growing new varieties increased very quickly from 88 households (7.7 ha) in 2000 up to at least 14,820 households on an area of about 7,849 ha in 2003. The new variety now mainly grown in Vietnam is KM 94; beside KM 94, each region has selected some other varieties such as KM 98-5 and SM 937-26 in the Southeastern region; KM 98-1 in the Central region; and KM 98-7 in Thai Nguyen. By rapidly disseminating these new varieties in cassava production areas the fresh root yield increased between 7.54 and 12.83 tonnes/ha. Yields in many areas doubled as compared to the local varieties. Consequently, by growing new varieties the higher yields obtained resulted in an additional gross income of 32,320 million VND over four years as compared to growing the local cassava varieties (**Table 10**).

Table 10. Extent of adoption of new varieties and the estimated increase in yield and gross income of farmers in the FPR pilot sites in Vietnam from 2000 to 2003 as a result of the Nippon Foundation project.

Year	Number of farmers	Area with new varieties (ha)	Cassava yield (t/ha)		Increase in gross income[1] (mil. VND)		
			Farmers' variety	Improved variety	Per ha	Total	Per household
2000	88	7.7	19.97	32.80	4.490	34.577	0.393
2001	447	76.5	20.75	28.66	1.015-3.08	233.222	0.522
2002	1,637	543.7	21.00	28.54	3.016	1,639.800	1.002
2003	14,820	7,849	17.61	29.93	3.942	30,943.897	2.088
Total	14,820	7,849				32,320.238	

[1] Prices: see footnote Table 7

7. Adoption of the Use of Cassava Root and Leaf Silage for Pig Feeding.

Results of research on using fresh cassava roots and leaf silage conducted at Huong Van commune, Huong Tra district in Hue province have shown the effective use of cassava roots and leaves for pig feeding. Moreover, these technologies allow farmers to store the feed for 6-12 months. Learning about this technology through training courses and field days, many households in the central part of Vietnam adopted this technology in on-farm animal feeding. Our survey indicates that in 2003 there were 1,172 households using the leaf and root silage technology for pig feeding, with the total number of pigs being 2,910. The total additional gross income over three years resulting from the use of this technology was 185.060 million VND (**Table 11**).

8. Adoption of Various New Technologies and the Estimated Increase in Gross Income of Farmers

Summarizing the results of the dissemination of new technologies of our project, we estimate that about 22,898 households adopted new technologies in an area of about

9,228 ha, while 3,370 pigs were fed with cassava root or leaf silage. The total additional gross income obtained was estimated at 34,082 million VND, equal to 2.20 mil US $ (**Table 12**). These are very worthy and encouraging results of the project.

Table 11. Extent of adoption of cassava silage in pig feeding and the estimated increase in gross income of farmers in the FPR pilot sites in Vietnam from 2000 to 2003 as a result of the Nippon Foundation project.

Year	Number of farmers	Number of pigs	Increase in gross income (VND/pig)	Total increase in gross income (mil. VND)
Cassava leaf silage				
2001	28	96	86,000	8.256
2002	60	290	86,000	24.940
2003	115	460	86,000	39.560
Cassava root silage				
2001	759	1,896	50,000	94.800
2002	967	2,452	50,000	122.600
2003	1,172	2,910	50,000	145.500
Total in 2003	**1,172**	**3,370**		**185.060**

Table 12. Adoption of new technologies and the estimated increase in gross income of farmers in the FPR pilot sites in Vietnam in 2003 as a result of the Nippon Foundation project.

Technology component	No. of households	Area (ha) or no. of pigs	Increase in gross income (mil. VND)
New varieties	14,820	7.849	30,943.897
Intercropping	4,250	160	224.000
Erosion control	831	612	955.699
Balanced fertilization	1,710	607	1,773.650
Root and leaf silage for pig feeding	1,287	3,370 (pigs)	185.060
Total	**22,898**	**9,228** **3,370(pigs)**	**34,082.306** **=2.20 mil US $**

CONCLUSIONS

- Phase 1 of the Nippon Foundation Project was considered a learning phase of our community on participatory approaches. The experiences drawn from the FPR activities in this phase were very useful in implementing the second phase.
- Most successful adoption of new technologies was achieved during the second phase. It is estimated that about 22,900 farmers in or near the FPR pilot sites adopted new technologies on about 9,228 ha, while 3,370 pigs were raised with cassava silage. These

technologies have increased farmers' gross income by about 34,000 million dong as compared to their traditional practices.

- The widespread adoption of new technologies and their impact on farmers' income indicate the useful role of FPR methods as well as the value of the Nippon Foundation contribution in capacity building of researchers, extension workers and farmers.
- The project has convinced not only scientists and extension workers, but also high officials at different levels of the effectiveness of the use of farmer participatory methodologies. As such, the full support of local leaders has played a very important part in the rapid dissemination and adoption of new technologies.
- The experiences gained during the implementation of the project was a great contribution on the part of the Nippon Foundation by introducing a new methodology for transferring new technologies to improve agricultural production in Vietnam.

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THE FPR CASSAVA PROJECT AND ITS IMPACT IN THAI NGUYEN, TUYEN QUANG AND PHU THO PROVINCES OF NORTH VIETNAM

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ABSTRACT

With the support of the Nippon Foundation and CIAT, a series of Farmer Participatory Research (FPR) trials were conducted by farmers in Thai Nguyen, Tuyen Quang and Phu Tho provinces of northern Vietnam. Four technological components were tested in 12 pilot sites in three provinces, such as soil erosion control for better land management, balanced fertilization for cassava, intercropping with leguminous crops, and new cassava varieties.

The FPR methodology not only improved the knowledge of farmers in the pilot sites but also in the surrounding areas. The FPR project affected cassava cultivation in the three provinces: yields of cassava increased significantly. New varieties were most widely and most rapidly adopted, followed by balanced fertilizer use, soil conservation practices and intercropping.

INTRODUCTION

With the support of the Nippon Foundation and CIAT, a series of Farmer Participatory Research (FPR) trials have been conducted by farmers in three provinces of North Vietnam, i.e. in Thai Nguyen, Tuyen Quang and Phu Tho provinces. These trials were coordinated by two institutions, namely Thai Nguyen University of Agriculture and Forestry (TUAF) and the National Institute for Soils and Fertilizers (NISF).

Four technological components were tested by farmers in 12 research sites in three provinces, such as soil erosion control for more sustainable land management, balanced fertilization for cassava, intercropping with leguminous crops, and new cassava varieties.

RESULTS

Number of Farmers Participating in the Project

From 1999 to 2002 a total of 1,561 farmers in the three provinces participated in the project, conducting FPR trials on four technological components, testing various erosion control practices, fertilizers, intercropping systems and new varieties. **Table 1** shows that most farmers wanted to test new varieties, while fewer farmers were interested in conducting erosion control trials.

Research on Soil Erosion Control and Intercropping

In order to identify the most suitable experimental treatments to test in FPR trials, all farmers participating in the project were invited to visit and evaluate FPR demonstration plots. After discussion, farmers selected mainly those treatments involving various types of contour hedgerows for their FPR trials to be conducted on their own land.

In Minh Duc commune of Pho Yen district of Thai Nguyen province, two FPR soil

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erosion control trials with five treatments were conducted for two years. The data in **Figure 1** shows that when cassava was intercropped with peanut, the amount of eroded soil was reduced to 77% as compared to the farmers' traditional practice of monocropping. When hedgerows of *Tephrosia candida* and/or vetiver grass were added, erosion declined to only 40-49% of the check treatment, and most farmers selected this treatment for adoption and dissemination.

Table 1. Number of farmers that participated in the cassava FPR trials.

		Technological components			
No.	Commune/villages	Erosion control	Fertilizers	Intercropping	New varieties
Pho Yen district, Thai Nguyen province					
1	Dac Son	3	17	11	17
2	Tien Phong	5	48	118	100
3	Minh Duc	3	10	27	68
4	Hong Tien	4			44
5	Nam Tien				18
6	Van Phai				42
Son Duong district, Tuyen Quang province					
7	Am Thang	21	17	2	23
8	Hong Tien	22	15	3	31
9	Dong Loi		10		20
Phu Tho province					
10	Phuong Linh	28	20	28	25
11	Thong Nhat	30	25	42	400
12	Bao Thanh	70	60	24	110
	Total	**186**	**222**	**255**	**898**

In Hong Tien commune in Son Duong district of Tuyen Quang province, in addition to *Tephrosia* and vetiver grass, two grass species, i.e. *Paspalum atratum* and *Panicum maximum*, were also used as hedgerows for erosion control. The average results of two years indicate that the amount of eroded soil in treatments 3, 4 and 5 was only between 6 and 7 % of that in the check plot without hedgerows (**Figure 2**). The treatment with *Tephrosia candida* hedgerows reduced the dry soil loss to 14.1% of the check plot, and 63% of farmers participating in the field day selected this as the most suitable practice. The effectiveness of erosion control was actually better in those treatments with grass barriers, but only 0-17% of farmers selected any of those treatments, mainly because they were not aware of the benefit that could be obtained from grass hedgerows.

Research on Fertilizer Use

Based on problem identification by farmers, researchers and farmers considered low yielding varieties, degraded land, inadequate and unbalanced fertilization as the major constraints to obtaining high cassava yields. To overcome these problems a wide range of experiments on the use of balanced fertilization have been conducted by farmers.

In Am Thang and Hong Tien communes in Son Duong district of Tuyen Quang province, FPR trials on NPK fertilization were carried out by four households in 2000 and 2001. The results, shown in **Figure 3**, indicate that applying only 40 kg N and 40 K_2O/ha increased cassava yields by 39%, while the application of 80 kg N, 40 P_2O_5 and 80 K_2O/ha (treatment 4) increased the yield by 77% compared to the check without fertilizers. On the field days at harvest, almost all farmers selected these two treatments for adoption and dissemination to other cassava growing areas.

In Phuong Linh, Thong Nhat and Bao Thanh communes in Phu Tho province, a total of ten households conducted two trials on the use of various combinations of FYM and NPK fertilizers (**Tables 2** and **3**). In Phuong Linh, application of 10 t/ha of FYM combined with 60 kg N, 40-60 P_2O_5 and 80-120 K_2O/ha increased cassava yields on average 21-30%. In Thong Nhat and Bao Thanh, using 10 t/ha of FYM plus 80 kg N, 40 P_2O_5 and 80 K_2O/ha resulted in the highest yield, which was 19% higher than that obtained with the traditional practice of applying 10 t/ha of FYM and 500 kg/ha of 5:10:3 fertilizers.

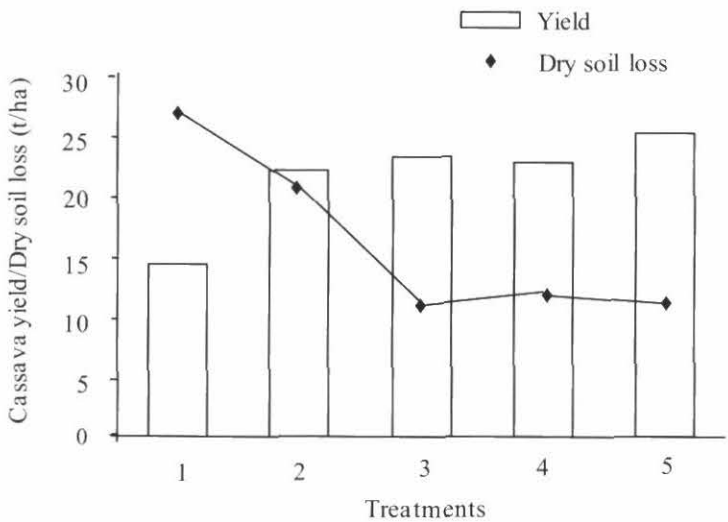

Figure 1. Average results of two FPR soil erosion control trials conducted by farmers in Minh Duc village, Thai Nguyen, in 1999 and 2000.

Treatments:

1. *Farmer practice (without hedgerows) + 12 tonnes FYM + 45 kg N + 30 P_2O_5/ha*
2. *C + peanut (without hedgerows) + 10 tonnes FYM + 80 kg N + 40 P_2O_5 + 80 K_2O/ha*
3. *C + peanut + vetiver (hed.) + 10 tonnes FYM + 80 kg N + 40 P_2O_5 + 80 K_2O/ha*
4. *C + peanut + Tephrosia (hed.) + 10 tonnes FYM + 80 kg N + 40 P_2O_5 + 80 K_2O/ha*
5. *C + peanut + Teph. and vetiver (hed.) + 10 tonnes FYM + 80 kg N + 40 P_2O_5 + 80 K_2O/ha*

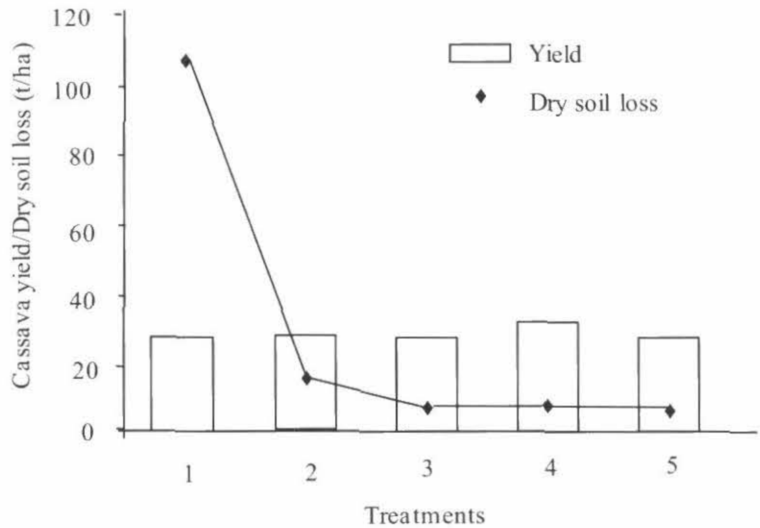

Figure 2. Average results of three FPR soil erosion control trials conducted by farmers in Hong Tien commune, Tuyen Quang, in 1999 and 2000.

Treatments:

1. *Farmer practice (without hedgerows) + 1,100 kg NPK (7:4:7)/ha*
2. *C + Tephrosia hedgerows + 1,100 kg NPK (7:4:7)/ha*
3. *C + vetiver hedgerows + 1,100 kg NPK (7:4:7)/ha*
4. *C + Paspalum atratum hedgerows + 1,100 kg NPK (7:4:7/ha)*
5. *C + Panicum maximum hedgerows + 1,100 kg NPK (7:4:7)/ha*

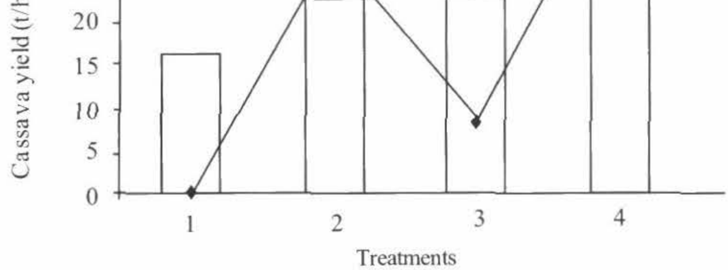

Figure 3. Combined results of four FPR fertilizer trials conducted by farmers in Am Thang and Hong Tien communes in Son Duong district of Tuyen Quang, in 2000 and 2001.

Treatments:
1. *Farmer practice (check without fertilizers)*
2. *40 kg N + 40 K_2O/ha*
3. *40 kg N + 20 P_2O_5 + 40 K_2O/ha*
4. *80 kg N + 40 P_2O_5 + 80 K_2O/ha*

Research on New Varieties

Based on problem identification by farmers, researchers and farmers considered low yielding varieties as one of major constraints to obtaining high cassava yields. To overcome these problems a wide range of experiments regarding the use of new varieties have been conducted by farmers.

Table 2. Average results of five FPR fertilizer trials conducted by farmers in Phuong Linh commune, Thanh Ba district of Phu Tho province from 1999 to 2001.

Treatments	Cassava yield (t/ha)				Compared to check plot (%)
	1999	2000	2001	**Average**	
1. 10 t/ha FYM (check plot)	13.5	18.5	18.5	**16.8**	100
2. 10 t/ha FYM + 60N + 60P_2O_5 + 120K_20	19.1	25.8	21.4	**22.1**	131
3. 10 t/ha FYM + 60N + 60P_2O_5 + 80K_20	18.9	28.5	20.7	**22.6**	134
4. 10 t/ha FYM + 60N + 40P_2O_5 + 120K_20	19.1	27.3	23.1	**23.2**	138

Table 3. Average results of five FPR fertilizer trials conducted by farmers in Thong Nhat and Bao Thanh communes, Phu Ninh district of Phu Tho province in 2001.

Treatments	Cassava yield (t/ha)			Compared to check plot (%)
	Thong Nhat	Bao Thanh	**Average**	
1. 10 t FYM + 500 kg NPK (5 :10 :3)	19.3	19.4	**19.4**	100
2. 10 t FYM + 40N + 20P_2O_5 + 40K_20	21.0	21.8	**21.4**	111
3. 10 t FYM + 80N + 40P_2O_5 + 80K_20	22.3	23.7	**23.0**	119
4. 10 t FYM + 80N + 40P_2O_5 + 120K_20	22.7	21.3	**22.0**	113
5. 10 t FYM + 80N + 60P_2O_5 + 120K_20	21.3	19.4	**20.4**	105

From 1999 to 2002, seven new varieties were tested by farmers in two villages of Son Duong district of Tuyen Quang province. The average results, shown in **Table 4**, indicate that the root yields of KM 60, KM 94 and KM 95-3 were considerably higher than those of the local varieties. On the field days at harvest, almost all farmers selected these varieties for adoption and dissemination to other cassava production areas.

In Phu Ninh district of Phu Tho province, six new varieties were tested by farmers in comparison with two local varieties. The result, shown in **Table 5**, indicate that most farmers selected KM 94 and KM 98-7 for adoption and dissemination to other cassava production areas.

In Pho Yen district of Thai Nguyen province, after testing many new varieties almost all farmers adopted and disseminated two varieties, i.e. KM 95-3 and KM 98-7 in six communes (**Table 6**).

IMPACT OF FPR PROJECT

The impact of the FPR project was not confined to only the pilot sites but extended also to other areas of these three provinces. The data shown in **Figure 4** indicate that the yield of cassava improved significantly from 1998 to 2002 in all three provinces.

Table 4. Average results of FPR variety trials conducted by farmers in two villages of Son Duong district in Tuyen Quang province from 1999 to 2002.

No.	Varieties	Cassava yield (t/ha)	Farmers' preference (%)
1	Vinh Phu (local)	25.45	2
2	La Tre (local)	24.70	17
3	KM 60	28.60	26
4	KM 94	33.80	65
5	KM 95-3	23.60	2
6	KM 98-7	25.12	26
7	OMR 38-72-12	26.41	0
8	OMR 37-52-6	24.90	0
9	OMR 37-52-8	22.70	0

Table 5. Average results of FPR variety trials conducted by farmers in Phu Ninh district of Phu Tho province.

No.	Varieties	Cassava yield (t/ha)	Farmers' preference (%)
1	Vinh Phu (local)	19.5	50
2	La Tre (local)	23.0	27
3	KM 94	29.0	80
4	KM 95-3	17.0	10
5	KM 98-7	24.7	76
6	OMR 37-52-8	20.5	2
7	OMR 37-51-26	20.6	3
8	OMR 37-71-12	20.0	0

Table 6. Adoption of new varieties in six communes of Pho Yen district in Thai Nguyen province in 2002.

Varieties	Item	Tien Phong	Dac Son	Minh Duc	Van Phai	Hong Tien	Nam Tien	Total
Vinh Phu (local)	No. households	18	6	34	9	12	9	88
	Area (ha)	0.64	0.27	1.62	0.32	0.61	0.40	3.86
	Yield (t/ha)	25.38	25.11	23.49	23.81	25.38	23.49	24.24
KM 95-3	No. households	50	5	34	17	16	9	131
	Area (ha)	1.60	0.22	0.65	0.70	0.58	0.29	4.04
	Yield (t/ha)	32.29	28.35	27.40	29.16	31.05	28.08	30.27
KM 98-7	No. households	50	11	34	17	16	9	137
	Area (ha)	3.56	0.49	0.86	1.46	1.42	0.36	8.15
	Yield (t/ha)	34.29	30.51	28.05	31.32	32.26	30.24	32.24

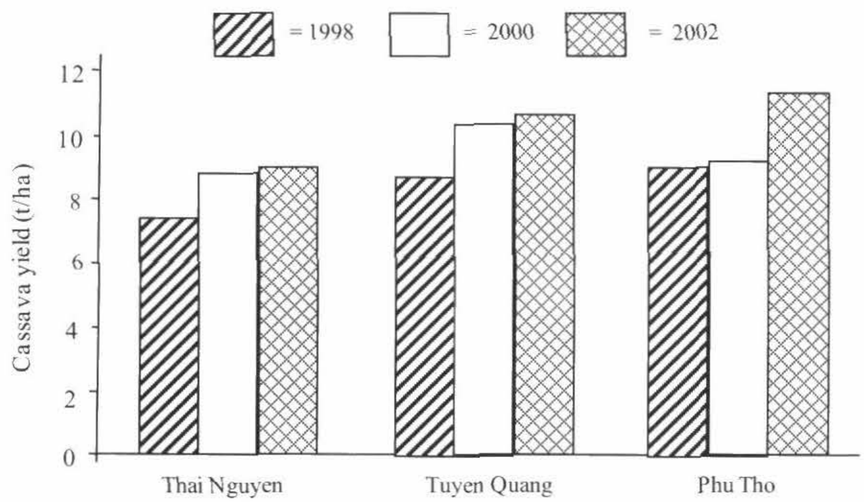

Figure 4. Average cassava yields in three provinces in 1998, 2000 and 2002.

CONCLUSIONS

- The FPR project not only improved the knowledge of farmers in the pilot sites but also in other surrounding areas.
- The FPR project markedly affected cassava cultivation in the three provinces, resulting in significant increases in cassava yields.
- The adoption of various technological components ranked as follows: new varieties > fertilizers > soil conservation > intercropping.

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THE FPR CASSAVA PROJECT AND ITS IMPACT IN HA TAY, HOA BINH AND THANH HOA PROVINCES OF NORTH VIETNAM

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ABSTRACT

Since 1999, a Farmer Participatory Research (FPR) methodology has been used with the objective of enhancing the development and adoption of efficient cassava production practices to reduce soil erosion, improve crop yields and increase the income of cassava farmers in Ha Tay, Hoa Binh and Thanh Hoa provinces. This FPR project was implemented by the Root Crops Research Center (RCRC) of the Vietnam Agricultural Sciences Institute (VASI) and by the National Institute for Soils and Fertilizers (NISF), both in Hanoi.

Rapid Rural Appraisals (RRAs) were conducted in cassava growing regions to select suitable pilot sites for the project in Ha Tay, Hoa Binh and Thanh Hoa provinces.

The first FPR trials were conducted in Hoa Binh province in 1995 by farmers on their own fields with help from FPR team members from NISF. Each trial tested one technology component, usually with 3-5 treatments. Many of these trials continued until 2003.

Similar FPR trials were started in Ha Tay in 2000 and in Thanh Hoa province in 2002, both by staff of RCRC of VASI, which continued until 2003.

During a field day at the end of each year, farmers and FPR team members jointly harvested all the plots and calculated cassava and intercrop yields as well as the amount of soil loss in each treatment of the erosion control trials. These results were discussed with the participating farmers in order to select the best treatments for next year; farmers generally selected 1-2 treatments that were considered most useful for their own conditions in order to try these in larger plots on their production fields.

This paper summarizes the results as well as the impacts of the project in Ha Tay, Hao Binh and Thanh Hoa provinces.

INTRODUCTION

Vietnam has a high potential for domestic consumption and export of cassava products. In the north of Vietnam, cassava is a significant source of food and animal feed for small-scale farm households.

Cassava is a suitable crop for farmers in remote areas and for rural development programs in mountainous areas. In the food security policies of Vietnam's government, cassava is an important staple food in mountainous areas.

At present, in the northern mountainous regions, the role of cassava is rapidly changing from a food crop to an industrial crop. Cassava roots are now an important raw material for production of starch by many factories in north Vietnam.

Problems of cassava production in the northern mountainous region are as follows:

- Low cassava yields in remote areas (10-15 t/ha on average) due to limited adoption

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of new varieties and appropriate production technologies.
- Serious soil erosion
- Low soil fertility
- Limited diversification of processed products
- Unstable price and lack of markets

Enhancing the adoption of more productive agronomic practices, reducing soil erosion, maintaining soil fertility and increasing the income of cassava farmers are very important and necessary.

The use of a farmer participatory research and extension methodology in the development and transfer of new technologies to cassava households has been quite successful in the mountainous and hilly areas of the north.

PILOT SITE SELECTION AND METHODS USED

Four villages in three provinces (Ha Tay, Hoa Binh and Thanh Hoa) were selected as the most suitable pilot sites for implementing the FPR project. The following activities were carried out:

1. Diagnostic surveys: these were conducted in the pilot sites using RRA and PRA methods in order to better understand the existing farming practices and to know the farmers' opinions about how to solve their limiting factors. These were conducted in 1999 in Thach Hoa commune in Thach That district and in Tran Phu commune of Chuong My district, both in Hay Tay province; in 1999 in Dong Rang village of Dong Xuan commune in Luong Son district of Hoa Binh province; and in 2002 in Nhu Xuan commune in Thanh Hoa province.

2. Conduct FPR trials: Four types of FPR trials were conducted by farmers on their own fields, i.e. on soil erosion control, fertilization, cassava intercropping with peanuts, mungbean or soybean, and on new cassava varieties.

3. Farmer meetings and field days: Meetings with farmers and farmer field days were organized many times during the year in each pilot site, to discuss and evaluate the results of the FPR trials, as well as to identify the most promising treatments to be tested next year.

RESULTS

1. Pilot Site Selection

The criteria for the selection of appropriate areas were:
- Cassava is an important crop in the area, both at present and in the future.
- Cassava is planted on slopes with serious soil erosion problems and low yields.

Four villages, namely Thach Hoa in Thach That district and Tran Phu in Chuong My district in Ha Tay province; Dong Rang village in Dong Xuan commune in Luong Son district of Hoa Binh province; and Yen Cat commune in Nhu Xuan district of Thanh Hoa province, were explored by conducting preliminary Rapid Rural Appraisals (RRAs). These were selected as suitable sites for the project (**Table 1**).

Table 1. Main problems in cassava production and the farmers' solutions in the four pilot sites in Ha Tay, Hoa Binh and Thanh Hoa provinces.

Village, district, province	Problems	Solutions
Thach Hoa, Thach That, Ha Tay and Dong Rang, Luong Son, Hoa Binh	-Soil erosion -Decreasing yield -Lack of knowledge about production and processing -Lack of capital	-Soil erosion control -Intercropping with peanut/soybean -Increasing fertilizer use
Tran Phu, Chuong My, Ha Tay	-Low yield and low price -Old variety -Poor knowledge about production and processing -Lack of capital -Decreasing yield	-Testing of new varieties -Cassava intercropping with peanut, mungbean and soybean -Need to apply fertilizers
Yen Cat, Nhu Xuan, Thanh Hoa	-Soil erosion -Low yield and low price -Old variety -Decreasing yield	-Soil erosion control -New varieties -Cassava intercropping with peanut -Increasing fertilizer use

2. Farmer Participatory Research (FPR) Trials.

2.1 Results of FPR variety trials

Tables 2, 3 and **4** summarise the results of promising clones in three sites in Ha Tay and Thanh Hoa provinces.

Table 2. Average results of FPR variety trials conducted by five farmers in Tran Phu village, Chuong My district, Ha Tay province from 2000 to 2002.

	Cassava yield (t/ha)			Average yield	Relative yield	Farmers' preference
Varieties	2000	2001	2002	(t/ha)	(%)	(%)
Du (control)	26.35	24.15	25.92	25.47	100.0	43
KM 98-7	-	30.10	28.56	29.33	115.2	82
KM 94	33.30	27.60	32.52	31.14	122.3	100
KM 60	30.30	28.43	33.90	30.88	121.2	100
KM 99-9	35.75	24.86	-	31.30	122.3	-
KM 95-3	27.0	26.25	-	26.63	104.6	-
Hainan 124	22.5	-	-	22.50	88.3	-
KM 21-10	-	-	30.00	30.00	117.8	-
KM 21-12	-	-	31.75	31.75	124.7	-

Table 3. Average results of FPR variety trials conducted by farmers in Thach Hoa village, Thach That district, Ha Tay province in 2002.

Varieties	Cassava yield (t/ha)	Relative yield (%)	Farmers' preference (%)
Vinh Phu (control)	19.70	100	0
KM 94	26.26	133	100
KM 60	25.30	128	50
KM 21-10	25.20	128	60
KM 21-12	32.20	163	100
KM 98-7	27.90	142	80

Table 4. Results of FPR variety trials conducted by farmers in Nhu Xuan district, Thanh Hoa province in 2002.

Varieties	Cassava yield (t/ha)	Relative yield (%)	Farmers' preference (%)
Vinh Phu (control)	22.0	100	-
KM 140-2	26.0	118	-
KM 98-7	24.0	109	-
KM 94	27.2	123	100
KM 108-2	40.2	183	-
SM 937-26	31.0	141	-
KM 60	20.6	94	-
KM 99-9	21.5	98	-
Local cultivar	19.2	87	-

The results show that:

- KM 94 and KM 60 continue to be the best varieties for cassava production in north Vietnam.
- New promising clones like KM 98-7, KM 21-10, KM 21-12 etc. will be further tested and may be selected in the future.

Dissemination of new cassava varieties

The dissemination of new cassava varieties in North Vietnam was evaluated by Dr. Kazuo Kawano (CIAT) and Vietnamese cassava breeders in 1997 as follows: in the north of Vietnam farmers grow new cassava varieties only on small pieces of land (360-500 m^2) and they raise pigs using this cassava. The dissemination of new cassava varieties is not as fast as in the south. However, at present cassava production in the mountainous and hilly areas of the north is changing very fast. The role of cassava in the North is rapidly changing from being an important food crop to an industrial crop, so the new cassava varieties are now rapidly being disseminated in the North as well as in the South (**Table 5**).

Table 5. Area (ha) planted to new cassava varieties in some provinces in North Vietnam.

Year	Yen Bai	Thanh Hoa	Hoa Binh	Ha Tay	Bac Can
2001	20	0.5	0.2	100	0
2002	1,050	1,000	0.5	200	0.5
2003	4,000	3,500	750	400	500

2.2 Results of FPR soil erosion control trials

Based on the information obtained through the RRA, a set of soil management technologies was tested in the FPR erosion control trials established in Thach That district of Ha Tay province, in Dong Rang village, Dong Xuan commune in Hoa Binh province, and in Nhu Xuan district of Thanh Hoa province (**Tables 6, 7, 8** and **9**).

Table 6. Results of an FPR erosion control trial conducted by a farmer in Thach That district of Ha Tay province from 2000 to 2002.

Year	Treatments	Dry soil loss (t/ha)	Relative dry soil loss (%)	Fresh cassava root yield (t/ha)	Farmers' preference (%)
2000	1. C without hedgerows (control)	9.3	100.0	25.5	0
	2. C+lemon grass hedgerows	3.9	22.5	25.5	0
	3. C+vetiver grass hedgerows	3.4	36.6	26.9	20
	4. C+pineapple hedgerows	6.7	72.0	25.6	20
	5. C+*Tephrosia candida* hedgerows	6.7	72.0	30.3	90
2001	1. C without hedgerows (control)	8.3	100.0	24.5	0
	2. C+*Paspalum atratum* hedgerows	6.8	81.9	22.4	0
	3. C+vetiver grass hedgerows	1.5	18.1	18.4	62
	4. C+pineapple hedgerows	2.4	28.9	16.0	16
	5. C+*Tephrosia candida* hedgerows	2.7	32.5	27.2	100
2002	1. C without hedgerows (control)	51.0	100.0	22.0	0
	2. C+*Paspalum atratum* hedgerows	2.0	3.9	23.7	38
	3. C+vetiver grass hedgerows	2.1	4.1	28.0	42
	4. C+pineapple hedgerows	21.0	41.2	23.3	35
	5. C+*Tephrosia candida* hedgerows	3.5	6.9	23.3	60

The results clearly show that contour hedgerows can significantly reduce soil erosion in cassava fields while also increasing cassava yields. Best results were obtained with contour hedgerows of vetiver grass. However, the selection by farmers are different: in Thach That, Ha Tay the farmers preferred contour hedgerow of *Tephrosia candida*; in Van Yen district, Yen Bai province the farmers preferred hedgerows of *Paspalum atratum*; in Nhu Xuan, Thanh Hoa province the farmers preferred hedgerows of pineapple; and in Dong Rang village, Luong Son district of Hoa Binh province, farmers preferred hedgerows of vetiver grass.

Table 7. Results of an FPR soil erosion control trial conducted by a farmer, Mr. Nguyen Van Chanh, in Dong Rang village, Hoa Binh. Data are average values for 2000 to 2002.

	Dry soil loss		Cassava yield	
Treatments	(t/ha)	(%)	(t/ha)	(%)
1. Cassava (C)without hedgerows	48.58	100	9.95	100
2. C+*Tephrosia candida* hedgerows	29.82	62	11.99	120
3. C+*Flemingia congesta* hedgerows	35.90	74	12.48	125
4. C+vetiver grass hedgerows	24.31	50	12.44	125
5. C+pineapple hedgerows	22.73	47	12.00	121

Table 8. Results of an FPR soil erosion control trial conducted by a farmer, Mr. Nguyen Van Tho, in Dong Rang village, Hoa Binh. Data are average values for 1996 to 2002.

	Dry soil loss		Cassava yield		Gross income	Production costs	Net income[1]	
Treatments	(t/ha)	%	(t/ha)	(%)	('000 VND/ha)			B/C
1. C+taro; no hedgerows	18.4	100.0	17.59	100	6,282	5,039	1,243	1.25
2. C+taro; vetiver hedgerows	3.2	17.4	21.80	124	7,701	5,809	1,892	1.33
3. C+taro; *Tephrosia* hedgerows	2.9	16.0	22.97	131	8,188	5,809	2,302	1.41
4. C+peanut; vetiver hedgerows	0.4	2.2	22.89	131	8,256	6,277	1,979	1.32
5. C+peanut; *Tephrosia* hedgerows	0.8	4.5	23.03	131	8,281	6,277	2,004	1.32

[1] Net income = Gross income – Production costs

Dissemination of soil erosion control technologies

It is rather difficult to disseminate contour hedgerow technologies to a large number of households; although farmers realize their importance, they don't like to actually do it. However, **Table 10** shows how this technology was adopted in some locations.

2.3 Results of FPR intercropping trials

Results of FPR intercropping trials conducted by farmers in Thach That and Chuong My districts in Ha Tay province and in Dong Rang, Hoa Binh province (**Tables 11** and **12**) show that the net income obtained from intercropping was higher than from cassava monoculture. Cassava intercropping with peanut gave the highest total gross and net income in all locations. Cassava was planted with 1 m in between rows and 1 m in between plants. The intercrops were planted along the sides of the cassava rows with either one or two rows between cassava rows. The data show that intercropping cassava with peanut increased net income between 50 and 100% as compared to cassava monoculture.

Dissemination of intercropping systems

Table 13 indicates that in 2000 cassava was basically grown only in monoculture. However, as a result of the positive results obtained in the FPR intercropping trials, the number of households practicing intercropping and the area under intercrops increased dramatically, reaching 999 households and 92.2 ha in 2003.

Table 9. The results of an FPR erosion control trial conducted by a farmer, Mr. Bui Thanh Mai, in Dong Rang, Luong Son, Hoa Binh from 1997 to 2001. For each treatment the top row indicates the cassava yield and the bottom row the peanut yield, both in t/ha.

	Year					
Treatment[1)]	1997	1998	1999	2000	2001	Average
1. C+P, no fertilizers, no hedgerows	10.75	10.90	13.90	14.17	14.17	12.78
	0.66	0.46	0.46	1.20	0.83	0.72
2. C+P, with fertilizers, no hedgerows	15.63	14.14	19.94	16.25	15.63	16.32
	0.82	0.49	0.43	0.90	1.00	0.73
3. C+P, with fertilizers, *Tephrosia* hedgerows	14.19	14.19	17.22	18.24	14.44	15.66
	0.74	0.47	0.46	0.91	1.02	0.72
4. C+P, with fertilizers, *Flemingia* hedgerows	14.19	14.14	18.30	18.59	13.57	15.76
	0.74	0.47	0.43	0.88	1.01	0.71
5. C+P, with fertilizers vetiver hedgerows	15.63	14.14	19.06	17.76	14.65	16.25
	0.69	0.67	0.46	0.71	0.83	0.67

[1)] C = cassava; P = intercropped peanut

Table 10. Number of households that adopted contour hedgerows for erosion control.

Year	Thach That Ha Tay	Nhu Xuan Thanh Hoa	Van Yen Yen Bai	Luong Son Hoa Binh
1999	0	0	0	15
2000	3	0	0	40
2001	14	0	3	40
2002	24	2	50	45
2003	30	10	>1000	45

2.4 Results of FPR fertilizer trials

Various FPR fertilizer trials, each with several combinations of N, P and K together with pig manure were conducted in Ha Tay and Hoa Binh provinces.

Results shown in **Tables 14, 15** and **16** indicate that almost all farmers preferred using medium levels of fertilizer for cassava, such as 40-60 kg N, 40 P_2O_5 and 80 K_2O/ha.

The results of these trials indicate that NPK fertilizers play a very important role for cassava in Thach That, Ha Tay. It is highly economic to apply 40-60 kg N, 40 P_2O_5 and 60-80 K_2O/ha if farmers want to get higher cassava yields. These are the rates that farmers also preferred (**Table 14**).

Dissemination of balanced fertilization practices

Up to now (2003) there are about 100 households in Thach Hoa, Thach That, Ha Tay and 50 households in Dong Rang, Luong Son, Hoa Binh who have adopted the use of improved fertilization practices such as 60 kg N + 40 P_2O_5 + 80 K_2O/ha plus 5-10 t/ha of pig manure.

Table 11. Average results of three FPR intercropping trials with cassava conducted by farmers in Tran Phu, Chuong My, Ha Tay, in 2001 and 2002.

Year	Cropping system	Cassava yield (t/ha)	Intercrop yield (t/ha)	Gross income[1]	Production costs[2]	Net income	Farmer Preference (%)
				('000 VND/ha)			
2001	1. C monoculture	29.46	-	8.838	0	8,838	0
	2. C+ peanut (1 row)	22.37	0.975	11,586	486	11,100	0
	3. C+ peanut (2 rows)	31.96	2.125	20,213	972	19,241	100
	4. C+ mungbean (2 rows)	33.45	0.400	13,235	500	12,700	12
	5. C+ watermelon	32.09	-	9,627	200	9,427	0
2002	1. C monoculture	22.2	-	7,700	0	7,700	0
	2. C+peanut (1 row)	25.0	0.884	13,170	486	12,684	35
	3. C+ peanut (2 rows)	24.0	1.916	17,982	972	17,054	85
	4. C+mung bean	22.9	0	8,001	500	7,501	10
	5. C+ soybean	25.7	0.400	10,981	500	10,481	10

[1] Prices: cassava roots 300 dong/kg fresh roots
peanuts 5,000 dong/kg dry pods
mungbean 8,000 dong/kg dry grain
soybean 9,000 dong/kg dry grain

[2] Costs: fertilizers 859,500 dong/ha
peanut seed 12,000 dong/kg dry pods
soybean seed 11,000 dong/kg
mungbean seed 10,000 dong/kg
labor from household is not included

Table 12. Average results of four FPR intercropping trials conducted by farmers in Thanh Hoa village, Thach That district, Ha Tay province in 2001.

Cropping systems[1]	Cassava yield (t/ha)	Intercrop yield (t/ha)	Gross income[2]	Production costs[3]	Net income	Farmers' preference (%)
			('000 VND/ha)			
1. C monoculture	24.9	-	7,470	-	7,470	0
2. C+peanut (1 row)	23.1	1.29	13,395	486	12,940	0
3. C+peanut (2 rows)	27.8	1.87	17,690	972	16,715	100
4. C+peanut (3 rows)	29.9	2.22	20,070	1,458	18,627	0

[1] Cassava is planted 2 weeks after peanut

[2] Prices: cassava 300 dong/kg fresh roots
peanuts 5,000 dong/kg dry pods

[2] Costs: peanut seed 12,000 dong/kg dry pods
fertilizers 859,500 dong/ha
labor from household not included

Table 13. Increase in the adoption of cassava intercropping systems in FPR pilot sites in five provinces of north Vietnam from 2000-2003.

Provinces	2000		2001		2002		2003	
	Area (ha)	No. households	Area (ha)	No. households	Area (ha)	No. households	Area (ha)	No. households
Ha Tay	0.2	5	-	60	12	250	20.0	400
Thanh Hoa	0	0	0	0	0	0	0.2	4
Hoa binh	0	0	0	0	0	0	10.0	50
Yen Bai	0	0	0.5	4	6	65	55.0	500
Son La	0	0	0	0	0	0	7.0	40
Total	0.2	5	0.5	64	12	315	92.2	994

Table 14. Results of three FPR fertilizer trials conducted by farmers in Thach That district, Ha Tay province, in 2000 to 2002.

Year	Treatments $N-P_2O_5-K_2O$ (kg/ha)	Cassava yield (t/ha)	Gross income[3] ('000VND/ha)	Fertilizer costs ('000VND/ha)	Net income ('000VND/ha)	Farmers' preference (%)
2000	1. 40-20-20[2]	27.1	8,130	409	4,821	10
	2. 40-40-0	30.7	9,210	462	5,848	0
	3. 40-0-40	29.3	8,790	356	5,534	0
	4. 60-40-80	32.5	9,750	880	5,910	90
	5. 80-40-120	32.3	9,690	1,138		0
2001	1. 40-20-20	23.0	6,900	409	3,591	0
	2. 40-40-40	25.0	7,500	622	3,978	60
	3. 60-40-80	27.2	8,160	880	4,380	100
	4. 80-40-120	27.6	8,280	1,138	4,242	0
2002	1. 60-0-60	21.7	6,510	533	3,077	0
	2. 60-40-60	24.3	7,290	800	3,590	75
	3. 60-80-60	26.3	7,890	1,066	3,924	55
	4. 60-120-60	31.8	9,540	1,333	5,307	60

[1] Net income = gross income-fertilizer costs

[2] Farmers' practice

[3] Prices; cassava dong 300 /kg fresh roots
urea (45% N) 2,200 /kg
fused Mg-phos (15% P_2O_5) 1,000 /kg
KCl (60% K_2O) 2,400 /kg
labor for monoculture without fertilizers = 2.8 mil. dong/ha
labor for fertilizer application = 0.1 mil. dong/ha

Table 15. Effect of various combinations of N, P and K fertilizers on cassava yields and gross and net income in Dong Rang, Luong Son, Hoa Binh. Data are average values for 2000 to 2002.

Treatments	Cassava yield (t/ha)	Gross income[2)]	Fertilizer costs[2)]	Production costs	Net income	B/C
		('000 VND/ha)				
1.No. fertilizers	13.07	4,574	0	2,800	1,774	1.63
2. NPK[1)]	21.21	7,424	809	3,709	3,715	2.00
3. NP	18.37	6,430	489	3,389	3,041	1.90
4. NK	17.76	6,216	542	3,442	2,774	1.81
5. PK	16.84	5,894	587	3,487	2,407	1.69
6. N	16.23	5,680	222	3,122	2,558	1.82
7. P	15.50	5,425	267	3,167	2,258	1.71
8. K	15.38	5,383	320	3,220	2,163	1.67

[1)] 40 kg N+40P_2O_5+80K_2O/ha

[2)] Prices: cassava dong 350/kg fresh roots
urea (45% N) 2,500/kg
fused Mg- phos. (15% P_2O_5) 1,000
KCl (60% K_2O) 2,400

Table 16. Effect of various combinations of N, P and K fertilizers on the yields of two cassava varieties in Dong Rang, Luong Son, Hoa Binh. Data are average values for 2000 to 2002.

Treatments	Cassava yield (t/ha)		Increase compared with T1 (t/ha)		Increase compared with T1 (%)		Increase in net income due to fert. ('000 VND/ha)		B/C	
N-P_2O_5-K_2O (kg/ha)	Vinh Phu	KM 98-7	Vinh Phu	KM 98-7	Vinh Phu	KM 98-7	Vinh Phu	KM 98-7	Vinh Phu	KM 98-7
1. no fertilizers	12.39	13.98	-	-	-	-	-	-	1.78	1.87
2. 40-40-80	18.34	22.55	5.95	8.58	48.0	61.4	1,849	2,498	2.09	2.33
3. 40-60-80	19.07	22.68	6.68	8.70	36.4	38.6	2,192	2,444	2.15	2.28
4. 60-40-80	16.88	20.64	4.49	6.66	23.6	29.4	1,267	1,718	1.91	2.10
5. 60-60-120	16.60	20.98	4.21	7.00	24.9	33.9	950	1,595	1.78	2.00

2.5 Training and farmer field days

Every year we have conducted farmer training sessions on "cassava production practices" during the field days in four sites of the project. Farmers and technicians participated in these training activities. **Table 17** shows the number of training sessions and the number of farmers participating.

The farmer field days were held in all the sites at the times of harvest of the intercrops and of the harvest of cassava. Those days, farmers, researchers, extensionists and local leaders worked together during the harvest, evaluation and discussion to select the best options to be tested again in the next season, and to select those technologies that were considered most useful for their own conditions. These were then later tried on their own farms.

Table 17. Farmers' field days and training in four sites.

		Year				
Commune, district, province	N° of training	2000	2001	2002	2003	Total
Thach Hoa, Thach That, Ha Tay	No. of training times	2	2	2	2	8
	No. of farmers	52	95	75	87	309
Tran Phu, Chuong My, Ha Tay	No. of training times	1	1	2	2	6
	No. of farmers	42	35	102	44	223
Nhu Xuan, Thanh Hoa.	No. of training times	-	-	1	1	2
	No. of farmers	-	-	35	70	105
Dong Rang, Luong Son, Hoa Binh	No. of training times	1	1	0	2	4
	No. of farmers	45	38	0	124	207

CONCLUSIONS

- FPR is a very useful methodology, both for the scientists and for the farmers, because the farmers know why we need to work together with them, and we can get feedback information about what farmers want to do. So, the researchers and extension workers can improve their skills in working with farmers.
- Using the various FPR methodologies can increase the adoption of new varieties and new technologies for improving cassava production.
- New cassava varieties and new technologies have been disseminated and have been adopted by a large number of households in the northern mountainous and hilly areas. So, farmers' incomes have increased.
- The following technologies were considered most useful and were adopted most widely by farmers in Ha Tay, Hoa Binh and Thanh Hoa provinces:
  - KM 94, KM 60 continue to be the most popular varieties for obtaining high yields. There are now some new promising clones like KM 98-7, KM 21-20 and KM 21- 12.
  - Cassava intercropping with two rows of peanut between cassava rows.
  - Applying a medium level of fertilizers such as 5-10 t/ha of pig manure plus 40-60 kg N, 40 P_2O_5 and 80 K_2O/ha.
  - Planting contour hedgerows of vetiver grass, *Paspalum atratum*, *Tephrosia candida*, or pineapple to control soil erosion in cassava fields.

THE FPR CASSAVA PROJECT IN THUA THIEN-HUE PROVINCE OF CENTRAL VIETNAM

Nguyen Thi Cach[1]

ABSTRACT

From FPR trials conducted in Hong Ha commune of A Luoi district, and in Thuong Long commune of Nam Dong district, it was found that the cassava varieties KM 98-1, KM 94, KM 140-2 and KM 108-2 grow well in Thua Thien-Hue province, with higher root yields, starch contents and economic benefits than the local varieties. It is recommended that these varieties be planted to supply the raw material for the cassava processing factories in Hue. The variety KM 98-1 can be planted for both food and industrial purpose as it has a low content of HCN.

KM 94 generally has the highest fresh leaf yield, dry leaf yield and protein content of the leaves, followed by KM 98-1; these two varieties tend to have higher yields than others such as SM 1447-7 and the local variety Nep.

Farmers selected red or black bean as the most suitable intercrops with cassava in upland areas, but preferred peanut or red bean for intercropping at lower elevations.

Ethnic minority people who are living in upland areas and tend to have low living standards selected the use of a mixture of 30 kg N, 30 P_2O_5 and 90 K_2O/ha to apply to their local cassava variety, in accordance to their limited investment potential.

Planting contour hedgerows of vetiver or *Paspalum* grass + pineapple or *Tephrosia candida* + pineapple on 21% slope was shown to be very effective in decreasing soil loss by erosion, and increasing cassava yields and income, as compared to planting cassava without hedgerows.

INTRODUCTION

Thua Thien-Hue province has mainly sloping land, corresponding to around 73.29% of the natural land area. Over time, soils in this tropical region have weathered, nutrients have leached out and soils on slopes have been lost by erosion resulting in poor soil physical and chemical characteristics. This has led to low cassava yields. Moreover, heavy rainfall and frequent typhoons have caused serious soil erosion. Thus, the soils used for growing cassava have to be improved by intercropping with legumes, by applying animal manures, compost, green manures and chemical fertilizers, especially potassium, and by the use of effective soil erosion control measures. Also, most farmers still plant local varieties which have low yields. By planting new cassava varieties which have higher fresh root yields and starch contents, farmers' income can be increased.

However, farmers should decide for themselves what is the best way to improve cassava. For that reason, participatory research (FPR) and action (FPA) is a good way to enhance the adoption of more sustainable cassava production practices.

In this paper we present the results of farmer participatory research, evaluation and selection of the most suitable new cassava varieties, which are adapted to the local soil and climate, and are suitable for current markets; similarly, we present the results of FPR trials on intercropping, fertilizer application and soil erosion control.

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METHODOLOGY

Hue University of Agriculture and Forestry (HUAF) evaluated and selected good cassava cultivars with farmer participation in Hong Ha, Thuong Long and Huong Van communes in Thua Thien-Hue province, in the central part of Vietnam.

The following farmer participatory methodologies were used:

- Establish groups of farmers interested in conducting FPR cassava trials
- Organize visits of these farmers to demonstration plots and train farmers and local extensionists
- Help farmers establish FPR trials on their own fields
- Monitor and evaluate the trials and treatments at field days/workshops
- Ask farmers to select new varieties or improved intercropping, fertilizer application or erosion control practices

RESULTS AND DISCUSSION

Results of Research on Cassava Varieties

The results of the FPR variety trials are shown in **Table 1**. The following varieties produced both high fresh root yields and starch yields: KM 98-1, KM 94, SM 1447-7, SM 937-26, KM 108-2 and KM 140-2. KM 98-1 had an average root yield of 31.2 t/ha and starch yield of 8.6 t/ha, while KM 94 had a root yield of 27.5 t/ha and starch yield of 8.1 t/ha. These two varieties have been tested for many years, from 1998 to 2002. In 2002 farmers also liked some of the other new varieties like KM 108-2 and KM 140-2. KM 98-1 produced especially high root yields and starch yields in upland areas; this variety was preferred by 100% of the farmers, because it not only produced high yields but also had a low cyanogenic potential, making this variety very suitable for both industrial use and for human consumption by ethnic minority people living in upland areas.

In another trial, four cassava varieties were evaluated for their production potential of both roots and leaves. **Table 2** shows that KM 94 produced the highest fresh leaf yield, dry leaf yield and protein yield. KM 98-1 had a higher fresh root yield, dry root yield and starch yield than KM 94 in this trial, but had a lower fresh leaf yield, dry leaf yield and protein yield. The other two varieties, SM 1447-7 and the local variety Nep, were not as productive in any of the root or leaf yield parameters.

Results of Research on Intercropping Cassava with Grain Legumes

Table 3, shows that 100% of farmers in Hong Ha commune of A Luoi district selected the intercropping of cassava with red or black beans because of the higher cassava root yields and net income obtained with these two intercropping systems. In Thuong Long commune of Nam Dong district farmers preferred intercropping with peanut or mungbean. At lower elevation in Huong Van commune of Huong Tra district, farmers preferred intercropping with peanut followed by mungbean, red bean and black bean.

Results of Research on Fertilization

In Hong Ha commune of A Luoi district, farmers conducted an FPR fertilizer trial with two different levels of N, P and K compared with a check without fertilizer using the local cassava variety Nep. **Table 4** shows that using the mixture of 60 kg N, 60 P_2O_5 and

120 K_2O/ha doubled the yield and increased the net income 2.3 times as compared to the check.

Table 1. Fresh root yield (FRY) and starch yield (SY) of cassava varieties tested in FPR trials conducted by farmers in two communes and at an experiment station in Thua Thien-Hue province of Central Vietnam from 1999-2003.

	Hong Ha				Thuong Long		Huong Tra[1]						
	1999/00		2000/01		2001/02		2002/03			Average		Farmers'	
Varieties	FRY (t/ha)	SY (t/ha)	FRY (t/ha)	SY (t/ha)	FRY (t/ha)	SY (t/ha)	FRY (t/ha)	SY (t/ha)	HCN	FRY (t/ha)	SY (t/ha)	preference (%)	Potential usage
Nep local	26.9	8.0	15.6	5.0	17.9	5.3	16.6	4.2	85	19.3	5.6	50-67	food, feed
Vinh Phu	28.3	8.5	24.2	7.4	21.7	5.7	21.5	5.8	111	23.9	6.9	35-37	food, feed
KM 94	29.2	8.8	24.9	7.9	28.0	8.0	27.8	7.7	202	27.5	8.1	40-91	starch
KM 98-1	31.8	9.5	34.8	8.8	29.1	8.2	28.9	7.8	115	31.2	8.6	100	food, feed, starch
SM 1447-7	32.1	8.2	-	-	24.0	7.2	-	-	-	28.1	7.7	37-51	feed, starch
SM 937-26	-	-	30.3	9.2	26.4	7.3	25.5	6.8	165	27.4	7.8	37-68	feed, starch
KM 98-5	-	-	-	-	29.0	8.1	23.4	6.1	179	26.2	7.1	36-50	feed, starch
KM 21-12	-	-	-	-	-	-	26.1	6.7	140	26.1	6.7	0	feed, starch
KM 111-1	-	-	-	-	-	-	21.2	5.1	138	21.2	5.1	0	feed, starch
KM 108-2	-	-	-	-	-	-	29.3	7.9	141	29.3	7.9	60-86	feed, starch
KM 140-2	-	-	-	-	-	-	29.6	7.6	143	29.6	7.6	60-86	feed, starch
KM 98-7	-	-	-	-	-	-	26.7	6.8	135	26.7	6.8	30	feed, starch

[1] Hue University Experiment Station in Huong Tra district.

Table 2. Results of the cassava leaf cutting trial conducted in Huong Hoa commune in Nam Dong district, Thua Thien Hue province in 2002.

Yield parameters	Nep (local)	KM 94	KM 98-1	SM 1447-7
Fresh leaf yield (kg/ha)	1,074.1	1,555.6	1,333.3	1,111.1
Leaf DM content (%)	25.5	27.5	26.0	26.5
Dry leaf yield (kg/ha)	273.9	427.8	346.7	294.1
Leaf protein content (%)	25.8	26.2	26.9	25.3
Leaf protein yield (kg/ha)	70.7	112.2	93.1	74.4
Fresh root yield (t/ha)	20.7	27.8	29.1	22.7
Root DM content (%)	30.3	32.1	30.9	30.2
Dry root yield (t/ha)	6.2	8.9	8.9	6.8
Root starch content (%)	24.3	25.6	24.9	24.4
Root starch yield (t/ha)	5.0	7.1	7.3	5.6

Table 3. Result of FPR cassava intercropping trials with peanut and various types of beans in Hong Ha, Thuong Long and Huong Van communes in Thua Thien-Hue in 2001/02.

	Hong Ha			Thuong Long			Huong Van			Farmers preference (%)		
Treatments[1)]	FRY (t/ha)	SY (t/ha)	Net income (mil. d/ha)	FRY (t/ha)	SY (t/ha)	Net income (mil. d/ha)	FRY (t/ha)	SY (t/ha)	Net income (mil. d/ha)	Hong Ha	Thuong Long	Huong Van
1.C monoculture	20.4	5.5	6.5	24.0	6.7	9.7	21.1	6.0	5.2	0	0	0
2.C+ red bean	22.0	6.0	9.4	25.7	7.2	10.1	24.7	6.9	8.2	100	100	50
3.C+ peanut	21.9	6.1	7.3	25.1	7.0	10.2	25.0	6.9	9.8	0	100	100
4.C+ black bean	22.1	6.2	7.6	24.9	6.9	9.6	24.5	6.8	7.9	100	10	42
5.C+ mungbean	21.8	6.0	6.6	25.0	7.0	9.9	24.7	6.9	8.2	54	75	56

[1)] cassava variety: KM 98-1
fertilizers: $30N+30P_2O_5+90K_2O$

[2)] Prices: cassava — dong — 500/kg fresh roots
peanut — 4,000/kg dry pods
red beans — 3,500/kg dry grain
black beans — 3,500/kg dry grain
mungbeans — 6,000/kg dry grain

[3)] Cost: peanut seed — 8,500/kg (need 160/kg/ha)
red/black bean seed — 6,000/kg (need 40 kg/ha)
mungbean seed — 12,000/kg (need 40 kg/ha)
labor — 15,000/man-day
labor for cassava monoculture: 1.8 mil. dong/ha (120 man-days)
labor for intercropping: 0.9 mil. dong/ha (60 man-days)

Table 4. Average results of three FPR fertilizer trials conducted by farmers in Thuong Long and Hong Ha commune, A Luoi district, Thua Thien-Hue in 2000.

Treatments (N, P and K in kg/ha)	Cassava root yield (t/ha)	Gross income[1)] ('000 dong/ha)	Production costs[2)] ('000 dong/ha)	Net income ('000 dong/ha)	Farmers' preference (%)
0 N+0 P+0 K	7.5	3,750	1,800	1,950	0
$30 N+30 P_2O_5+90 K_2O$	12.5	6,250	2,613	3,637	66
$60 N+60 P_2O_5+120 K_2O$	15.6	7,800	3,131	4,669	34

[1)] Prices: cassava — dong — 500/ kg fresh roots
urea (45% N) — 2,500/ kg
SSP (15% P_2O_5) — 1,100/ kg
KCl (50% K_2O) — 2,200/ kg

[2)] Cost of cassava cultivation: 1.8 mil. dong/ha (120 man-days)
Cost of fertilizer application: 0.03 mil. dong/ha (2 man-days)

Results of Research on Soil Erosion Control

Results of an FPR erosion control trial conducted by a farmer on 18% slope in Hong Ha commune is shown in **Table 5**. All types of hedgerows planted along contour lines decreased soil loss by erosion, and markedly increased cassava yields and income as compared to the check without hedgerows. Soil losses decreased dramatically with hedgerows of vetiver/*Paspalum* grass + pineapple, from 41.2 t/ha in 2001 down to 14.7 t/ha, in 2003; and with *Tephrosia candida* + pineapple from 49.6 down to 10.8 t/ha. The net income also increased markedly from 7.3 mil. dong/ha in 2001 to 14.6 mil. dong in 2003 using hedgerows of *Tephrosia candida* plus pineapple. All farmers preferred the use of *Tephrosia candida* + pineapple, while 76% preferred vetiver/*Paspalum* grass + pineapple as hedgerows for erosion control in Hong Ha commune.

Table 5. Results of an FPR erosion control trial with cassava conducted by a farmer on 18% slope in Hong Ha commune, A Luoi district, Thua Thien Hue, in 2001 and 2003.

	Dry soil loss (t/ha)		Cassava yield (t/ha)		Gross income[2]		Product. costs[3] ('000 dong/ha)		Net income		Farmers' preference (%)	
Hedgerow treatments[1]	2001	2003	2001	2003	2001	2003	2001	2003	2001	2003	2001	2003
Vetiver/*Paspalum*+pineapple	41.2	14.7	25.6	26.1	13.3	16.9	6.8	3.8	6.5	13.1	74	76
Sesbania cananabira+pineapple	57.5	54.8	26.8	27.5	12.9	16.1	6.8	3.8	6.1	12.3	0	0
Crotalaria usaramoeses+pineapple	63.3	49.3	27.2	27.9	13.6	16.5	6.8	3.8	6.8	12.7	0	0
Tephrosia candida+pineapple	49.6	10.8	28.0	30.2	14.1	18.4	6.8	3.8	7.3	14.6	100	100
Phaseolus calcaratus+pineapple	55.6	42.5	24.9	24.8	12.5	15.2	6.8	3.8	5.7	11.4	0	0
No hedgerows	91.2	89.4	17.5	16.0	8.8	8.2	6.8	3.8	2.0	4.4	0	0

[1] Fertilizers: 30 kg N + 30 P_2O_5 + 90 K_2O/ha
[2] Price: cassava dong 500/kg fresh roots
[3] Cost: urea (45% N) 2,500/ kg
SSP (17% P_2O_5) 1,000/ kg
KCl (50% K_2O) 2,200/ kg
total fertilizers = 0.74 mil. dong/ha
labor = 15,000 dong/man-day
labor for cassava cultivation (120 mdays/ha) = 1.8 mil. dong/ha
labor for fertilizer application (20 mdays/ha) = 0.3 mil. dong/ha
labor hedgerow planting + maintenance (10 mdays/ha) = 0.15 mil. dong/ha
hedgerow seed = 0.25 mil. dong/ha
pineapple planting material: 500 dong/shoot (need 6.000 shoots/ha) = 3.0 mil.dong/ha

CONCLUSIONS

1. In the central part of Vietnam, many new cassava varieties were evaluated by researchers at Hue University, and the best ones were tested by farmers on their own fields. KM 98-1 was the variety preferred by 100% of farmers, because of its high yield and low cyanogenic potential, so it can be used for both starch production and human consumption. Besides KM 98-1, farmers also liked KM 94, KM 108-2 and KM 140-2.
2. In a leaf production trial, KM 98-1 produced a higher fresh root yield, dry root yield and starch yield than KM 94, but had a lower fresh leaf yield, dry leaf yield and leaf protein yield. The other varieties, SM 1447-7 and the local variety Nep, were less productive in terms of both root and leaf yields. So, KM 94 is probably the best variety for production of both roots for starch production and leaves for animal feeding, followed by KM 98-1.
3. In upland areas of A Luoi and Nam Dong districts, the best cassava intercropping system was found to be that of red or black bean; but also peanut in Nam Dong in an area nearby a stream which had good soil. In lowland areas such as Huong Tra district farmers preferred intercropping with peanut.
4. In Hong Ha commune, farmers selected the application of 30 kg N, 30 P_2O_5 and 90 kg K_2O/ha as the most suitable fertilizer mixture for cassava, since this produced nearly double the yield as compared with the check without fertilizer, while it is still affordable for ethnic minority people who have a low living standard in the uplands.
5. Hedgerows of *Tephrosia candida* + pineapple or vetiver/*Paspalum atratum* + pineapple planted along contour lines were very effective in reducing soil losses by erosion in Hong Ha commune. Because soil loss decreased, both cassava yields and income increased. For that reason, most farmers preferred these two types of hedgerows.

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THE FPR CASSAVA PROJECT AND ITS IMPACT ON THE USE OF ENSILED CASSAVA ROOTS AND LEAVES FOR ON-FARM PIG FEEDING IN CENTRAL VIETNAM

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and Reinhardt Howeler[2]

ABSTRACT

Cassava *(Manihot esculenta* Crantz*)* is the third most important food crop in Vietnam, after rice and maize. In 2002 root production was about 3.145 million tonnes, much of which was used for on-farm animal feeding.

Making silage is an appropriate method to preserve cassava roots and leaves in order to reduce the toxicity of HCN; it is also easy to use under village conditions. Processing cassava roots and leaves by ensiling may be easier than sun-drying, especially during the wet season. Two communes, i.e. Huong Van commune in Huong Tra district and Hong Ha commune in A Luoi district of Thua Thien-Hue province were selected as pilot sites for conducting FPR pig feeding trials.

In trials conducted in Hong Ha, the inclusion of 20% as dry matter (DM) of ensiled cassava roots (ECR) in the diet of pigs increased the daily weight gain 4% and decreased the feed cost. In Huong Van commune the inclusion of 30% ECR (as DM) in the pigs' diet also improved the daily weight gain and decreased the feed cost by 7.3%.

Under village conditions, ensiled cassava roots can be used up to 45 to 60% of DM in the diet of pigs without affecting the animals' health or overall performance; it also resulted in a 15.5-18.3% reduction in feed cost when the diet was carefully balanced.

Using various additives for ensiling cassava leaves, it was found that the inclusion of rice bran or cassava root meal at levels of 5 or 10% and fresh cassava roots at levels of up to 50% (on fresh cassava leaves basis) produces good quality silage that could be stored for at least five months. The HCN content of ensiled cassava leaves (ECL) decreased very quickly during the first 30 days, and the HCN content was only about 20-28% of the initial level at 90 days after ensiling.

In diets for growing pigs, the inclusion of 15% (as DM) of ensiled cassava leaves improved the daily weight gain and the feed conversion ratio, and reduced the feed cost by 25%.

Substituting 45% DM with ensiled cassava (13% ECL + 32% ECR) in the diet of growing pigs increased the daily weight gain by 9.32% and significantly reduced the feed cost/kg gain by 26.83%.

In Huong Van commune the use of 16% ensiled cassava leaves or dry cassava leaf meal in the diet of growing pigs (as DM) had no statistically significant effect on the live weight gain or feed conversion ratio, but reduced the feed cost by 12-16% as compared to pigs fed a diet containing 16% ensiled sweet potato vines (ESP).

Additionally, supplementation with 0.1% DL-methionine in diets of pigs containing 45% (as DM) ensiled cassava (15% ECL and 30% ECR) increased the daily weight gain and reduced the feed cost.

In conclusion, ensiled cassava roots and leaves were used effectively for feeding pigs, and resulted in increased incomes for farmers.

Ensiling is the best method of preserving cassava when the harvest of cassava coincides with the rainy season; the technique is simple, cheap and suitable for farm conditions in Central Vietnam.

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Farmer Participatory Research (FPR) is the best method to develop technologies and transfer these to farmers.

INTRODUCTION

Cassava *(Manihot esculenta* Crantz*)* is the third most important food crop in Vietnam, after rice and maize. In 2002 root production was about 3.145 million tonnes (Pham Van Bien *et al.*, 2007), much of which was used for animal feeding. In 2001/02 the cassava area was more than 288,000 ha of which about 94,500 ha were planted with new varieties such as KM 60, KM 94, KM 95, KM 95-3 and KM 98-1. This corresponds to about 33% of the total cassava area in the country (Pham Van Bien *et al.,* 2007). These new high-yield cassava varieties usually have higher HCN contents than the local varieties.

At root harvesting time, the fresh leaf yield is about 5 t/ha and the yield of total green foliage is about 7 t/ha (Duong and Ngoan, 1993). Because of their high protein content of 21-28% (Nguyen Thi Hoa Ly *et al.*, 2001; 2002) with almost 85% of the crude protein fraction as true protein (Ravindran, 1993), cassava leaves are a good source of protein for pigs. Supplementation with DL-methionine has been reported necessary for the detoxification of cyanide and to improve the utilization of protein in pigs (Job, 1975; Portela and Maner, 1973).

Cassava roots contain high levels of energy and have been used as an energy source for animals, while cassava leaves contain high level of crude protein and are a good source of protein for animals. However, their high contents of cyanide limits their use as an animal feed.

The most common procedures for reducing the cyanide content are sun-drying and ensiling (Duong Thanh Liem *et al.*, 2000; Nguyen Thi Hoa Ly and Nguyen Thi Loc, 2000; Nguyen Thi Hoa Ly *et al.,* 1999, 2001; Nguyen Thi Loc, 2001; Bui Huy Nhu Phuc *et al.*, 2001; Wanapat, 2001).

When the root harvest corresponds with the rainy season it is difficult to sun-dry, so making silage is an appropriate method to preserve cassava roots and leaves and to reduce the toxicity of HCN; it is also applicable under village conditions. Processing cassava roots and leaves by ensiling is simpler than sun-drying, especially during the wet season.

Farmer Participatory Research in Thua Thien-Hue started in 2000 as part of the Nippon Foundation Cassava Project. This is a collaborative project between Hue University of Agriculture and Forestry (HUAF) and the Centro Internacional de Agricultura Tropical (CIAT). Two communes, Huong Van commune in Huong Tra district and Hong Ha commune in A Luoi district in Thua Thien Hue province, were selected as pilot sites for the FPR project.

Some treatments, evaluated on-station of the effect of additives on the quality of ensiled cassava leaves (ECL), were tested in FPR trials conducted in Huong Van and Hong Ha communes to identify the effects of using ensiled cassava roots (ECR) and ensiled cassava leaves (ECL) in diets of pigs from 2000 to 2003.

The project aimed:

- To introduce preservation methods of cassava roots and leaves by ensiling.
- To evaluate the use of ensiled cassava roots and leaves for pig feeding on the pigs' performance under real farm conditions in central Vietnam.

RESULTS

1. Ensiled Cassava Roots (ECR) for Feeding Growing Pigs

In Central Vietnam making silage is an appropriate method to preserve cassava roots to be used for pig feeding and is applicable under village conditions. After harvesting, roots (local or KM 94 variety) were cleaned, grated and mixed with 0.5% salt. The mixture was put into large plastic bags of 20-30 liters, the wet mass was compacted to expel all air and the bags were tied. The roots were left to ferment naturally. The mixture could already be used after 2-3 weeks of ensiling, or could be stored for 6-8 months.

An FPR trial was carried out in four households of Hong Ha commune in 2001 to determine the effect on pig performance of using ensiled cassava roots (ECR) in the diet. The results indicate that the daily weight gain of pigs fed 20% ECR (as DM) in the diet was 4% higher than that of pigs fed the control diet. Using a 20% of DM inclusion of ECR in the pigs' ration increased the growth rate and reduced feed cost/kg gain by 3.9%. A similar trial conducted in Huong Van commune, using a 30% of DM inclusion of ECR in the pigs' ration improved both the daily weight gain and feed cost by 7.3%. The effect of even higher levels of ensiled cassava roots (ECR) in the diets of growing pigs is shown in **Table 1**.

Table 1. Effect of increasing levels of ensiled cassava roots in the diets of growing pigs on the pigs' performance in Huong Van commune, Huong Tra district of Thua Thien-Hue province, Vietnam, in 2002/03.

Treatments	Control[1)]	45% ECR[1)]	60% ECR[1)]
Live weight, (kg)			
- initial	27.7	27.6	28.4
- final	76.0	78.0	80.3
Live weight gain (g/day)	536.0	560.0	577.0
(%)	100.0	104.5	107.6
Daily feed intake (kg DM/day)	1.58	1.55	1.63
Feed conversion ratio (kg DM/kg gain)	2.89	2.73	2.76
(%)	100.0	94.5	95.5
Feed cost (VND)/kg gain	7,057.0	5,960.0	5,763.0
(%)	100.0	84.5	81.7

[1)]Control: Control diet with rice bran, maize, fish meal and sweet potato vines.
45 ECR: Diet containing 45 % ensiled cassava roots (as DM)
60 ECR: Diet containing 60 % ensiled cassava roots (as DM)

The data in **Table 1** indicate that there were no statistically significant differences in live weight gain (LWG), daily feed intake (DFI) as well as feed conversion ratio (FCR) between the pigs fed the 45 and 60% ECR and the control diet ($P>0.05$). However, the daily weight gain of pigs fed 45 and 60% ECR in the diet were 4.5 and 7.6% higher, respectively, than the control diet (**Figure 1**). The feed conversion ratio (FCR) of pigs fed 45 and 60% ECR in the diet were 5.5 and 4.5% lower, respectively, while the feed costs per kg gain were 15.5 and 18.3% lower, respectively, than those of pigs fed the control diet (**Figure 2**).

The present study has shown that under village conditions, ensiled cassava roots (ECR) can be used up to 45 to 60% of DM in the diet of pigs without affecting the animals' health or overall performance. It also resulted in a 15.5-18.3% reduction in feed cost when the diet was carefully balanced.

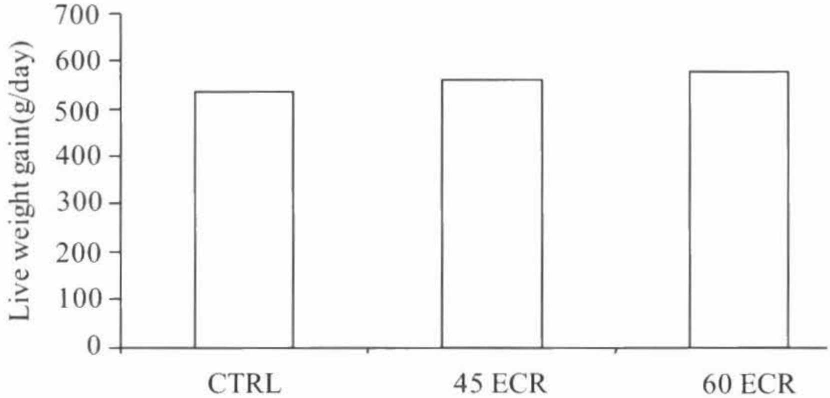

Figure 1. Effect of increasing levels of ensiled cassava roots in the diets of growing pigs on live weight gain in Huong Van commune in 2002/03.

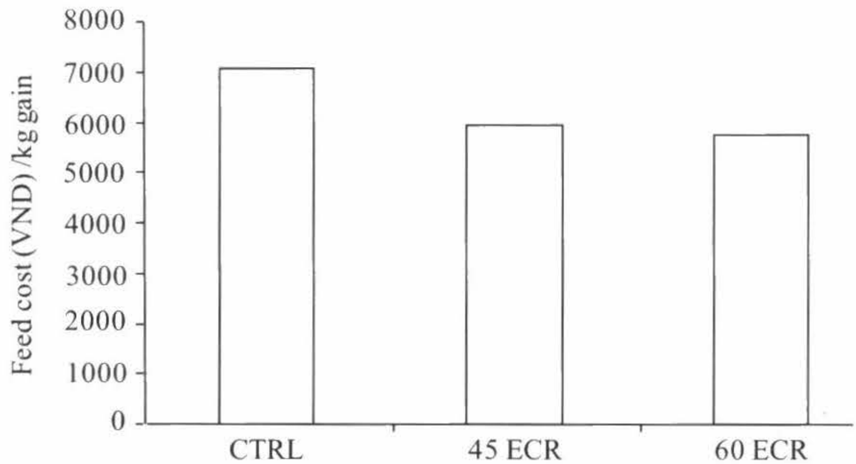

Figure 2: Effect of increasing levels of ensiled cassava roots in the diets of growing pigs on feed cost in Huong Van commune in 2002/03.

2. Ensiled Cassava Leaves (ECL) for Feeding Growing Pigs

Fresh leaves of cassava (Ba Trang variety) were collected at time of root harvest and spread out on the floor some hours or overnight for wilting. The leaves were separated from the stems and petioles, chopped into small pieces (2-3 cm), mixed with 0.5% salt and additives: rice bran, cassava root meal at 5 and 10% levels, and fresh cassava grated roots at four different levels: 20, 30, 40 and 50% (fresh basis). The eight treatments were:

1. Cassava leaves + 5 % rice bran
2. Cassava leaves + 10 % rice bran
3. Cassava leaves + 5 % cassava root meal
4. Cassava leaves + 10 % cassava root meal
5. Cassava leaves + 20 % fresh cassava roots (fresh basis)
6. Cassava leaves + 30 % fresh cassava roots (fresh basis)
7. Cassava leaves + 40 % fresh cassava roots (fresh basis)
8. Cassava leaves + 50 % fresh cassava roots (fresh basis)

The ensiled cassava leaves (ECL) were analyzed for dry matter (DM), crude protein (CP) and hydrogen cyanide (HCN) at 30, 60 and 90 days after ensiling. The analysis was done in the University laboratories from 12/2002 to 3/2003.

The inclusion of the additives such as rice bran or cassava root meal at levels of 5 and 10%, or fresh cassava roots at 20, 30, 40 and 50% (on fresh weight basis) is meant to maintain good quality silage for at least five months. The DM content of the silage using different additives varied from 26.4-33%, while the CP content varied from 19.8-27.5% (as DM) at 90 days after ensiling (**Table 2**). The HCN content of ECL decreased very quickly from the first day to 30 days and then continued to decrease from 30 to 90 days; the HCN content was only about 20-28% of the initial level at 90 days after ensiling.

Table 2. The effect of adding various amounts of rice bran, cassava root meal and fresh (grated) cassava roots to cassava leaves during ensiling on the dry matter, crude protein and hydrogen cyanide content of the silage 1, 30 and 90 days after ensiling at Hue Univ. of Agric. and Forestry, in 2002/03.

	Dry matter (%)			Crude protein (% DM)			HCN (mg/kg fresh)		
Treatments	1 day	30 days	90 days	1 day	30 days	90 days	1 day	30 days	90 days
Fresh cassava leaves (CL)	25.5	-	-	29.8	-	-	323	-	-
1. CL+5% rice bran	33.8	30.8	30.1	29.8	27.2	26.9	283	137	75
2. CL+10% rice bran	34.8	32.9	31.9	28.0	25.8	24.6	269	130	78
3. CL+5% root meal	31.7	32.3	31.5	29.2	28.3	27.5	287	143	89
4. CL+10% root meal	34.7	33.8	33.0	26.8	24.9	25.1	274	125	70
5. CL+20% fresh cassava roots	26.8	25.7	26.4	27.0	26.4	25.1	292	146	80
6. CL+30% fresh cassava roots	28.2	26.7	27.8	24.5	24.2	22.6	272	141	71
7. CL+40% fresh cassava roots	29.6	27.4	28.3	22.5	21.6	21.7	252	148	71
8. CL+50% fresh cassava roots	29.4	28.6	28.4	21.4	20.8	19.8	232	112	65

An FPR trial on the effect of using 15% (as DM) of ensiled cassava leaves in the diet of growing pigs on performance conducted by farmers in Huong Van commune in 2001 showed that using a 15% of DM inclusion of ECL in the pigs' ration did not affect the growth rate but reduced feed cost/kg gain by 25.62% ($P<0.001$).

A similar FPR trial using ensiled cassava roots (ECR) and ensiled cassava leaves (ECL) in the diet of growing pigs at Hong Ha commune in 2002 showed that daily weight gain was 9.32% higher and the feed conversion was 9.73% lower with the use of 45% of DM as ensiled cassava (13% ECL + 32% ECR) in the diet of growing pigs. The feed cost was 26.83% lower using ECR and ECL in the diet ($P < 0.05$). The inclusion of 45% of DM as ensiled cassava (13% ECL and 32% ECR) in the pigs' diet increased the daily weight gain and reduced the feed cost by 26.83 %.

Another FPR trial on the effect of using cassava leaves after either ensiling or sun drying in the diet of growing pigs was carried out by five families at Huong Van commune in 2002. These five families raised a total of 30 pigs, all cross-breeds between Mong Cai and Large White, with initial live weight of around 22-26 kg. Each farmer raised six randomly assigned pigs, distributed into three treatments with two pigs per pen for each treatment.

The basal diet (traditional diet) consisted of rice bran + fermented fish + ensiled cassava roots (25% as DM) + sweet potato vines, combined with the following treatments:

Treat. 1: pigs fed 84 % basal diet + 16 % (as DM) ensiled sweet potato vines (ESP)
Treat. 2: pigs fed 84 % basal diet + 16 % (as DM) ensiled cassava leaves (ECL)
Treat. 3: pigs fed 84 % basal diet + 16 % (as DM) cassava leaf meal (CLM)

The experiment lasted for 92 days. The effect of using ESP, ECL and CLM in growing pigs ration is shown in **Table 3**.

Table 3. Average results of five FPR pig feeding trials on adding ensiled cassava and sweet potato leaves or cassava leaf meal to the diet, conducted by farmers in Huong Van commune, Huong Tra, Thua Thien-Hue, Vietnam in 2002.

Treatments	No. of pigs	Life weight (kg) initial	3 months	LWG[1)] (g/day)	FCR[2)] (kg DM/kg gain)	Feed cost[3)] (mg/kg fresh)
84% control diet+16% ESP	10	25.70	74.04	525.1	3.92	8,419
84% control diet+16% ECL	10	23.70	71.61	520.8	3.86	7,416
84% control diet+16% CLM	10	22.20	67.00	486.9	3.85	7,076
F test				NS	NS	

[1)] LWG = live weight gain
[2)] FCR = feed conversion ratio
Control diet of rice bran 56%, fermented fish 6%, ensiled cassava root 30%, and sweet potato vine 8% (as DM)
16% ESP = 16% ensiled sweet potato vines on DM basis
16% ECL = 16% ensiled cassava leaves on DM basis
16% CLM = 16% dry cassava leaf meal on DM basis
Note: price of feed in Huong Van: rice bran: 2000 VND/kg; fermented fish: 2200 VND/kg; ECR: 400 VND/kg; fresh SP vine 400 VND/kg; plastic bag 3000 VND; cassava leaves at harvest considered free.

There were no statistically significant differences in live weight gain (LWG) or in feed conversion ratio (FCR) between the pigs fed 16% ESP in the diet (as DM) and the ECL or CLM diet ($P>0.05$). However daily weigh gain of pigs fed 16% ESP and ECL in diet were 7.8 and 6.3% higher, respectively, than the CLM diet (**Figure 3**).

Using 16% ensiled cassava leaves (ECL) or dry cassava leaf meal (CLM) in the diet of growing pigs (as DM) had no statistically significant effect on live weight gain (LWG) or feed conversion ratio (FCR), but reduced the feed cost by 12-16%, as compared to pigs fed a diet containing 16% ensiled sweet potato vines (ESP).

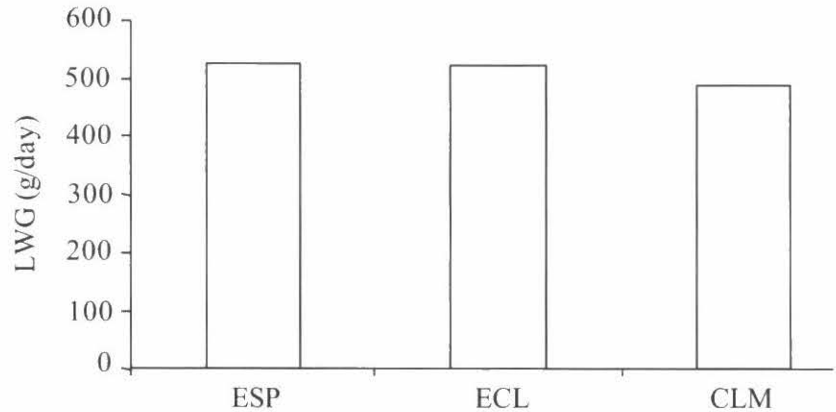

Figure 3: Daily live weight gain (LWG) of growing pigs in three treatments using ensiled sweetpotato vines (ESP),ensiled cassava leaves (ECL) or cassava leaf meal (CLM) in the pigs' diet in Huong Van commune in 2002.

Results of another FPR trial on the effect of methionine supplementation in the diet of growing pigs containing 45% of DM from cassava (30% DM from ECR and 15% from ECL) is shown in **Table 4.**

Table 4. Results of an FPR trial on methionine supplementation of pig feed containing ensiled cassava root (ECR) and leaves (ECL) in diets of growing pigs conducted by farmers in Huong Van commune, Huong Tra district of Thua Thien-Hue ,Vietnam in 2003.

Treatments	Control[1)]	0.05% Met[1)]	0.1% Met[1)]
Live weight, (kg)			
- initial	20.1	20.8	20.6
- final	69.9	71.5	74.2
LWG (g/day)	553.3	563.0	595.6
%	100.0	101.8	107.6
FCR (kg DM/kg gain)	2.85	2.83	2.66
%	100.0	99.3	93.3
Feed cost/kg gain (VND	5,270.0	5,326.0	5,038.0

[1)] 0.05% Met and 0.1% Met: diets supplemented with 0.05 and 0.1% Methionine (as DM), respectively.

The data in **Table 4** indicate that supplementing with 0.05 or 0.1% DL-methionine in diets containing 45% ensiled cassava (30% ECR+15% ECL) increased the daily weight gain and reduced the feed cost. Supplementation with 0.1% methionine in the diet of these pigs was highly economic.

Similar findings were also reported by Nguyen Thi Loc and Le Khac Huy (2003) who found that supplementation with DL-methionine at 0.2% level in ensiled cassava roots-based diets of F_1 (MC x LW) fattening pigs improved the live weight gain, daily gain, feed conversion ratio and feed cost.

3. Adoption of the Use of ECR and ECL in Pig Feed in Huong Van and Hong Ha Communes

Ensiling is a convenient way of preserving the nutritional value and reducing the toxicity of fresh cassava roots and leaves. In Central Vietnam, ensiling is the best method of preserving cassava, as the harvest of cassava roots coincides with the rainy season. The technique is simple, cheap and suitable for the conditions of farmers. FPR is the best method to develop and transfer technologies with farmers. The number of farmers that adopted the use of ECR and ECL in the diets of pigs increased in Hong Ha and Huong Van communes from 2000/01 to 2003/04, indicating the effectiveness of the farmer participatory approach in Central Vietnam.

Table 5: Adoption trends of the use of ensiled cassava roots and leaves as well as cassava root meal in pig feeding diets in Hong Ha and Huong Van communes in Thua Thien-Hue province from 2000 to 2003.

Commune - Year	Number of households (hh)	No hh. keeping pigs	No hh. using ECR	No hh. using ECL	No hh. using CLM
Hong Ha - 2000/01	187	66	31	8	0
- 2001/02	229	89	48	20	0
- 2002/03	244	86	53	28	0
- 2003/04	246	134	65	27	0
Huong Van - 2000/01	1281	1041	728	20	0
- 2001/02	1300	1171	819	40	5
- 2002/03	1302	1205	964	190	10

CONCLUSIONS AND RECOMMENDATIONS

- Ensiling cassava leaves with either rice bran or cassava root meal at 5 or 10%, or with fresh grated cassava roots at levels of 20-50% (on fresh weight basis) produced good quality silage that could be stored for up to five months.
- Under village conditions using 20-60% ECR in the diets (as DM) of growing pigs increased the live weight gain (LWG), decreased the feed conversion ratio (FCR), and reduced feed cost by 7.3-18.3%.
- Using a 13-15% of DM inclusion of ECL in the pigs' ration containing 30% ECR (as DM) as replacement for sweet potato vines and partial replacement of fish meal in diets of growing pigs did not significantly effect the growth rate, but reduced feed cost/kg gain by 12-26.83%.
- Supplementation with 0.1% methionine in diets containing 30% ECR and 15% ECL of growing pigs improved the performance of these pigs.
- Ensiled cassava leaves can be used as a supplemental source for feeding pigs.

- The use of diets based on ensiled cassava roots (ECR) and ensiled cassava leaves (ECL) can bring economic benefits to farmers, especially those raising pigs in Central Vietnam.
- Conducting FPR trials with farmers to identify the most appropriate preservation methods of cassava roots and leaves by ensiling, is the best method to develop and transfer these technologies to farmers.

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THE FPR CASSAVA PROJECT AND ITS IMPACT IN SOUTH VIETNAM

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ABSTRACT

Farmer Participatory Research (FPR) in South Vietnam has been carried out since 1998 in collaboration with CIAT and with financial support from the Nippon Foundation in Japan. The main objective was to increase the adoption of better agronomic practices and improved varieties of cassava in farmers fields. The pilot sites for implementing the FPR methodology were as follows: one village in Thong Nhat district, Dong Nai province; two villages in Dong Phu and Binh Long districts, Binh Phuoc province; two villages in Chau Duc district, Ba Ria-Vung Tau province; and one village in Chau Thanh district, Tay Ninh province.

Using RRA and PRA methods we first conducted a diagnostic survey. Some main limiting factors in cassava production were identified, such as lack of new cassava varieties with high yield and high starch content, and lack of new technologies for weed control, fertilization, intercropping and control of soil erosion.

Demonstration plots and farmer field days were held in each pilot site for discussion and selection of the most promising treatments. Farmers also discussed how to organize, manage and evaluate the FPR trials in their own fields. Since then, many FPR trials have been conducted by farmers on their own fields, while new technologies were disseminated to other cassava farmers in the region of the pilot sites. This research produced the following results:

- Results of 17 erosion control trials, conducted by farmers in Dong Tam village, Dong Phu district, Binh Phuoc province, and in Suoi Rao village, Chau Duc district, Ba Ria-Vung Tau province, indicate that planting contour hedgerows of vetiver grass or *Paspalum atratum* markedly reduced soil losses by erosion and produced high cassava yields and net income.
- Results of 20 FPR cassava intercropping trials, conducted by farmers in An Vien, Dong Tam and Suoi Rao villages indicate that cassava intercropping with peanut and mungbean gave the highest yields and net income. The cropping pattern of cassava intercropped with one row of peanut was more suitable than the cropping pattern with two rows of peanut between cassava rows.
- The results of 26 cassava fertilizer trials using chemical fertilizers and bio-fertilizers indicate that in cassava fields the application of 80 kg N+40 P_2O_5+80 K_2O/ha or 40 kg N+40 P_2O_5+ 80 K_2O+5 t/ha manure, and the use of 1 t/ha bio-fertilizer/ha gave high economic returns.
- For controlling weeds in cassava fields, the results in most of the trials conducted by farmers showed that the application of the pre-emergence herbicide Dual or the use of plastic to cover the soil could control most of the weeds and gave high economic returns. And also, it is more convenient than the traditional method of controling weeds by hand using a hoe.
- 22 FPR cassava variety trials were conducted by farmers. Five varieties, i.e. KM 94, KM 98-5, KM 140-4, KM 146 and KM 9123 have already been selected as the most suitable in most of the pilot sites, as these varieties gave the highest yields and economic returns.
- The project in South Vietnam organized one training course for trainers, ten training courses for farmers, and held 12 field days with total participation of 750 farmers.
- From 1999 to 2003 the project has been working with 431 households and the total area of adoption of new technologies was 286.4 ha. Beside that, the project had a marked effect on cassava

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production in South Vietnam, where an estimated 600 ha are now planted with new cassava varieties, use balanced fertilizer application and good weed control.

INTRODUCTION

In South Vietnam, cassava (*Manihot esculenta* Crantz) was an important food crop, which occupied about the fifth position in terms of area planted, after rice, maize, sweet potato and vegetables. It was mainly grown by farmers in marginal areas, characterized by poor soil quality, especially in sloping areas and in tropical climates with mean monthly temperatures of about 26.3-28.9^{0}C, and rainfall ranging from 3.3 mm to 384.4 mm in a month (**Figure 1**).

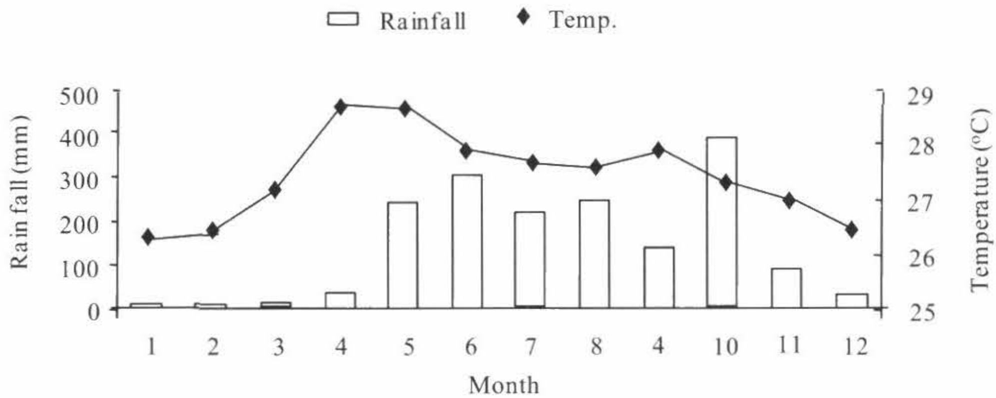

Figure 1. Monthly rainfall and temperature distribution in South Vietnam.
Source: *Vietnam Government Statistics in 2000-2002.*

Cassava is produced throughout the country but is more important in southern Vietnam than in the north. In 2001 the total cassava planted area was about 163,600 ha and the average yield was 11.30 t/ha (Vietnam Government Statistics). Recently, cassava in South Vietnam has become a cash crop because the region now has more than 30 starch factories, while it is estimated that more than 500 households are also processing cassava into starch and other products.

Results of the nation-wide cassava survey conducted in 1991-1992 showed that the major constraints were low cassava yields and low economic returns in cassava production areas of South Vietnam. This is due to lack of new technologies to improve soil fertility and reduce soil losses by erosion, which has resulted in serious soil degradation; and lack of new cassava varieties with high yield and high starch content (Pham Van Bien *et al.*, 1996).

From 1998 till 2003, Farmer Participatory Research (FPR) in South Vietnam was carried out in collaboration with CIAT and with financial support from the Nippon Foundation in Japan. In South Vietnam the FPR project was implemented by Hung Loc Agricultural Research Center (HARC) and by the University of Agriculture and Forestry (UAF).

The objectives of the research are to develop appropriately crop and soil management practices for more sustainable cassava-based cropping systems in South Vietnam.

Therefore, the research was focused on:

1) Developing new technologies for the sustainable production of cassava grown on sloping and nutrient poor soil by reducing erosion and preventing soil degradation.

2) Selection, introduction and dissemination of new cassava varieties with high yield, high starch content and adapted to the environments in South Vietnam.

FPR METHODOLOGIES USED

In early 1999, the project started by preselecting some villages in Dong Nai, Tay Ninh and Binh Phuoc provinces, as well as in Ba Ria-Vung Tau province as the pilot sites for implementing the FPR methodology. Some villages in Binh Long district of Binh Phuoc province and in Quang Ngai province were also selected as additional sites.

To implement the FPR methodology the following activities were carried out:

1. Diagnostic surveys were conducted in the pilot sites using RRA and PRA methods, in order to find out the problems, limiting factors and solutions. The tools used included village transects, bio-resources mapping, stakeholder analysis, gender analysis, village mapping, crop calendars…etc.
2. Demonstration plots and on-farm research were established at Tay Hoa and An Vien villages of Dong Nai province; Hao Duoc village of Tay Ninh province and in Dong Xoai town of Binh Phuoc province.
3. Five types of FPR trials were conducted by farmers on their own fields:
   - *Erosion control:* soil erosion control by using different types of soil and crop management practices.
   - *Cassava intercropping:* to select the cropping pattern giving the highest yields and economic returns, to enhance soil fertility, and to reduce soil degradation.
   - *Cassava weed control by herbicide application and the use of plastic mulch:* to select the kind of herbicide and plastic, the best time and quantity to apply for controlling weeds in cassava fields in the rainy season.
   - *Fertilization:* to determine the best rates of NPK to obtain high yields and economic benefits on Haplic Acrisol and Ferrasol soils.
   - *Cassava varietal selection:* to select new cassava varieties with high yield and high starch content, short duration and for multi-purpose use, and adapted to the conditions of farmers in South Vietnam.
4. Farmers, technicians and extension workers received training before conducting the trials. Farmer field days were also organized to visit the demonstration plots for selecting good treatments, and at harvesting time to discuss and evaluate the results of the FPR trials and to identify the most promising treatments for the next year.

RESULTS

1. Erosion Control

Based on the results of previous research on erosion control we established an experiment with various soil and crop management practices at Hung Loc Agricultural Research Center, while two demonstration plots with 16 treatments were established on about 8-20% slope in Tay Hoa village, Thong Nhat district, Dong Nai province, and in Dong Xoai town, Binh Phuoc province. These plots showed various alternatives for growing cassava on slopes, and farmers could select the most promising treatments during the farmers' field day at harvest. After conducting these demonstrations, 17 FPR erosion control trials were conducted by farmers in Dong Tam village, Dong Phu district, Binh Phuoc province, and in Suoi Rao village, Chau Duc district, Ba Ria-Vung Tau province from 2000 to 2003. The results of these trials, shown in **Table 1,** indicate that in Dong Tam village of Binh Phuoc province, planting cassava with hedgerows of *Paspalum atratum* or vetiver grass reduced the soil loss by erosion and gave the highest cassava yields and net income. Similarly, **Table 2** shows that in Suoi Rao village of Ba Ria-Vung Tau province planting cassava with contour hedgerows of vetiver grass or *Paspalum atratum* reduced the soil loss and produced high yields and net income. In both locations these two treatments had the highest farmers' preference.

Table 1. Average results of nine FPR erosion control trials conducted by farmers in Dong Tam village, Dong Phu district, Binh Phuoc province, Vietnam, in 2000/03.

Treatment	Dry soil loss (t/ha)	Cassava yield (t/ha)	Gross income[1]	Production costs[2] ('000 dong/ha)	Net income	Farmers' preference (%)
1. Cassava monoculture	34.97	19.89	6,962	3,851	3,111	16.7
2. C + vetiver hedgerows	15.90	22.50	7,875	3,984	3,891	26.7
3. C + *Leucaena* hedgerows	24.73	21.07	7,375	3,917	3,458	6.7
4. C + *Gliricidia* hedgerows	26.87	21.37	7,479	3,917	3,562	8.3
5. C + *Paspalum* hedgerows	15.70	23.17	8,109	3,984	4,125	41.7

[1] Prices:	cassava:	dong	290/kg fresh roots (to be harvested)
[2] Costs:	urea (46%N)		2,300/kg
	SSP (17% P_2O_5)		1,000/kg
	KCl (60% K_2O)		2,300/kg
	fertilizers (80N+ $40P_2O_5$+ $80K_2O$)		942,000/ha
	land preparation		900,000/ha
	planting		300,000/ha
	weeding + cutting hedges		1,709,000/ha
	hedgerow planting material		66,000-127,000/ha

2. Intercropping Cassava with Legume Crops

In South Vietnam cassava is generally intercropped with legumes and other economic crops; this is practiced in about 30-40% of the total area of cassava production (Pham Van Bien *et al*., 1996).

Cassava intercropping trials with leguminous crops have been conducted in Hung Loc Agricultural Research Center since 1992. The results of ten years indicate that cassava intercropped with peanut and cassava grown with hedgerows of *Leucaena leucocephala* and *Gliricidia sepium as* alley crops gave the higher cassava root yields and net income. These cropping systems also returned the highest amount of green manure for improving soil fertility and reducing soil degradation ((Nguyen Huu Hy *et al*., 1995; 1998; 2000; and 2007).

The RRAs and PRAs conducted in the pilot sites indicate that the most common systems of cassava intercropping in South Vietnam are interplanting cassava with peanut, mungbean, maize and cowpea.

Based on the results of previous research in Hung Loc Agricultural Research Center and the constraints identificed for cassava intercropping in farmers' fields by RRA, farmers conducted 20 intercropping trials in An Vien village, Thong Nhat district, Dong

Nai province; in Dong Tam village, Dong Phu district, Binh Phuoc province; and in Suoi Rao and Son Binh villages, Chau Duc district, Ba Ria-Vung Tau province.

Table 2. Average results of eight FPR erosion control trials conducted by farmers in Suoi Rao village, Chau Duc district, Ba Ria-Vung Tau, Vietnam, in 2000/03.

Treatments	Dry soil loss (t/ha)	Cassava yield (t/ha)	Maize yield (t/ha)	Gross income[1)]	Production costs[1)]	Net income	Farmers' preference (%)
				('000 dong/ha)			
1. Cassava monoculture	64.89	41.82	-	18,526	7,210	11,316	6.7
2. C+pineapple hedgerows	15.56	37.61	-	16,661	7,226	9,435	5.5
3. C+*Paspalum* hedgerows	12.72	39.12	10.31	17,333	7,429	9,904	60.0
4. C+vetiver hedgerows	18.97	39.24	6.90	17,383	7,309	10,074	54.4
5. C+maize intercrop	7.96	28.64	3.82	12,687	8,435	4,252	10.7

[1)] Prices:	cassava:	dong	443/kg fresh roots
	maize		1,000/kg dry grain
[2)] Costs:	cassava fertilizers		1,143,600/ha
	maize fertilizers		556,000/ha
	cassava stakes		500,000/ha
	maize seed		373,000/ha
	labor for cassava production (200 man-days)		4,426,000/ha
	labor for maize production (21.4 man-days)		533,000/ha
	labor in hedgerow planting (8 man-days)		200,000/ha

Note: hedgerows of *Paspalum atratum* and vetiver grass also produced 10.31 and 6.90 t/ha of cut forages, respectively.

The results, shown in **Tables 3** to **7,** indicate that in most of the pilot sites cassava intercropping with grain legumes such as peanut was the most suitable cropping system, while this also gave a higher net income than other treatments. The results of intercropping trials conducted on grey sandy loam soil in Suoi Rao of Ba Ria-Vung Tau province indicate that intercropping cassava with maize gave the lowest net income (**Tables 5** and **6**).

Intercropping trials conducted on grey podzolic soil of An Vien village, Thong Nhat district, Dong Nai province, showed that the planting of one row of peanut grown between two rows of cassava gave the highest net income as compared with cassava monoculture or the inter-planting of two rows of peanut between two rows of cassava (**Table 7**).

3. Fertilization

Two on-farm fertilizer trials were conducted in An Vien village, Thong Nhat district, Dong Nai province, and in Hao Duoc village, Chau Thanh district, Tay Ninh province in 1999. The results of these trials gave farmers some ideas about the response of cassava to fertilizers. In both sites the response of cassava to different levels of N, P and K was not clear in the first year. The application of 120 kg N, 20 P_2O_5 and 120 K_2O/ha or 60 kg N, 40 P_2O_5 and 120 K_2O/ha gave the highest cassava root yields and economic returns (Nguyen Huu Hy *et al.*, 2007).

From 2000 to 2003, 26 FPR fertilizer trials were conducted by farmers in An Vien village, Thong Nhat district, Dong Nai province; in Dong Tam village, Dong Phu district, Binh Phuoc province as well as in Suoi Rao village, Chau Duc district, Ba Ria-Vung Tau province. The results of these trials, shown in **Tables 8** to **12**, indicate that the response of cassava to fertilizers on the farmers' fields depend on the type of soil and the rates of the applied fertilizer. On poor soils in An Vien village the application of 80 kg N+ 40 P_2O_5+ 80 K_2O/ha and 40 kg N+ 40 P_2O_5+ 80 K_2O/ha + 5 t/ha manure gave the highest yields and economic returns. But in the rather fertile soil in Suoi Rao village the application of 40 kg N+ 40 P_2O_5+ 80 K_2O/ha with and without farm-yard manure gave the highest cassava root yields and net income. In most sites the farmers' preference was higher for treatments 2 or 3 than for treatment 1.

Table 3. Average results of three FPR intercropping trials conducted by farmers in An Vien village, Thong Nhat district, Dong Nai province, Vietnam, in 2000/01.

Treatments	Yield (t/ha) Cassava	Yield (t/ha) Intercrop	Gross income[1)]	Production costs[2)]	Net income	Farmers' preference (%)
			('000 dong/ha)			
Cassava monoculture	30.60		8,885	3,448	5,437	60
C + peanut intercrop	30.28	0.20	9,781	4,148	5,633	70
C + mungbean intercrop	23.89	0	6,928	3,948	2,980	0
C + cowpea intercrop	29.74	0	8,624	3,648	4,976	20

1) Prices:	cassava:	dong	290/kg fresh roots (to be harvested)
	peanut		5,000/kg dry pods
2) Costs:	urea (46% N)		2,300/kg
	SSP (17% P_2O_5)		1,000/kg
	KCl (60% K_2O)		2,000/kg
	land preparation		600,000/ha
	planting cassava		300,000/ha
	planting intercrops		200,000/ha
	weeding		1,600,000/ha
	fertilizers		948,000/ha
	intercrop seeds		200,000/ha
	harvesting intercrops		300,000/ha

4. Weed Control

Based on the results of previous research on the use of herbicides and plastic mulch for weed control at Hung Loc Center, and on-farm research conducted in An Vien village, Thong Nhat district, Dong Nai province, and in Hao Duoc village, Chau Thanh district, Tay Ninh province in 1999, nine FPR weed control trials were conducted by farmers in An Vien village, Thong Nhat district, Dong Nai province. The results of these trials (**Tables 13** to **15**) show that the pre-emergence herbicide Dual (metolachlor) could control most of the weeds in cassava fields and gave higher economic returns. This is also more convenient in places where there is a lack of labor. Also, weed control by using plastic mulch to cover the soil gave higher cassava yields and made harvesting easier even in the grey podzolic soil, but it markedly increased the cost of production.

5. Cassava Varieties

In 1999 five national cassava variety trials (NVT) were conducted in An Vien and Xa Doi 61 villages, Thong Nhat district, Dong Nai province. The results of these trials indicate that most of the new varieties, i.e. KM 98-5, KM 98-1, SM 937-26, KM 94 and KM 99-4, had higher root yields and starch contents than the local varieties.

Table 4. Average results of three FPR intercropping trials conducted by farmers in Dong Tam village, Dong Phu district, Binh Phuoc province, Vietnam, in 2000/01.

	Yield (t/ha)		Gross income[1)]	Production costs[2)]	Net income	Farmers' preference
Treatments	Cassava	Intercrop	('000 dong/ha)			(%)
Cassava monoculture	30.23	-	8,766	3,467	5,299	60
C + cowpea intercrop	29.33	0	8,505	4,343	4,162	0
C + peanut intercrop	30.22	0.22	9,863	4,787	5,076	60
C + mungbean intercrop	29.70	0	8,613	4,367	4,246	0

[1)] Prices:	cassava	dong	290/kg fresh roots (to be harvested)
	peanut and cowpea		5,000/kg dry pods
	mungbean		6,000/kg dry pods
[2)] Costs:	urea (46% N)		2,300/kg
	SSP (17% P_2O_5)		1,000/kg
	KCl (60% K_2O)		2,300/kg
	fertilizers		967,000/ha
	cowpea seeds		376,000/ha
	peanut seeds		320,000/ha
	mungbean seeds		400,000/ha
	land preparation		600,000/ha
	planting cassava		300,000/ha
	weeding		1,600,000/ha
	planting + managing intercrops		500,000/ha
	harvesting peanut		500,000/ha

Table 5. Average results of two FPR intercropping trials conducted by farmers in Suoi Rao village, Chau Duc district, Ba Ria-Vung Tau, Vietnam, in 2000/01.

Treatments	Cassava yield (t/ha)	Starch content (%)	Intercrop yield (t/ha)	Gross income[1)]	Product. costs[1)]	Net income	Farmers' preference (%)
				('000 dong/ha)			
Cassava monoculture	35.75	31.2	-	13,942	6,897	7,045	15
C + peanut intercrop	37.93	30.8	0.616	14,793	8,705	6,088	35
C + mungbean intercrop	37.61	30.4	0.555	14,668	7,785	6,883	0
C + maize intercrop	24.76	27.4	2.327	9,656	8,414	1,242	0

[1)] Prices:	cassava	dong	390/kg fresh roots
	peanut		5,700/kg dry pods
	mungbean		6,500/kg dry grain
	maize		1,060/kg dry grain

In order to select the best varieties for release, new cassava varieties were selected from these NVT trials and tested in 22 FPR trials conducted by farmers: 14 trials in Dong Tam and Minh Lap villages in Dong Phu and Binh Long districts, Binh Phuoc province, and eight trials in Suoi Rao and Son Binh villages, Chau Duc district, Ba Ria-Vung Tau province. The results of these trials, shown in **Tables 16** to **21**, indicate that in Dong Tam and Minh Lap villages two varieties, i.e. KM 98-5 and KM 94, gave high yields and had high levels of farmers' preference. But in eight FPR trials in Suoi Rao and Son Binh villages five varieties, i.e. KM 94, KM 98-5, KM 140-4, KM 146 and KM 9123 gave high yields and had high levels of farmers' preference. In general, six new varieties and KM 94 were widely adopted in these sites.

Table 6. Average results of three FPR intercropping trials conducted by farmers in *Suoi Rao and Son Binh* villages, Chau Duc district, Ba Ria-Vung Tau, Vietnam in 2001/02.

Treatments	Cassava yield (t/ha)	Starch content (%)	Intercrop yield (t/ha)	Gross income[1)]	Production costs[1)]	Net income	Farmers' preference (%)
				('000 dong/ha)			
C + peanut intercrop	30.74a	27.66	1.483	25,805	10,071	15,734	48
C + mungbean intercrop	29.81a	26.66	0.570	20,383	8,640	11,743	42
C + soybean intercrop	34.54a	27.50	0	18,997	8,620	10,377	6
C + maize intercrop	21.00b	24.30	3.643	15,557	8,588	6,900	35
Cassava monoculture	31.88a	27.93	-	17,534	7,116	10,418	29
CV% =	2.16%						
LSD 0.05 =	6.872						

[1)] Prices: cassava dong 550/kg fresh roots
peanut 6,000/kg dry pods
mungbean 7,000/kg dry grain
maize 900/kg dry grain

Table 7. Average results of nine cassava intercropping trials conducted by farmers on Haplic Acrisol in An Vien village, Thong Nhat district, Ñong Nai, Vietnam, in 1999/00.

Treatments	Yield (t/ha) Cassava	Yield (t/ha) Intercrop	Gross income[1)]	Production costs[2)]	Net income	Farmers' preference (%)
			('000 dong/ha)			
Cassava monoculture	29.46	-	9,604	3,282	6,322	33
C+ 1 row of peanut	31.47	0.66	10,259	4,049	6,210	53
C+ 2 rows of peaut	28.79	0.28	9,386	4,280	5,106	13

[1)] Prices: cassava dong 326/kg fresh roots
peanut 4,660/kg dry pods
[2)] Costs: urea (46% N) dong 2,200/kg
SSP (17% P_2O_5) 1,000/kg
KCl (60% K_2O) 2,266/kg
fertilizer (80 N+ 40 P_2O_5+ 80 K_2O) 962,000/ha
labor 20,000/man-day
intercrop seeds + management 1 row 767,000/ha
intercrop seeds + management 2 rows 998,000/ha
land preparation 600,000/ha
planting cassava 220,000/ha
weeding 1,500,000/ha

Table 8. Average results of three FPR fertilizer trials conducted by farmers in An Vien village of Thong Nhat district, Dong Nai province, Vietnam, in 2000/01.

Treatments (kg/ha)	Cassava yield (t/ha)	Gross income[1)]	Production costs[2)]	Net income	Farmers' preference (%)
		('000 dong/ha)			
1. $0N + 0P_2O_5 + 0K_2O$	19.66	5,701	2,500	3,201	10
2. $80N + 40P_2O_5 + 80K_2O$	28.37	8,227	3,448	4,779	50
3. $40N + 40P_2O_5 + 80K_2O$ + 5 t/ha manure	31.96	9,268	3,848	5,420	40

[1)] Prices: cassava dong 290/kg fresh roots (to be harvested)
[2)] Costs: urea (46% N) 2,300/kg
SSP (17% P_2O_5) 1,000/kg
KCl (60% K_2O) 2,300/kg
fertilizer and labor (T_2) 948,000/ha
fertilizer and labor (T_3) 1,348,000/ha
land preparation 600,000/ha
planting 300,000/ha
weeding 1,600,000/ha

Table 9. Average results of six FPR fertilizer trials conducted by farmers in An Vien village of Thong Nhat District, Dong Nai, Vietnam from 2001 to 2003.

Treatments (kg/ha)	Cassava yield (t/ha)	Gross income[1)]	Production costs[2)]	Net income	Farmers' preference (%)
		('000 dong/ha)			
1. $120N + 20P_2O_5 + 120K_2O$	34.80	12,066	3,681	8,235	20
2. $80N + 40P_2O_5 + 80K_2O$	31.82	10,978	3,448	7,530	40
3. $60N + 40P_2O_5 + 120K_2O$	32.83	11,326	3,500	7,826	40

[1)] Prices: cassava dong 345/kg fresh roots (to be harvested)
[2)] Costs: urea (46% N) 2,300/kg.
SSP (17% P_2O_5) 1,000/kg.
KCl (60% K_2O) 2,300/kg.
fertilizer (1) 1,181,000/ha
fertilizer (2) 948,000/ha
fertilizer (3) 1,000,000/ha
land preparation 600,000/ha
planting 300,000/ha
weeding 1,600,000/ha
labor 2,500/man-day

6. Farmer Field Days, Seminars and Training

- **In 1999:** the FPR project held one field day with 63 farmers participating, and organized training for 80 researchers, extension workers and farmers.
- **In 2000:** The FPR project organized five field days with a total of 150 farmers participating; in addition, the FPR project, together with CIAT and VEDAN, organized the 6th Regional Workshop, including a one day field trip, with 80 people participating.
- **In 2001:** The FPR project trained 140 farmers in four villages (An Vien, Dong Tam, Minh Lap, Suoi Rao), and organized a farmers field day at the time of harvest

in the pilot sites with 80 people participating. The project also organized one seminar and a farmers field day in Binh Phuoc province with 60 delegates participating.

- **In 2002:** The FPR project trained 140 farmers in five villages (An Vien, Minh Lap, Dong Tam, Suoi Rao and Son Binh), while it organized a farmers field day at time of harvest in the pilot sites with 100 people participating. A seminar and farmers field day were also held in Chau Duc district, Ba Ria-Vung Tau province, with 50 delegates participating at the time of harvest.
- **In 2003:** The FPR project trained 120 farmers in five villages (An Vien, Minh Lap, Dong Tam, Suoi Rao and Son Binh); a seminar and field day will also be held at time of harvest.

Table 10. Average results of six FPR fertilizer trials conducted by farmers in Dong Tam and Minh Lap villages, Dong Phu and Binh Long districts in Binh Phuoc province, Vietnam, in 2000/01.

Treatments (kg/ha)	Cassava yield (t/ha)	Gross income[1)]	Production costs[2)]	Net income	Farmers' preference (%)
		('000 dong/ha)			
1. $0N+0P_2O_5+0K_2O$	16.30	5,542	2,200	3,343	15
2. $80N+40P_2O_5+80K_2O$	23.55	8,001	3,285	4,716	50
3. $80N+40P_2O_5+80K_2O$+5 t/ha manure	29.10	9,894	3,960	5,934	50

[1)] Prices: cassava dong 290/kg fresh roots (to be harvested)

[2)] Costs:

urea (46% N)	dong	2,300/kg
SSP (17% P_2O_5)		1,000/kg
KCl (60% K_2O)		2,300/kg
manure		100,000/tonne
land preparation		400,000/ha
planting material		100,000/ha
planting		200,000/ha
weeding		1,200,000/ha
labor		25,000/man-day
harvesting		500,000/ha

Table 11. Average results of three FPR bio-fertilizer trials conducted in Minh Lap village, Binh Long district, Binh Phuoc province of Vietnam in 2002/03.

Treatments (kg/ha)	Cassava yield (t/ha)	Gross income[2)]	Production costs[3)]	Net income	Farmers' preference (%)
		('000 dong/ha)			
1. Bio-fertilizer (1.0 t/ha)	28.6	3,450	8,580	5,130	40
2. Bio-fertilizer (1.5 t/ha)	31.5	3,950	9,450	5,500	30
3. $80N+40P_2O_5+80K_2O$	27.6	3,493	8,280	4,787	30

[1)] Variety: KM 98-5
[2)] Prices: cassava dong 300/kg fresh roots (to be harvested)
[3)] Costs: urea (46% N) 2,300/kg
SSP (17% P_2O_5) 1,100/kg
KCl (60% K_2O) 2,300/kg
bio-fertilizer 1,000/kg
land preparation 600,000/ha
planting cassava 300,000/ha
weeding 1,550,000/ha
chemical fertilizers 1,043,000/ha

Table 12. Average results of 11 FPR fertilizer trials conducted by farmers in Suoi Rao and Son Binh villages, Chau Duc district, Ba Ria-Vung Tau, Vietnam, from 2000/01 to 2003/04.

Treatments (kg/ha)	Cassava yield (t/ha)	Gross income[1)]	Production costs[2)]	Net income	Farmers' preference (%)
		('000 dong/ha)			
0N+0P+0K	28.54	12,643	5,247	7,396	0
$80N+40P_2O_5+80K_2O$	38.17	16,909	6,333	10,576	15
$40N+40P_2O_5+80K_2O$	39.35	17,432	6,136	11,296	54
$40N+40P_2O_5+40K_2O$+5 t FYM/ha	46.27	20,498	6,970	13,528	39

[1)] Prices: cassava dong 443/kg fresh roots
[2)] Costs: urea (46% N) 2,267/kg
SSP (17% P_2O_5) 1,100/kg
KCl (60% K_2O) 2,500/kg
FYM 200/kg
fertilizer application 100,000/ha

Table 13. Effect of various weed control practices on cassava yields, economic returns and farmers' preference when cassava, KM 94 variety, was grown on grey podzolic soil of An Vien, Thong Nhat, Dong Nai (A) and Hao Duoc, Chau Thanh, Tay Ninh (B) in 1999/00.

	Cassava yield (t/ha)		Net income ('000)		Farmers' preference (%)	
Weed control treatments	A	B	A	B	A	B
1. by hoe (3 times)	28.44	29.13	5,354	4,222	10	30
2. by Dual (2.4 L/ha)	31.95	29.33	6,306	4,942	70	50
3. by Dual (1.5 L/ha)	25.85	28.80	4,858	4,570	-	20
4. by Roundup (2 L/ha)	29.79	28.67	5,901	4,377	10	-
5. by Dual (1.5 L/ha)+Roundup (1.5 L/ha)	25.78	27.00	4,778	4,160	-	-
6. by Dual (1.5 L/ha)+Gramoxone (2 L/ha)	28.91	26.89	5,674	4,172	10	-
	NS	NS				

Table 14. Average results of three FPR weed control trials conducted by farmers in An Vien village of Thong Nhat district, Dong Nai province, Vietnam, in 2000/01.

Weed control treatments	Cassava yield (t/ha)	Gross income[1)]	Production costs[2)]	Net income	Farmers' preference (%)
		('000 dong/ha)			
1. by hoe (3 times)	26.66	7,731	3,448	4,173	30
2. by Dual (2.4 L/ha)	29.40	8,526	2,728	5,798	70

1) Prices: cassava dong 290/kg fresh roots. (to be harvested)
2) Costs: urea (46% N) dong 2,300/kg
SSP (17% P_2O_5) 1,000/kg
KCl (60% K_2O) 2,000/kg
herbicide+ application 380,000/ha
fertilizer 948,000/ha
planting 200,000/ha
land preparation 600,000/ha

Table 15. Average results of six FPR weed control trials conducted by farmers in An Vien village of Thong Nhat district, Dong Nai province, Vietnam, from 2000 to 2002.

Weed control treatments	Cassava root yield (t/ha)	Gross income[2]	Production[2] costs[1]	Net income	Farmers' preference (%)
		('000 dong/ha)			
1. by hand (3 times)	32.39	11,175	3,488	7,727	50
2. by Dual (2.4 L/ha)	27.95	9,643	2,368	7,275	30
3. by plastic mulch	39.44	13,607	6,848	6,759	20

[1] Prices: cassava dong 345/kg fresh roots (to be harvested)
[2] Costs: urea (46% N) 2,300/kg
SSP (17% P_2O_5) 1,000/kg
KCl (60% K_2O) 2,300/kg
herbicide+application 380,000/ha
fertilizer 948,000/ha
plastic mulch 4,850,000/ha
planting 200,000/ha
land preparation 600,000/ha

Table 16. Average results of three FPR cassava variety trials conducted by farmers in Dong Tam village of Dong Phu district, Binh Phuoc province, Vietnam in 2000/01.

Varieties	Cassava root yield (t/ha)	Gross income[1]	Production costs[2]	Net income	Farmers' preference (%)
		('000 dong/ha)			
1. KM 98-5	39.7	11,513	3,467	8,046	50
2. KM 98-1	33.7	9,773	3,467	6,306	20
3. KM 99-4	24.3	7,047	3,467	3,580	0
4. SM 937-26	32.4	9,396	3,467	5,929	10
5. KM 94	32.8	9,512	3,467	6,045	50

[1] Prices: cassava dong 290/kg fresh roots (to be harvested)
[2] Costs: urea (46% N) 2,300/kg
SSP (17% P_2O_5) 1,000/kg
KCl (60% K_2O) 2,300/kg
land preparation 600,000/ha
planting 300,000/ha
weeding 1,500,000/ha
fertilizers 1,067,000/ha

Table 17. Average results or three cassava variety trials conducted by farmers in Dong Tam village, Dong Phu district, *Binh Phuoc province*, Vietnam, in 2001/02.

Varieties	Cassava root yield (t/ha)	Gross income[1)]	Production costs[2)]	Net income	Farmers' preference (%)
		('000 dong/ha)			
KM 98-1	29.5	11,210	3,293	7,917	10
KM 98-5	28.1	10,678	3,293	7,385	40
SM 937-26	27.1	10,298	3,293	7,005	10
KM 94	24.2	9,196	3,293	5,903	30

[1)] Prices: cassava dong 380/kg fresh root
[2)] Costs: fertilizers (80 N+40 P_2O_5+ 80 K_2O) 1,043,000/ha
land preparation 600,000/ha
planting 200,000/ha
weeding 1,450,000/ha

Table 18. Average results of five FPR cassava variety trials conducted in Dong Tam village, Dong Phu district of Binh Phuoc province, Vietnam, in 2002/03.

Varieties	Cassava root yield (*t/ha*)	Starch content (%)	Gross income[1)]	Production costs[2)]	Net income	Farmers' preference (%)
			('000 dong/ha)			
1. KM 98-1	20.70	27.5	6,200	3,493	2,707	10
2. KM 98-5	23.00	30.0	6,900	3,493	3,470	50
3. SM 937-26	16.00	28.5	4,800	3,493	1,370	-
4. KM 94	21.70	29.5	6,510	3,493	3,017	70

[1)] Prices: cassava dong 300/kg fresh roots (to be haravested)
[2)] Costs: urea (46% N) 2,300/kg
SSP (17% P_2O_5) 1,100/kg
KCl (60% K_2O) 2,300/kg
fertilizers (80N+40P_2O_5+ 80K_2O) 1,043,000/ha
land preparation 600,000/ha
planting 250,000/ha
weeding 1,600,000/ha

Table 19. Average results of three FPR cassava variety trails conducted by farmers *in Minh Lap* village, Binh Long district, Binh Phuoc province, Vietnam, in 2001/02.

Varieties	Cassava root yield (t/ha)	Gross income[1)]	Production costs[2)]	Net income	Farmers' preference (%)
		('000 dong/ha)			
KM98-1	26.40	10,296	3,093	7,023	20
KM98-5	29.60	11,544	3.093	8,451	40
SM937-26	24.80	9,672	3,093	6,579	10
KM94 (C)	23.30	9,087	3,093	5,994	30

[1)] Prices: cassava dong 390/kg fresh roots
[2)] Costs: urea (46% N) 2,300/kg
SSP (17% P_2O_5) 1,100/kg planting dong 200,000/ha
KCL (60% K_2O) 2,300/kg weeding 1,350,000/ha
land preparation 500,000/ha fertilizers (80N+40P_2O_5+80K_2O) 1,043,000/ha

Table 20. Average results of two FPR variety trials conducted by farmers in Suoi Rao village, Chau Duc district, Ba Ria-Vung Tau province, Vietnam, in 2000/01.

Varieties	Cassava root yield (t/ha)	Farmers' preference (%)
1. HL 20	42.46	0
2. SM 937-26	38.77	0
3. KM 94	57.57	100
4. KM 98-1	42.34	71
5. KM 98-5	48.65	71
6. KM 99-2	55.78	0
7. KM 99-4	47.89	0

Table 21. Average results of three FPR variety trials conducted by farmers in Suoi Rao and Son Binh villages, Chau Duc district, Ba Ria-Vung Tau province, Vietnam, in 2001/02.

Varieties	Cassava root yield (t/ha)	Starch content (%)	Farmers' preference (%)
1 KM 1111-1	27.37 bc	26.15	
2. KM 108-2	28.10 b	26.40	
3. KM 140-2	33.47 ab	27.05	
4. KM 94	35.88 a	27.60	51
5. KM 98-1	29.85 ab	26.50	
6. KM 98-5	30.57 ab	27.16	23
7. KM 104-4	33.23 ab	26.08	
8. KM 140-4	34.79 a	27.06	51
9. Local variety	19.96 c	23.76	
CV (%)	14.86		
LSD 0.05	7.815		

7. Dissemination of New Technologies

From 1999 to 2003, the project was working together with 431 households in South Vietnam and released five types of new technologies; these were adopted in the FPR pilot sites in a total area of 296.4 ha (**Table 23**). Among the new technologies, new cassava varieties with high yield and starch content were adopted in most of the sites. Beside that, the project had a significant effect on cassava production in South Vietnam, where the new technologies on soil erosion control, intercropping cassava with legumes, chemical fertilizer application, chemical weed control and new varieties were adopted in an estimated 600 ha.

Table 22. Average results of three FPR variety trials conducted by farmers in Suoi Rao and Son Binh villages, Chau Duc district, Ba Ria-Vung Tau province, Vietnam, in 2002/03.

Varieties	Cassava root yield (t/ha)	Starch content (%)	Gross income[1]	Production costs[2]	Net income	Farmers' preference (%)
			('000 dong/ha)			
1. SM 937-26	40.90 abc	26.8	19,632	8,240	11,392	20
2. KM 163	38.30 abc	27.4	18,384	7,980	10,404	
3. KM 98-5	33.40 c	27.1	16,032	7,490	8,542	
4. KM 140	37.00 bc	28.1	17,760	7,850	9,910	
5. KM 146	52.10 a	25.4	25,008	9,360	15,648	40
6. KM 9123	49.60 ab	28.0	23,808	9,110	14,698	40
7. KM 94	31.80 c	29.5	15,264	7,330	7,934	
CV (%)	14.94					

[1] Prices: cassava dong 480/kg fresh roots
[2] Costs: urea (45% N) 2,500/kg
SSP (17% P_2O_5) 1,100/kg
KCl (60% K_2O) 2,500/kg

LESSONS LEARNED FROM THE FPR PROJECT

1. To conduct farmer participatory research it is important to select the right villages (pilot sites) where the main cropping system is based on cassava, and where the net income of most of the households in the village come mainly from cassava production.
2. To work with farmers, to encourage them to test various technologies and select those that are most suitable for their own conditions; this will enhance adoption and increase their cassava yields.
3. To achieve the adoption of new technologies requires that researchers, extension workers, local government officials, traders and farmers work together to strengthen the project.
4. By working together, researchers and farmers learn from each other, and also learn by themselves.

Table 23. Adoption of new technologies in cassava-based cropping systems in FPR pilot sites in South Vietnam (2000-2004).

Technologies	Number of households	Area (ha)
1. New varieties	302	219.5
2. Intercropping	25	10.1
3. Erosion control	52	33.7
4. Fertilizers	30	24.2
5. Weed control	22	8.9
Total	**431**	**296.4**

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INTEGRATION OF NORTHERN UPLAND PROGRAM WITH FARMER PARTICIPATORY RESEARCH FOR SUSTAINABLE CASSAVA PRODUCTION IN NORTH VIETNAM

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GENERAL INTRODUCTION

- Dramatic progress in cassava production in Vietnam since establishment of cooperation with CIAT and participation in Asian Cassava Project in 1988
- Technology transfer became effective only after starting to work with different programs and stakeholders (scientists-farmers-processors-government officials).
- Cooperation between National Science and Technology Program for Northern Mountainous Region (NSTPNMR), Farmer Participatory Research (FPR) for cassava (FPR) of CIAT, VASI scientists, Vietnam Cassava Program, different provincial departments of Yen Bai and other provinces, farmers and processing factories has brought about note-worthy results.

RESULTS

- Integration of in-country cassava research programs with the CIAT FPR project in 1999-2003: Promotion and application of sustainable technologies for cassava production, preventing soil erosion, improving soil fertility and increasing farmers' income.
- Farmers' groups were established to participate in Cassava R & D

Technologies applied:

- Incorporation of contour hedgerows (*Tephrosia candida*, vetiver grass, *Paspalum atratum*, pineapple….) for erosion control
- Cassava-peanut intercropping
- Development of new cassava varieties: KM 94, KM 60, KM 98-7, etc.
- Silage making from cassava leaves and roots for pig feeding

Effects of applied technologies on soil erosion and cassava yield in Ha Tay province

- Soil loss reduced 90%
- Yields increased in all treatments up to 22%
- The most effective was the combination of cassava and groundnut (the income increased by 50 to 100%)
- KM 94 and KM 60 gave highest yields
- Other promising varieties were KM 98-7, KM 95-3, KM 21-10, KM 21-12.

Lessons learned from multi-lateral cooperation

- Cooperation between scientists, producers, processors and government officials can promote cassava production very fast (from self-supply to commercial production); the yield may increase by 100% or more; the production area of new varieties increased many-fold; farmers' income from cassava production also increased.

- Integration of national programs with international projects is very effective in scaling up cassava production in more sustainable ways by applying diversified techniques and making most use of the know-how and resources of all partners
- Multi-lateral cooperation provides conditions for multi-location testing, which is a very useful tool in technology transfer.

Problems remained

- Cassava starch processing factories seem not to have a long-term and integrated plan in terms of raw material supply, so there is no plan to invest in the application of more sustainable technologies for cassava, and the links between processors and scientists are still weak
- Cassava producers (farmers) benefit a little, but most of the added value is obtained from the processed commodity
- The cassava starch price is not stable in international markets; that reduces the processor's willingness to sign contracts with farmers, and the farmers hesitate to invest in cassava production
- Government officials should pay more attention to support cassava producers; for example, by taking necessary measures to reduce risks and to harmonize cassava production so as to keep demand and supply in balance.

Conclusions and suggestions

- Sustainable technologies for cassava production (high yielding varieties, balanced fertilization, intercropping, erosion control, etc.) have brought about economic and environmental benefits, and should be promoted
- Integration of national programs with international projects can mobilize more know-how and resources of all partners, hence providing more opportunities for rapid progress and greater success
- Participation of four groups (scientists, farmers, processors and government officials) proved to be very effective, and their cooperation should be further promoted
- It is requested that the government pay more attention to helping solve the remaining constraints to promote sustainable cassava production in Vietnam.

Table 1. Effects of hedgerows on soil erosion and cassava yield in Ha Tay.

Treatment	Yield (t/ha)	Dry soil loss (t/ha)	Percent of control	Farmers' preference (%)
Cassava without hedgerows (control)	22.2	51.0	100.0	0
Cassava + vetiver grass hedgerows	23.3	3.5	6.9	60
Cassava + *Tephrosia candida* hedgerows	28.0	2.1	4.1	42
Cassava + *Paspalum atratum* hedgerows	23.7	2.0	3.9	38
Cassava + pineapple hedgerows	23.3	21.0	41.2	35

Table 2. Income from different cassava intercroppjng combinations.

Province	Treatment	Cassava *yield* (t/ha)	Intercrops *yield* (t/ha)	Gross income —('000VND/ha)	Net income ——	Farmers' preference (%)
Ha Tay	Cassava monoculture	29.46	-	8.84	8.84	0
	Cassava + 1 row of peanut	22.37	0.98	11.59	11.10	0
	Cassava + 2 rows of peanut	31.96	2.13	20.21	19.24	100
	Cassava + mungbean	33.45	0.40	9.62	9.42	0
Tuyen Quang	Cassava monoculture	23.60	-	11.86	10.38	11
	Cassava + maize	26.30	1.08	14.77	12.14	0
	Cassava + peanut	29.10	0.76	18.35	15.62	50

Table 3. Yield (t/ha) of different cassava varieties in four provinces of north Vietnam.

Variety	Ha Tay	Yen Bai	Tuyen Quang	Thai Nguyen	**Average**	Rel. yield (%)
Vinh Phu (control)	22.0	15.0	20.2	14.0	**17.8**	100
HL23	-	15.3	24.4	14.0	**17.9**	101
KM 111-1	23.0	21.7	22.5	22.0	**22.3**	125
KM 104-4	26.1	17.8	26.2	27.0	**24.3**	136
KM 21-10	27.2	21.8	22.5	31.0	**25.6**	144
KM 95-3	26.2	-	-	-	**26.2**	147
KM 140-2	29.2	24.3	25.7	27.0	**26.6**	149
KM 98-7	29.7	22.7	28.8	31.0	**28.1**	158
KM 94	33.0	26.8	26.6	29.0	**28.8**	162
KM 21-12	31.9	27.6	28.3	25.0	**30.7**	172

Table 4. Results of cassava-peanut intercropping in Van Yen district of Yen Bai province in 2001.

Treatments	Cassava yield (t/ha)	Peanut yield (t/ha)	Gross income ——	Production costs ('000 VND/ha)	Net income ——	Farmers' preference (%)
Cassava monoculture	41.5	-	12,450	4,162	8,288	
Cassava + 1 row of peanut	39.2	0.97	16,610	6,567	10,043	30
Cassava + 2 rows of peanut	38.5	1.66	19,850	7,587	12,263	
Cassava + 1 row of peanut	39.6	0.89	16,330	6,567	9,763	70
Cassava + 2 rows of peanut	39.0	1.53	19,350	7,587	11,763	
Cassava + 1 row of peanut	40.8	0.69	15,690	6,567	9,123	0
Cassava + 2 rows of peanut	40.0	0.96	16,800	7,587	9,213	

Table 5. Results of cassava intercropping in Yen Bai province.

Commune	Area (ha)	Yield (t/ha)		
			Cassava	
		Peanut	KM 60	KM 94
Dong An	2.0	1.33	36.6	-
An Binh	2.0	1.25	33.3	36.0
Mau Dong	2.0	1.38	50.0	47.0
Average	**2.0**	**1.32**	**40.0**	**41.2**

Table 6. Results of cassava intercropping in some provinces of north Vietnam.

Province	Area (ha)	Yield (t/ha)	
		Peanut	Cassava
Yen Bai	55	1.0-2.0	30-40
Son La	7	1.5-1.7	40-50
Ha Tay	20	1.5-2.5	25-35
Hoa Binh	10	0.5-1.5	30-40

Table7. Scaling up (ha) of new cassava varieties in northern provinces of Vietnam.

Year	Yen Bai	Thanh Hoa	Hoa Binh	Ha Tay	Bac Kan
2001	20	0.5	0.2	100	0
2002	1,050	1,000	0.5	200	0
2003	4,000	3,500	750	400	500

RESULTS, ACHIEVEMENTS AND IMPACT OF THE NIPPON FOUNDATION CASSAVA PROJECT[1]

Reinhardt H. Howeler[2]

ABSTRACTS

During the 5-year second phase of the project, farmers in 99 pilot sites in the three countries conducted a total of 1,154 FPR trials, mostly testing new varieties, erosion control measures, fertilization, intercropping, weed control, plant spacing and pig feeding.

From the FPR variety trials farmers selected the most suitable variety for their particular location. The most commonly adopted variety in both Thailand and Vietnam was KU-50, in Vietnam called KM 94. Some other improved varieties were also selected because of better adaptation to specific local soil or climatic conditions, or for different end uses, such as eating varieties *versus* industrial varieties.

With respect to erosion control measures, farmers in Thailand overwhelmingly selected the planting of vetiver grass contour hedgerows, while in Vietnam farmers often selected vetiver grass as the most effective measure, but adopted the planting of *Tephrosia candida, Paspalum atratum* or pineapple, because these were easier to plant and had secondary uses. About 30% of farmers also adopted contour ridging, which can be quite good for erosion control (if slopes are not too steep) and may also increase yields or facilitate planting and harvesting.

From FPR fertilizer trials farmers realized the beneficial effect of applying modest amounts of animal manure (5-10 t/ha) in combination with chemical fertilizers high in N and K, such as 80N-80K_2O or 80N-40P_2O_5-80K_2O. In Thailand where farmers use mostly compound fertilizers, there was a shift away from 15-15-15 to fertilizers like 15-7-18, if and when those were available on the local market.

Cassava farmers in Thailand also became interested in trying out different green manures and different ways of managing these within their cassava cropping system, either by planting before cassava and incorporating the green manure into the soil before planting cassava, or planting cassava first, interplanting the green manure between cassava rows and pulling up and mulching the green manure after 1½-2 months. These practices have sofar been adopted in only a few places.

By the end of the project in late 2003, farmers in 24 villages in Thailand had planted a total of 145 km of vetiver grass hedgerows, practically all had adopted one or more of the recommended new varieties, about 80-100% were using chemical fertilizers, but almost none had adopted intercropping, mainly because of limitations of labor and frequent crop failures of intercrops.

In Vietnam the number of households adopting various new technology components increased year by year, reaching a total of 15,000-20,000 households in or near 15 of the older pilot sites. New varieties were adopted by the greatest number of households and over the largest area, covering at least 7,000 ha in or near those pilot sites. A nation-wide survey indicated that new varieties were being planted in about 92,500 ha corresponding to 35-40% of the total cassava area in 2002. Better fertilization and erosion control measures had been adopted in about 600 ha each, while intercropping was practiced by many farmers but covering only a total of 160 ha. In the pilot sites of three districts of Hue province over one thousand households had raised about 3,370 pigs fed with silage of cassava roots and leaves. The increase in cassava yield and additional pig meat resulting from the adoption of these new technologies was valued at 2.2 million US dollars per year in those 15 pilot sites.

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[1] This paper is a modified and shortened version of part of the End-of-Project Report submitted to the Nippon Foundation in April 2004.

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In China farmers tested mainly new varieties. Out of many promising breeding lines farmers in one village in Hainan selected two lines and these were later released as recommended varieties under the names of SC 5 and SC 6. Once released these two varieties spread rapidly and now cover about 1,300 ha in Hainan. In the major cassava growing province of Guangxi, two recently released varieties, GR 911 and GR 891, as well as two older ones, SC 124 and Nanzhi 199, are now planted in about 16,000 ha. It is estimated that in all of China new varieties are now planted in over 30,000 ha covering about 8% of the total cassava area. Soil conservation practices have been tested extensively in FPR trials in Hainan, but have been adopted in only very small areas. Interestingly, many farmers, especially in some areas of Guangxi, are now planting cassava on plastic mulch, which not only increases yields and income but also seems effective in reducing erosion. This needs further research.

In order to estimate the economic benefit of all cassava research and extension activities (not only of this project) in China, Thailand and Vietnam, we can look at the overall effect of the adoption of new varieties and production practices on yield. According to FAO data, cassava yields in China over the past ten years increased 0.79 t/ha with an approximate value of 5.4 million US dollars; in Thailand yields increased 5.49 t/ha (40%) with a total value of 123 million US dollars; while in Vietnam yields increased 5.84 t/ha (69%) resulting in an additional income for cassava farmers in the country valued at 54.3 million US dollars per year. For all of Asia yields increased 3.68 t/ha (28%), resulting in additional income for cassava farmers valued at **318 million US dollars** per year. By far the greatest yield increases occurred in Thailand and Vietnam where the project was most actively involved. Although it is impossible to say for certain how much the Nippon Foundation project has contributed to these yield increases, there is no doubt that the direct involvement of several thousand farmers in testing, selecting and adopting locally-suitable varieties and practices, and their participation in field days and training courses have made a significant contribution.

The Impact Assessment conducted at the end of 2003 concluded that new varieties would probably have been disseminated equally well without the participatory approach, and that fertilizer adoption is highly dependent on each farmer's purchasing power. The adoption of more balanced fertilization, of soil conservation practices and intercropping, while not as widespread as that of new varieties, was significantly higher for those farmers that had participated in the project as compared to non-participants. The use of a farmer participatory approach as a novel new way of developing and disseminating new technologies together with farmers, was enthusiastically embraced by those participating directly in the project; this may eventually become more accepted as a useful approach in mainstream national programs with hopefully a long-lasting and positive effect. The working together of researchers and extensionists from various national and international institutions, and the opportunities provided by the project to participate in national and international training courses, workshops or scientific meetings have enriched the capacities of many individuals, and this will undoubtedly lead to improved efficiency in their institutions to the benefit of poor farmers and to the sustainable development of their countries.

1. RESEARCH ON NEW SOIL/CROP MANAGEMENT OPTIONS

Farmers are interested in testing new technologies only if those technologies promise substantial economic benefits over their traditional practices. Thus, strategic and applied research need to continue to produce and select still better varieties, better production practices and new utilization options.

Besides the continuing efforts to breed and select new high-yielding and high starch varieties, mainly by cassava breeders in national programs with some input from CIAT headquarters in Colombia, collaborative research in the area of agronomy and soil management continued.

Table 1 list the topics and institutions that were involved in this research from

1999 to 2003. Initially this research concentrated on integrated and long-term soil fertility maintenance through the application of N, P and K as well as Ca, Mg and micronutrients in chemical fertilizers; the selection and management of green manure species; intercropping and alley cropping; and the combined use of animal manures and fertilizers. Other topics included the identification of effective and practical soil conservation measures and the selection of hedgerow species with minimum competitive effect on nearby cassava. Later topics included weed control and land preparation practices, as well as the identification of varieties and management practices to optimize the production of cassava leaves as a source of protein for animal feeding.

Results of this research have been published in CIAT's Annual Reports for 1999 to 2003 and have been presented at the 7th Regional Cassava Workshop held in Oct 2002 in Bangkok. The more than 70 PowerPoint presentations were copied on CDs and distributed to all collaborating and participating institutions. The full papers have been published as the Proceedings of this Workshop (Howeler, 2007). Both the PP presentations and the pdf file of the Workshop Proceedings are available on the web at www.ciat.cgiar.org/asia_cassava/index.htm

Only a few examples and salient results of the strategic and applied research conducted as part of the second phase of the Nippon Foundation project are presented here:

1.1 Long-term fertility maintenance

Long-term NPK trials were continued in four locations, one each in north and south Vietnam, one in Hainan island of China and one in southern Sumatra of Indonesia. **Figure 1** shows the effect of annual applications of various levels of N, P, and K on the yield and starch content of two varieties during the 16th year of continuous cropping in Hung Loc Center in south Vietnam. It is clear that, similar to most other locations, the main yield response was to the application of K, while there were minor responses to the application of N and P and mainly in the higher yielding variety SM 937-26. The combined application of 160 kg N, 80 P_2O_5 and 160 K_2O/ha increased yields from about 8 to 36 t/ha. **Figure 2** shows the absolute and relative response to application of N, P and K as well as the change in P and K status of the soil during the entire 16-year period. Initially there was no signifant response to any nutrient as the organic matter, P and K levels were still adequate and root yields were relatively low. With the introduction of new higher yielding varieties in the 4th year, the root yields increased and nutrient depletion, especially K, increased, leading to an ever more pronounced response to K application. Even after 16 years soil-P remains above the critical level, which explains why there was only a minor P response.

1.2 Combined use of animal manure and chemical fertilizer

Table 2 shows the effect of combining various rates of farm-yard (pig) manure (FYM) with chemical fertilizers, in this case N and K, in Thai Nguyen University in north Vietnam. Without manure or fertilizers the yield was only 3.25 t/ha; with the application of only 80 kg N and 80 K_2O/ha yields increased to 15.47 t/ha; with a high rate of 15 t/ha of manure it was 13.11 t/ha, while the combined application of 10 t/ha of manure with N and K produced the highest yield of 18.70 t/ha. However, the combination producing the highest net income was 5 t/ha of manure with 80 kg N and 80 K_2O/ha. From this and other trials it is clear that farmers can increase yields and income by reducing their application of pig manure as long as it is combined with adequate levels of N and K in chemical fertilizers.

Table 1. Strategic/applied research conducted as part of the Nippon Foundation Project from 1999 to 2003/04.

Research topic	Institution	Location	Years
1. Long-term fertility trial	Thai Nguyen Univ. (TNU)	Thai Nguyen, Vietnam	1999-2006
	Inst. Agric. Sciences (IAS	Hung Loc, Dongnai, Vietnam	1999-2007
	Chinese Acad. Trop. Agr. Sci. (CATAS)	Danzhou, Hainan, China	1999-2007
	Central Research Inst. Food Crops (CRIFC)	Tamanbogo, Indonesia	1999-2007
	Univ. Agric. Forestry (UAF/TP)	Tu Duc, Vietnam	1999
2. Grass barrier trial	Kasetsart University (KU)	Khaw Hin Sorn, Thailand	1999-2001
	Chinese Acad. Trop. Agric. Sci. (CATAS)	Danzhou, Hainan, China	1999-2001
3. Intercropping/alley cropping trial	Inst. Agric. Sciences (IAS)	Hung Loc, Dongnai, Vietnam	1999-2007
4. Green manure/mulch trial	Dept. of Agriculture (DOA)	Rayong, Thailand	1999
	Kasetsart Univ. (KU)	Khaw Hin Sorn, Thailand	2002-2006
5. Erosion control trial	Inst. Agric. Sciences (IAS)	Hung Loc, Dongnai, Vietnam	1999-2007
	Thai Tapioca Dev. Inst. (TTDI)	Huay Bong, Thailand	1999
	Central Research Inst. Food Crops (CRIFC)	Tamanbogo, Indonesia	1999-2001
	Central Research Inst. Food Crops (CRIFC)	Yogyakarta, Indonesia	1999
	Thai Nguyen Univ. (TNU)	Thai Nguyen, Vietnam	2002
6. Weed control trial	Inst. Agric. Sciences (IAS)	Hung Loc, Dongnai, Vietnam	1999-2003
7. Live barrier trial	Thai Nguyen University (TNU)	Thai Nguyen, Vietnam	1999
8. Sweet potato intercropping trial	Thai Nguyen University (TNU)	Thai Nguyen, Vietnam	1999-2001
9. Variety trial	Central Research Inst. Food Crops (CRIFC)	Yogyakarta, Indonesia	1999-2003
	Univ. Agric. Forestry (UAF/TD)	Thu Duc, Vietnam	1999
	Hue Univ. Agric. Forestry (HUAF)	Hue, Vietnam	1999
	Hue Univ. Agric. Forestry (HUAF)	Hong Ha, Hue, Vietnam	1999
10. Intercropping trial	Univ. Agric. and Forestry (UAF/TD)	Thu Duc, Vietnam	1999
	Hue Univ. Agric. Forestry (HUAF)	Hue, Vietnam	1999
11. Manure/fertilizer trial	Thai Nguyen Univ. (TNU)	Thai Nguyen, Vietnam	2000-2001
12. Micronutrient application trial	Central Research Inst. Food Crops (CRIFC)	Yogyakarta, Indonesia	2000-2002
	Thai Tapioca Dev. Inst. (TTDI)	Huay Bong, Thailand	2001
	Dept. of Agriculture (DOA)	Banmai Samrong, Thailand	2002
	Dept. of Agriculture (DOA)	Roy Et, Thailand	2002
	Dept. of Agriculture (DOA)	Kalasin, Thailand	2002
13. Reduced tillage trial	Dept. of Agriculture (DOA)	Rayong, Thailand	2001-2003
	Kasetsart Univ. (KU)	Khaw Hin Sorn, Thailand	2001-2006
	Thai Tapioca Dev. Inst. (TTDI)	Huay Bong, Thailand	2001-2003
14. Varieties for forage prod. trial	Dept. of Agriculture (DOA)	Rayong, Thailand	2001-2003
	Thai Tapooca Dev. Inst. (TTDI)	Huay Bong, Thailand	2001-2003
	Inst. Agric. Sciences (IAS)	Hung Loc, Dong Nai, Vietnam	2001-2003
	Dept. of Agriculture (DOA)	Khon Kaen, Thailand	2002-2003
	Dept. of Agriculture (DOA)	Songklaa, Thailand	2002-2003
	Dept. of Agriculture (DOA)	Banmai Samrong, Thailand	2003
15. Pig feeding with cassava leaf silage trial	Hue Univ. Agric Forestry (HUAF)	Guang Tri, Vietnam	2001
16. Fertilization for forage prod. trial	Dept. of Agriculture (DOA)	Rayon, Thailand	2002-2003
	Dept. of Agriculture (DOA)	Khon Kaen, Thailand	2002-2003
17. Plant spacing for forage prod. trial	Dept. of Agriculture (DOA)	Rayong , Thailand	2002-2003
	Dept. of Agriculture (DOA)	Khon Kaen, Thailand	2002-2003
18. Cutting heightxfrequency for forage prod. trial	Thai Tapioca Dev. Inst. (TTDI)	Rayong, Thailand	2002-2003
	Thai Tapioca Dev. Inst. (TTDI)	Khon Kaen Thailand	2002-2003
19. Zinc application trial	Thai Tapioca Dev. Inst. (TTDI)	Huay Bong, Thailand	2002-2003
	Dept. of Agriculture (DOA)	Banmai Samrong	2003
20. Varietal adaptation trial to intercropping	Central Research Inst. Food Crops (CRIFC)	Tamanbogo, Indonesia	2002-2003
21. Ca/Mg application trial	Dept. of Agriculture (DOA)	Kalasin, Thailand	2003
22. Bentonite application trial	Dept. of Agriculture (DOA)	Kalasin, Thailand	2003

Table 2. Effect of the application of FYM[1] and chemical fertilizers on cassava yield and economic benefit at Thai Nguyen University of Agric. and Forestry in Thai Nguyen province in 2001 (2^{nd} year).

Treatments[1]	Cassava root yield (t/ha)	Height at 8 months (cm)	Leaf life at 3 months (days)	HI	Gross income[2]	Fert. costs[2]	Product. costs[3]	Net *income*
					------------('000 dong/ha)----------			
1. no fertilizers, no FYM	3.25	87.1	46.5	0.39	1,625	0	2,800	-1.175
2. 5t FYM/ha	7.79	116.6	55.2	0.49	3,895	500	3,300	0.595
3. 10t FYM/ha	10.02	133.9	65.0	0.52	5,010	1,000	3,800	1.210
4. 15t FYM/ha	13.11	151.8	66.1	0.52	6,555	1,500	4,300	2.255
5. 80N+80K_2O/ha, no FYM	15.47	154.5	66.8	0.50	7,735	680	3,580	4.155
6. 80N+80K_2O/ha + 5t FYM/ha	17.98	180.0	68.5	0.48	8,990	1,180	4,080	4.910
7. 80N+80K_2O/ha + 10t FYM/ha	18.70	188.3	70.8	0.49	9,350	1,680	4,580	4.770
8. 80N+80K_2O/ha + 15t FYM/ha	18.50	196.6	73.1	0.48	9,250	2,180	5,080	4.170

[1]FYM = farm yard manure (pig manure)
[2]Prices: cassava dong 500/kg fresh roots
urea (45% N) 2,100/kg
KCl (60% K_2O) 2,300/kg
manure+application 100/kg
[3]Cost of cassava cultivation: 2.8 mil. dong/ha; cost of chem. fert. application 0.10 mil. dong/ha

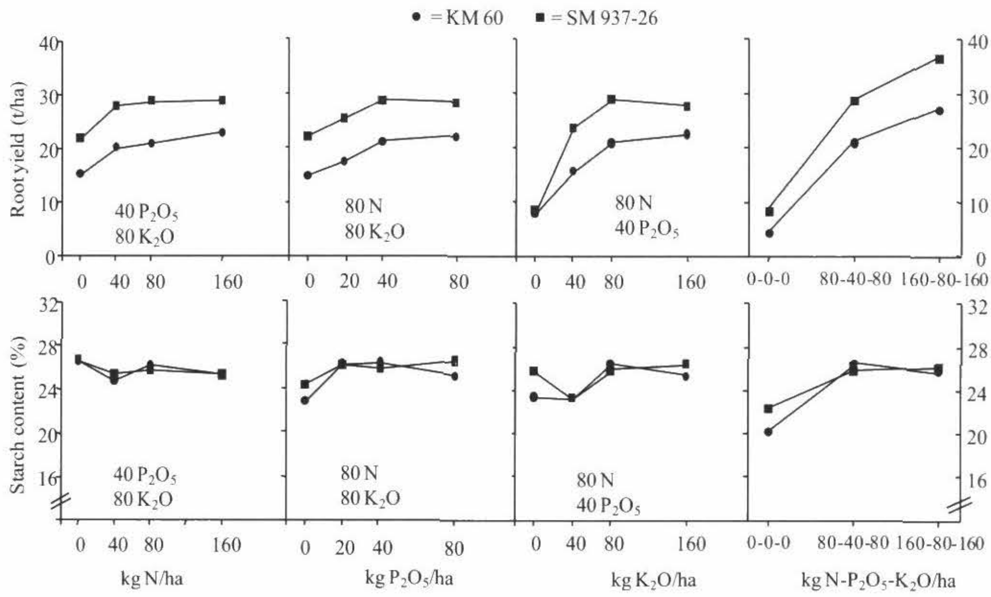

Figure 1. Effect of annual applications of various levels of N, P and K on the root yield and starch content of two cassava varieties grown at Hung Loc Agriculture Research Center, Thong Nhat, Dongnai, Vietnam in 2005/06 (16th year).

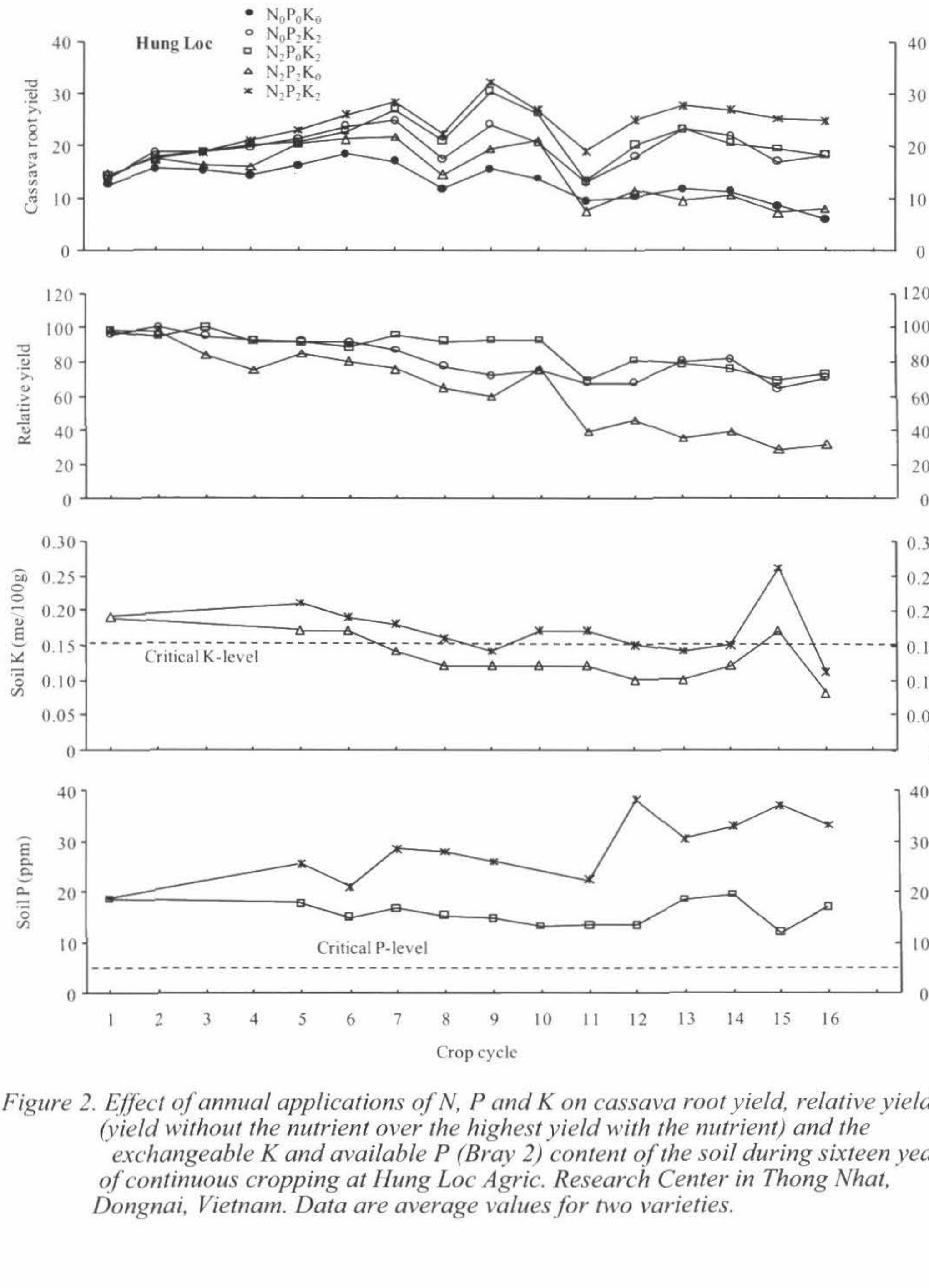

Figure 2. Effect of annual applications of N, P and K on cassava root yield, relative yield (yield without the nutrient over the highest yield with the nutrient) and the exchangeable K and available P (Bray 2) content of the soil during sixteen years of continuous cropping at Hung Loc Agric. Research Center in Thong Nhat, Dongnai, Vietnam. Data are average values for two varieties.

1.3. Green manures and/or chemical fertilizers

Table 3 shows the first 5-year results of a green manure experiment conducted in Khaw Hin Sorn station in Chachoengsao, Thailand. In this case all green manure species were intercropped between cassava rows and planted one month after planting cassava; they were pulled out and mulched two months later. Highest average yields were obtained when cassava was planted without green manures but fertilized with either 75 or 25 kg/rai of 15-7-18 fertilizers. All green manures, but especially *Mucuna* and *Crotalaria juncea* reduced cassava yields due to competition for light, nutrients and water. Among the various green manures, mungbean and *Canavalia ensiformis* were the least competitive intercrops. It was expected that the beneficial effect of green manures will increase over time, but the data indicate that that was not the case.

Table 3. Effect of green manures and/or chemical fertilizers on the root yield and average starch content of cassava, KU 50, when cassava was planted for five consecutive years at Khaw Hin Sorn Research Station in Khaw Hin Sorn, Chachoengsao, Thailand from 2002/03 to 2006/07.

	Cassava yield (t/ha)						Starch
	1st	2nd	3rd	4th	5th		content
Treatments[1)]	year	year	year	year	year	**Av.**	(%)
1. Check without GM; 25 kg/rai 15-7-18	46.45	26.28	32.48	36.08	18.86	**32.03**	24.2
2. *Crotalaria juncea;* 25 kg/rai 15-7-18	36.58	20.83	29.26	31.19	19.03	**27.38**	23.7
3. *Canavalia ensiformis;* 25 kg/rai 15-7-18	40.35	27.07	31.16	29.79	19.00	**29.47**	24.2
4. Pigeon pea ICPL 304; 25 kg/rai 15-7-18	38.23	24.18	31.86	30.79	19.64	**28.94**	23.6
5. Cowpea CP 4-2-3-1; 25 kg/rai 15-7-18	38.54	21.66	32.12	32.06	20.76	**29.03**	23.2
6. *Mucuna;* 25 kg/rai 15-7-18	36.73	21.17	28.58	32.09	16.45	**27.00**	24.3
7. Mungbean; 25 kg/rai 15-7-18	40.07	25.08	33.49	36.38	16.51	**30.31**	23.9
8. Check without GM; 75 kg/rai 15-7-18	43.44	32.16	37.78	34.51	27.56	**35.29**	24.4

1.4 Long-term effect of contour hedgerows on yield and soil loss by erosion

Figure 3 shows the long-term effect of contour hedgerows of vetiver grass and *Tephrosia candida* on relative cassava yields and soil loss as compared to the check plot without hedgerows; data are average values from two FPR erosion control trials conducted for ten consecutive years in north Vietnam. Although the results are rather variable, there is a clear trend that both types of hedgerows caused a 20-40% increase in cassava yields and reduced soil losses by erosion to 20-30% of those in the check plots without hedgerows. Vetiver grass was generally more effective in reducing soil losses than *Tephrosia*, firstly because the grass is more effective in filtering out suspended soil sediments, and secondly because *Tephrosia* hedgerows need to be replanted every 3-4 years, in contrast to vetiver grass which is more or less permanent. While farmers claim that *Tephrosia* improves the fertility of the soil more so than vetiver grass, the data show that vetiver increased cassava yields more than *Tephrosia*, probably by reducing losses of top soil and fertilizers and improving water infiltration and soil moisture content.

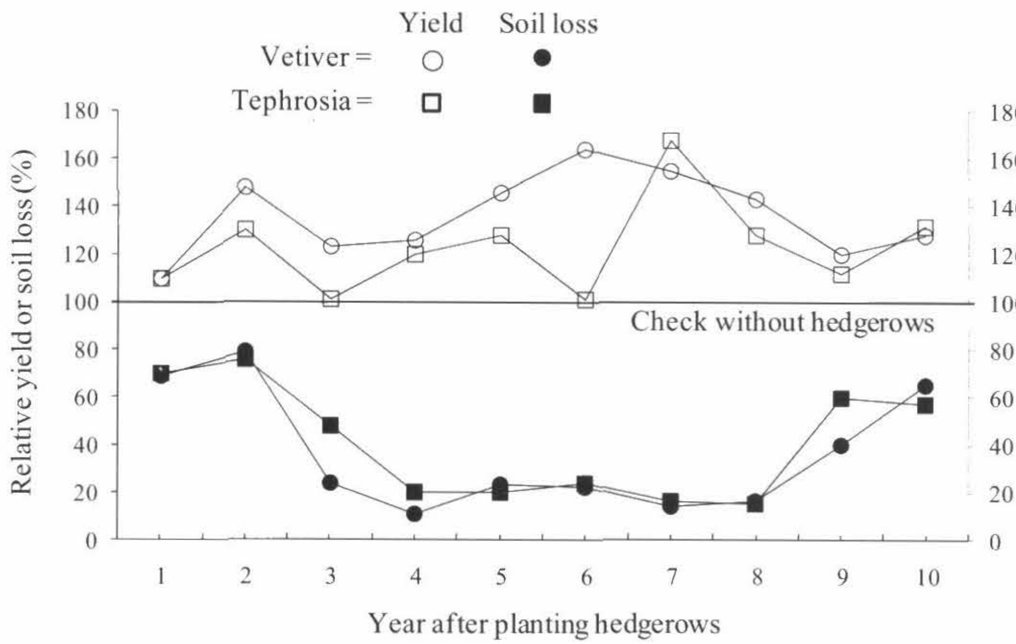

Figure 3. Trend in relative yield and relative soil loss by erosion when cassava was planted with contour hedgerows of vetiver grass or Tephrosia candida in comparison with the check without hedgerows during ten consecutive years of cassava cropping. Data are average values of two FPR erosion control trials conducted by farmers in Kieu Tung and Dong Rang villages in North Vietnam from 1995 to 2004.

Figure 4 shows similar results from a soil erosion control experiment conducted for ten consecutive years on about 15% slope at Hung Loc Center in south Vietnam. In this case, contour hedgerows of vetiver grass, *Leucaena* and *Gliricidia* all increased cassava yields as compared to the check plot without hedgerows; they also decreased soil losses by erosion. *Leucaena* and vetiver grass were the most effective in increasing yields while vetiver was the most effective in reducing erosion. Similar to the data from north Vietnam in **Figure 3**, the effectiveness in controlling erosion increased over time. After the 4th year, the soil loss with vetiver hedgerows was only about 20-30% of that without hedgerows. These data corroborate those in **Tables 26** and **31** below that hedgerows of vetiver grass are among the most effective ways to control erosion; they also indicate that the effectiveness of all types of hedgerows increases over time.

1.5 Varieties and agronomic practices for high leaf and root production for use in animal feed

Table 4 summarizes the results of variety trials for leaf production conducted in two of four locations in Thailand for two consecutive years. In these trials cassava stakes were planted vertically at 30 x 30 cm, and young tops were cut off at 20 cm from the ground at about 2½, 4½, 6½, 9 and 12 months after planting (MAP), while cassava roots were also harvested at 12 MAP. The harvested tops, including leaves, petioles and green stems, were chopped up, sun and oven dried, weighed fresh and dry and a sample was analyzed for protein content.

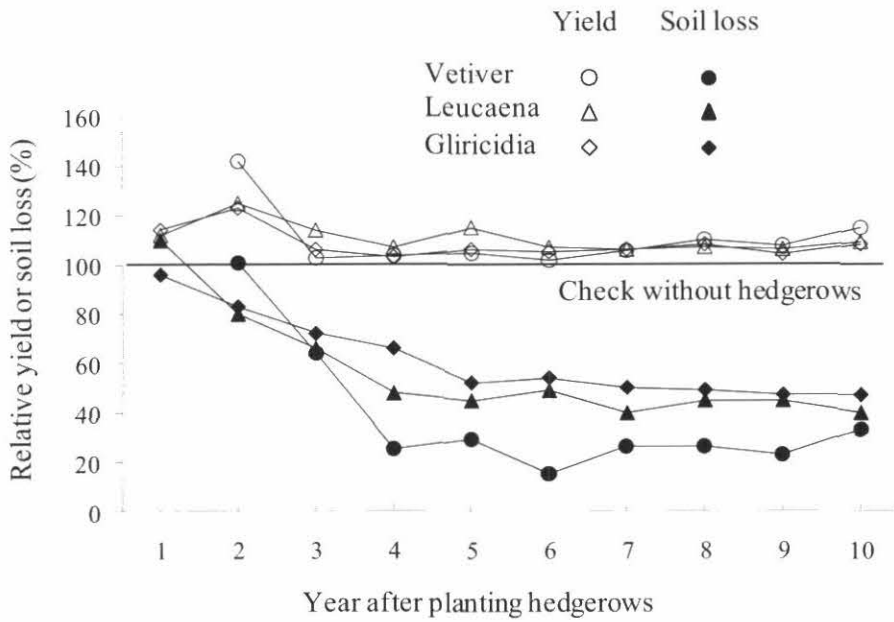

Figure 4. Trend in relative yield and relative soil loss by erosion when cassava was planted with contour hedgerows of vetiver grass, Leucaena leucocephala or Gliricidia sepium in comparison with the check without hedgerows during ten consecutive years in Hung Loc Agric. Research Center in South Vietnam from 1997/98 to 2006/07.

Table 4 shows that some varieties produced over 13 t/ha of dry "leaves" (this includes petioles and young stem) which contained over 2 t/ha of crude protein. This is 2-3 times higher than a good crop of soybeans! Even after four cuts of leaves some varieties still produced over 20 t/ha of fresh roots with more than 18% starch. Using an estimated (low) price of 24 baht/kg leaf protein, it was found that the two recommended varieties, KU 50 and Rayong 90 as well as the breeding lines CMR 41-111-129 and CMR 41-42-3 produced the highest net incomes due to the high yields of both roots and leaves.

Other experiments on fertilizer rates, plant spacing, frequency and height of cutting indicate that:

a. highest dry leaf yields were obtained with 600 kg N/ha combined with either 150 or 300 kg P_2O_5 and 150 or 300 kg K_2O/ha, but that highest net income was obtained with 300 kg N, 0 P_2O_5 and 150 K_2O/ha (**Table 5**).
b. Highest dry leaf and protein yields were obtained at a plant spacing of 30 x 30 cm, but highest fresh root yields and net income were obtained at 60 x 60 cm (**Table 6**).

c. Cutting height at 15, 20 or 25 cm above the soil had little effect on leaf yield, but cutting at 25 cm produced the highest root yield, starch content and net income.
d. Cutting at 2½-month intervals produced highest leaf and protein yields as well as net income but cutting at 3-month intervals produced highest root yields (**Table 7**).

Table 4. Average results of varietal evaluations for leaf production conducted in Rayong and Khon Kaen FCRC in Thailand in 2002/03 and 2003/04.

Variety/line	Total dry leaf yield[1)] (t/ha)	Average protein content (%)	Leaf protein yield[1)] (t/ha)	Fresh root yield (t/ha)	Root starch content (%)	Gross income[2)]	Production costs[3)] ('000 baht/ha)	Net income
1. Rayong 1	13.23	15.95	2.11	15.52	11.25	63.44	58.63	4.82
2. Rayong 5	11.16	18.71	2.09	17.72	18.05	67.12	56.72	10.40
3. Rayong 60	9.60	18.33	1.76	18.10	12.51	57.63	55.07	2.56
4. Rayong 90	11.27	18.46	2.08	23.70	19.74	73.50	57.86	15.64
5. Rayong 72	11.22	18.22	2.05	24.32	18.10	72.47	57.92	14.55
6. KU 50	13.42	16.90	2.27	20.54	20.49	75.16	59.69	15.47
7. OMR 41-23-41	12.51	17.55	2.20	15.78	15.82	67.14	57.88	9.26
8. CMR 41-42-3	12.45	18.76	2.34	18.54	19.87	74.53	58.28	16.25
9. CMR 41-60-24	11.64	19.62	2.28	16.85	19.38	71.42	57.10	14.32
10. CMR 41-61-59	13.70	17.05	2.34	18.81	12.54	72.04	59.70	12.34
11. CMR 41-111-129	13.46	17.72	2.39	20.46	16.81	76.39	59.72	16.67
12. CMR 41-114-125	10.67	17.60	1.88	13.95	17.31	58.26	55.54	2.72
13. CMR 35-22-196	11.29	18.50	2.09	17.82	22.02	68.64	56.88	11.76
14. CMR 41-20-58	11.96	17.65	2.11	10.93	19.40	61.44	56.45	4.99
15. CMR 41-96-2	10.71	16.44	1.76	11.20	14.80	52.28	55.12	-2.84
16. OMR 41-33-34	13.19	16.11	2.13	12.23	16.36	62.33	58.02	4.31
17. CMR 42-01-2	12.19	16.35	1.99	12.25	16.85	59.30	56.92	2.37
18. CMR 42-07-9	13.09	16.65	2.18	12.62	13.01	63.18	57.98	5.19
19. CMR 42-54-53	10.82	17.93	1.94	14.78	18.34	60.85	55.86	5.00
20. CMR 42-59-173	11.72	18.19	2.13	6.99	15.40	57.52	55.52	2.00
21. CMR 42-61-108	11.09	18.19	2.02	8.37	15.01	55.95	55.06	0.89
22. CMR 42-87-318	11.50	15.91	1.83	14.44	12.97	56.33	56.54	-0.22
23. CMR42-90-338	12.82	15.71	2.02	11.86	19.24	60.03	57.56	2.48
24. Huay Bong 60	12.06	17.77	2.14	21.56	18.55	72.35	58.36	13.99
Average	**11.95**	**17.51**	**2.09**	**15.80**	**16.82**	**64.97**	**57.27**	**7.71**

[1)] Sum of 4-5 cuts

[2)] Prices: cassava roots: 1.2 baht/kg at 30% starch with a 0.02 baht reduction per 1% starch reduction
cassava leaves: 24 baht/kg crude protein

[3)] Costs:

15-15-15 fertilizers	baht	520/50 kg
urea		430/50 kg
3 applications of 80 kg/rai of 15-15-15		2,496/rai
2 applications of 35 kg/rai of urea		602/rai
land preparation		330/rai
fertilizer application		200/rai
stakes (0.09 baht/stake)		1,600/rai
planting (0.045 baht/stake)		800/rai
weeding		600/rai
harvesting + chopping + drying leaves		1,100/t dry leaves
harvest + transport roots		170/t fresh roots

Note: 1 ha = 6.25 rai; 1 US$ is 40 baht in 2003.

Table 5. Effect of the application of different combinations of N, P and K on the average total dry leaf and protein yields, fresh root yield and net income obtained in two experiments conducted at Rayong and Khon Kaen Field Crops Research Centers in Thailand in 2002/03.

Treatments[1)]	Total dry leaf yield[2)] (t/ha)	Total protein yield[2)] (t/ha)	Fresh root yield[3)] (t/ha)	Root starch content (%)	Net income ('000B/ha)	Total nutrients in harvested leaves[4)] (kg/ha) N	P	K	Ca	Mg
1. $N_0P_0K_0$	4.72	0.83	13.52	22.4	5.65	132	20	56	61	21
2. $N_0P_2K_2$	5.19	0.87	15.17	21.2	-3.96	139	22	77	68	23
3. $N_1P_2K_2$	6.88	1.17	16.73	19.6	-0.78	187	25	88	86	30
4. $N_2P_2K_2$	10.03	1.67	24.00	17.9	10.00	267	33	125	121	40
5. $N_3P_2K_2$	12.03	2.18	22.55	17.2	12.71	349	36	145	142	46
6. $N_2P_0K_2$	9.65	1.65	21.25	17.6	15.47	265	31	123	117	38
7. $N_2P_1K_2$	9.81	1.58	22.76	18.4	11.24	253	30	121	118	39
8. $N_2P_3K_2$	10.53	1.79	22.42	18.0	3.30	287	34	132	128	42
9. $N_2P_2K_0$	8.48	1.50	18.65	18.0	5.65	239	31	79	103	37
10. $N_2P_2K_1$	9.70	1.61	22.88	19.4	9.80	258	32	109	116	40
11. $N_2P_2K_3$	9.47	1.55	20.16	16.9	2.11	248	30	141	116	37
12. $N_3P_3K_3$	12.29	2.20	21.78	14.2	0.98	352	37	190	145	41
Average	**9.06**	**1.55**	**20.15**	**18.4**	**6.01**					

[1)] N_0 = 0 N; N_1 = 150 kg N/ha; N_2 = 300 kg N/ha; N_3 = 600 kg N/ha
P_0 = 0 P; P_1 = 75 kg P_2O_5/ha; P_2 = 150 kg P_2O_5/ha; P_3 = 300 kg P_2O_5/ha
K_0 = 0 K; K_1 = 75 kg K_2O/ha; K_2 = 150 kg K_2O/ha; K_3 = 300 kg K_2O/ha

[2)] sum of five cuts

[3)] at 12 MAP

[4)] data are average values for two varieties in Rayong and Khon Kaen FCRC

2. WORKING WITH FARMERS

2.1 Results of FPR Trials

Tables 8 and **9** show the number and types of FPR trials conducted in 2003/04 in the various pilot sites in Thailand and Vietnam, respectively, while **Table 10** summarizes the same data for China, Thailand and Vietnam for the entire second phase of the project. In China, especially in the final two years, the emphasis was mainly on testing and disseminating new cassava varieties in Hainan and Guangxi, and on pig feeding in Yunnan. In both Thailand and Vietnam the initial emphasis was on testing new varieties, erosion control practices and fertilization, but in later years farmers also wanted to test animal and green manures (mainly in Thailand), intercropping (mainly in Vietnam), weed control, plant spacing, leaf production and pig feeding (only in Vietnam). The number of FPR trials increased markedly during the first four years, but decreased again in the 5th year, especially in China due to the outbreak of SARS. Over the course of five years about 1,150 FPR trials were conducted in farmers' fields, including 200 erosion control trials. This has made many farmers acutely aware of the seriousness of soil erosion on their own fields;

they also saw how it can be prevented and this has led to widespread adoption of soil conservation measures in cassava fields (see Section 4 below). Although not all trials produced useful results, from this large number of trials, conducted under so many different conditions of slope, rainfall, soil type and cropping practices, a wealth of data was obtained that can illucidate the relative effectiveness of various practices in controlling erosion as well as their effect on yield (see **Tables 26** and **31** below).

Table 6. Average effect of plant spacing of three cassava varieties on total dry leaf and protein yields, fresh root yield and net income obtained in two experiments conducted in Rayong and Khon Kaen Field Crops Research Centers in Thailand in 2002/03 and 2003/04.

Plant spacing (cm)	Total dry leaf yield (t/ha)	Average protein content (%)	Total protein yield (t/ha)	Fresh root yield (t/ha)	Starch content (%)	Net income ('000B/ha)
60x60	8.74	20.33	1.77	21.60	17.01	19.39
50x50	7.86	20.00	1.57	19.87	16.92	12.45
40x40	8.75	19.30	1.69	19.81	16.89	11.28
30x30	10.90	18.55	2.02	16.97	15.91	7.83
Average	**9.06**	**19.54**	**1.76**	**19.56**	**16.68**	**12.74**

Table 7. Average effect of cutting frequency of Rayong 72 on the total dry leaf and protein yields, fresh root yield and net income obtained in two experiments conducted in Rayong and Khon Kaen Field Crops Research Centers in Thailand in 2002/03 and 2003/04. Data are averaged over three cutting heights of 15, 20 and 25 cm above the ground.

Cutting frequency[1)] (months)	Total dry leaf yield (t/ha)	Average protein content (%)	Total protein yield (t/ha)	Fresh root yield (t/ha)	Starch content (%)	Net income ('000B/ha)
1½ months	9.06	19.50	1.77	16.45	14.58	2.87
2 months	9.99	17.64	1.76	20.54	15.06	5.13
2½ months	11.52	17.56	2.02	24.35	15.30	18.49
3 months	10.59	16.71	1.77	27.68	16.52	16.89
Average	**10.29**	**17.85**	**1.83**	**22.26**	**15.36**	**10.85**

[1)] the first cut was at 2½ MAP for all treatments.

Table 8. Number and type of FPR trials conducted by farmers in various sites in Thailand in 2003/04.

Province	District	Subdistrict	Varietes	Erosion control	Chemical fertilizers	Chemical + org. fert.	Green manures	Weed control	Plant spacing
8. Kalasin	Huay Phueng	Nikhom	2	-	2	-	2	2	2
10. Roy Et	Phoo Chai	Khampha-ung	8	3	5	-	4	-	-
20. N. Ratchasima	Khonburi	Tabaekbaan	2	2	2	2	2	-	-
28. Chonburi	Bo Thong	Kaset Sawan	2	2	4	5	3	-	-
31. Ratchaburi	Baan Poong	Khaw Khalung	4	2	-	4	4	4	-
33. Kanchanaburi	Sai Yook	Sai Yook	7	2	4	-	-	4	-
Total			**25**	**11**	**17**	**11**	**15**	**10**	**2**

Total no. of FPR trials: 91

Table 9. Number and type of FPR trials conducted by farmers in various sites in Vietnam in 2003/04.

Province	District	Commune	Village	Varietes	Erosion control	Fertili-zation	Inter-cropping	Plant spacing	Weed control	Varieties for leaf prod.	Pig feeding
1. Thai Nguyen	Pho Yen	Tien Phong		-	-		-	-	-	-	-
2.	"	Dac Son		-	-	-	-	-	-	-	-
3.	"	Minh Duc		-	-	-	-	-	-	-	-
4.	Pho Yen	Hong Tien		1	-	-	-	-		-	-
5.	Phu Luong	Yen Do		3	1	3	3	-		-	-
6. Bac Can	Na Ri	Hao Nghia		2	1	-	1	-	-	-	-
7. Tuyen Quang	Son Duong	Thuong Am	Am Thang	-	-	1	-	-	-	-	-
8.	"	" "	Hong Tien	3	3	2	1		-	-	-
11. Yen Bai	Van Yen	Mau A		1	-	1	1				
13. Son La	Yen Chau			1	-	-	3	-	-	-	-
14. Phu Tho	Thanh Ba	Phuong Linh	Kieu Tung	-	1	-	-	-	-	-	-
15.	Phu Ninh	Thong Nhat	Phu Ho	-	2	3	-	-	-	-	-
16.	"	Bao Thanh		1	1	-	-	-	-	-	-
17. Ha Tay	Thach That	Thach Hoa		2	1	3	3	-	-	-	-
18.	Chuong My	Tran Phu		5	-	-	3	-	-	-	-
19. Hoa Binh	Luong Son	Dong Rang		-	4	-	4	5	-	-	-
20.	Lac Son			1	-		3				
22. Thanh Hoa	Nhu Xuan	Yen Cat		2	1	-	-	-	-	-	-
26. T.T. Hue	A Luoi	Hong Ha		1	1	-	-	3	-	-	5
27.	Nam Dong	Thuong Long		2	2	-	-	-	-	-	-
28.	"	Huong Hoa		1	-	-	-	-	-	1	-
29.	Huong Tra	Huong Van		-	-	-		-	-	-	8
30. Dong Nai	Thong Nhat	An Vien		1	-	3	-	-	-	-	-
31. Binh Phuoc	Dong Phu	Dong Tam		1	1	2	-	-	-	-	-
32.	Chan Than	Minh Lap		3	-	2	-	-	3	-	-
33. B. Vungtau	Chau Duc	Suoi Rao		2	2	2	2	-	-	-	-
34.	"	Son Binh		2	2	2	2	-	-	-	-
Total				**35**	**23**	**24**	**26**	**8**	**3**	**1**	**13**

Total no. of FPR trials = 133

At time of harvest, a field day was organized for participating and non-practicipating farmers from the village and nearby communities, as well as local officials and extension workers. Usually, the central part of each plot had been harvested, either early in the morning or the day before, leaving heaps of cassava roots with a sign indicating the yield in each plot. Farmers and officials received a paper with all trial lay-outs and treatments. They then visited each trial and evaluated the different treatments. Later in the day, the average yields of treatments in each type of trial were presented together with their gross income, production cost and net income. These were discussed after which farmers voted for the most preferred treatments by raising hands. From this the farmers could select new treatments to be tested in FPR trials next season, or they could try the selected treatments on parts of their production field. Through these field days, farmers themselves selected the most suitable practices, and both the knowledge and planting material of new varieties, intercrops or hedgerow species would spread, both in the village and in neighboring villages. A few examples of results of different types of FPR trials are shown in **Tables 11-20**.

Table 10. Number of FPR trials conducted in the 2d phase of the Nippon Foundation Project in China, Thailand and Vietnam.

Country	Type of FPR trial	1999	2000	2001	2002	2003	**Total**
China	Varieties	9	9	20	69	20	**127**
	Erosion control	3	5	8	17	-	**33**
	Fertilization	-	-	-	4	-	**4**
	Intercropping	-	-	-	9	-	**9**
	Pig feeding	-	-	-	59	-	**59**
		12	**14**	**28**	**158**	**20**	**232**
Thailand	Varieties	11	16	16	19	25	**87**
	Erosion control	14	10	6	-	11	**41**
	Chemical fertilizers	16	6	23	17	17	**79**
	Chem.+org fertilizers	-	-	10	11	11	**32**
	Green manures	-	-	13	11	15	**39**
	Weed control	-	-	17	5	10	**32**
	Plant spacing	-	-	3	-	2	**5**
	Intercropping	-	-	16	7	-	**23**
		41	**32**	**104**	**70**	**91**	**338**
Vietnam	Varieties	12	31	36	47	35	**161**
	Erosion control	16	28	29	30	23	**126**
	Fertilization	1	23	36	24	24	**108**
	Intercropping	-	14	32	31	26	**103**
	Weed control	-	3	-	-	3	**6**
	Plant spacing	-	1	7	19	8	**35**
	Leaf production	-	-	2	2	1	**5**
	Pig feeding	-	-	11	16	13	**40**
		29	**100**	**153**	**169**	**133**	**584**
Total		**82**	**146**	**285**	**397**	**244**	**1,154**

Table 11. Average results of two FPR variety trials conducted by farmers in Hong Tien commune, Son Duong district, Tuyen Quang, Vietnam in 2002.

Varieties	Cassava yield (t/ha)	Gross income	Product. costs	Net income	B/C	Farmers' preference[1] (%)
		('000 dong/ha)				
1. Vinh Phu	28.70	14,350	4,330	10,020	3.31	5
2. La Tre (SC205)	32.00	16,000	4,330	11,670	3.70	5
3. KM60	35.70	17,850	4,330	13,500	4.12	18
4. KM94	39.50	19,750	4,330	15,420	4.56	84
5. KM95-3	32.00	16,000	4,330	11,670	3.70	3
6. KM98-7	32.60	16,300	4,330	11,970	3.76	13
7. OMR38-71-12	38.00	19,000	4,330	14,670	4.39	29
8. OMR37-52-6	55.70	27,850	4,330	23,520	6.43	100
9. OMR37-52-8	27.50	13,750	4,330	9,420	3.18	0

[1] out of 38 farmers

Table 12. Results of FPR cassava variety trials conducted by farmers in six sites in Hainan province, China in 2002/03.

Variety	Cassava root yield (t/ha)							Ranking
	A[1]	B	C	D	E	F	Average A-E-F	
SC 205	23.25	24.06	-	-	12.50	22.37	**19.37**	7
SC 124	-	24.69	-	-	-	-		
SC 8002	-	31.25	-	-	-	-		
SC 5[2]	27.50	34.38	81.25	57.81	-	-		
SC 6[2]	33.25	-	-	-	18.87	32.87	**28.33**	1
ZM 8229	21.00	-	-	-	12.75	31.87	**21.87**	5
ZM 8316	-	-	-	-	14.62	31.25		
ZM 8639	21.25	-	-	-	-	52.60		
ZM 8641	27.00	-	-	-	10.75	26.25	**21.33**	6
ZM 8803	21.25	-	-	-	18.62	29.37	**23.08**	4
MBra 900	21.50	-	-	-	18.50	32.37	**24.12**	2
OMR 36-40-9	24.00	-	-	-	13.87	34.37	**24.08**	3
CMR 36-40-12	-	-	-	-	15.62	-		

[1] A = old Songtao village, Qiongzhong county
B = Nanlao village, Nankun town, Tunchang county
C = Maling village, Nankun town, Tunchang county
D = Qiaozhi farm, Danzhou city
E = October field farm, Changjiang county (average 2 Reps, based on 5 plants/plot)
F = Qifang town, Baisha county (average 2 Reps, based on 5 plants/plot)
[2] SC 5 = ZM 9057; SC 6 = OMR 33-10-4

Table 13. Results of three FPR erosion control trials conducted by farmers in Dong Rang village, Dong Xuan commune, Luong Son district, Hoa Binh Vietnam in 2002.

1. Nguyen Van Tho; 16% slope

Treatments[1)]	Dry soil loss (t/ha)	Yield (t/ha) Cassava	Taro	Peanut	Gross income[2)]	Product. costs[2)]	Net income	B/C
					——— ('000 dong/ha) ———			
1. C+T; no NPK; no hedgerows (TP)	12.4	8.75	2.60	-	6,798	4,780	2,018	1.42
2. C+T; with NPK; vetiver hedgerows	0	16.87	2.60	-	10,452	5,732	4,720	1.82
3. C+T; with NPK; *Tephrosia* hedgerows	0	15.30	3.00	-	10,185	5,732	4,453	1.78
4. C+P; with NPK; vetiver hedgerows	0	15.30	-	0.51	9,690	6,242	3,448	1.55
5. C+P; with NPK; *Tephrosia* hedgerows	0	14.63	-	0.60	9,884	6,242	3,642	1.58

2. Mr. Bui Thanh Mai; 12% slope

Treatments[1)]	Dry soil loss (t/ha)	Yield (t/ha) Cassava	Peanut	Gross income[2)]	Product. costs[2)]	Net income	B/C
				——— ('000 dong/ha) ———			
1. C+P; no NPK; no hedgerows (TP)	8.80	10.00	0.53	7,415	5,290	2,125	1.40
2. C+P; with NPK; no hedgerows	2.60	14.60	0.48	9,210	6,192	3,018	1.49
3. C+P; with NPK; *Tephrosia* hedgerows	0.25	14.40	0.45	8,955	6,242	2,713	1.43
4. C+P; with NPK; *Flemingia* hedgerows	0.25	15.60	0.40	9,220	6,242	2,978	1.48
5. C+P; with NPK; vetiver grass hedgerows	0	15.60	0.40	9,220	6,242	2,978	1.48

3. Mr. Bui Thi Bam; 16% slope

Treatments[1)]	Dry soil loss (t/ha)	Yield (t/ha) Cassava	Peanut	Gross income[2)]	Product. costs[2)]	Net income	B/C
				——— ('000 dong/ha) ———			
1. C; no NPK; no hedgerows (TP)	26.00	6.50	-	2,925	3,000	-75	0.98
2. C+P; with NPK; vetiver grass hedgerows	0	13.75	0.60	9,487	6,242	3,245	1.52

[1)] C = cassava, T = taro, P = peanut; NPK = 40 kg N+ 40 P_2O_5 + 80 K_2O/ha; TP = traditional practice

[2)] prices:

cassava	dong		450/kg fresh roots
taro			1,100/kg fresh corms
peanut			5,500/kg dry pods
urea (45% N)			2,500/kg
fused Mg phosphate (15% P_2O_5)			1,000/kg
KCl (60% K_2O)			2,500/kg
peanut seed (84 kg/ha)			10,000/kg dry pods
taro corms (300 kg/ha)			1,100/kg
labor			10,000/manday
labor for monoculture without fert. (300 md/ha)		=	3.0 mil. dong/ha
labor for intercropping without fert. (445 md/ha)		=	4.45 mil. dong/ha
labor for fertilizer applic. (8 md/ha)		=	0.08 mil. dong/ha
labor for hedgerow planting and maintenance		=	0.05 mil. dong/ha
cost of NPK fertilizers		=	0.822 mil. dong/ha

Table 14. Average results of two FPR erosion control trials conducted by farmers in Khook Anu village, Thep Sathit district of Chayaphum province, Thailand, in 2001/02.

Treatments	Dry soil loss (t/ha)	Yield (t/ha) Cassava	Intercrop	Starch content (%)	Gross income	Product. costs[2]	Net income	Farmers' preference (%)
					(baht/ha)			
1. farmer's practice	13.99	12.61	-	20.3	12,736	12,018	718	0
2. contour plowing	10.16	8.41	-	20.0	8,410	11,471	-3,061	100
3. up/down plowing	31.10	12.34	-	18.3	11,970	11,974	-4	0
4. mungbean intercrop	10.30	8.70	0.306	24.0	15,516	15,392	124	82
5. vetiver grass hedgerows	8.03	13.02	-	22.3	13,619	13,083	536	100
6. lemon grass hedgerows	4.53	15.94	-	21.0	16,259	13,550	2,709	0[3]

[1] Prices: cassava — baht 1.20/ kg fresh roots at 30% starch
mungbean — 20/ kg dry grain

[2] Cost of production without harvest — baht 10,000/ha
harvest + transport — 160/tonne
contour plowing — 125/ha extra
C+mungbean intercrop — 14,000/ha
hedgerow planting + maintenance — 1,000/ha

[3] Although lemon grass hedgerows produced the highest net income, farmers do not like this practice because lemon grass does not tolerate drought and it is difficult to sell in large quantities.

Table 15. Average results of three FPR fertilizer trials conducted by farmers in Suoi Rao and Son Binh villages, Chau Duc district, Ba Ria-Vung Tau, Vietnam in 2002/03.

Treatments	Cassava yield (t/ha)	Gross income[1]	Fertil. costs	Product. costs	Net income	B/C	Farmers' preference (%)
		('000 dong/ha)					
1. 0N+0P+0K	25.88c	12,422	0	5,640	6,782	2.20	0
2. 80N+40P_2O_5+80K_2O	29.23bc	14,030	1,037	6,777	7,253	2.07	0
3. 40N+40P_2O_5+80K_2O	46.93a	22,526	814	6,554	15,972	3.44	100
4. 40N+40P_2O_5+40K_2O +5t/ha FYM	42.73ab	20,510	1,648	7,388	13,122	2.78	0
CV (%)	14.49						

[1] Prices: cassava — dong 480/kg fresh roots
urea (45% N) — 2,500/kg
SSP (17% P_2O_5) — 1,100/kg
KCl (60% K_2O) — 2,500/kg
FYM — 200/kg
labor for cassava monoculture without fertilizer: 5.64 mil dong/ha
labor for fertilizer application: 0.1 mil dong/ha

Table 16. Results of an FPR fertilizer and manure trial conducted in Khut Dook village, Baan Kaw, Daan Khun Thot, Nakhon Ratchasima, Thailand in 2001/02.

Treatments[1)]	Root yield (t/ha)	Starch content (%)	Gross income[2)]	Fertilizer cost[3)]	Production costs[3)]	Net income
			('000 baht/ha)			
1. No fertilizers or manure	18.75	25.0	21.56	0	10.87	10.69
2. Chicken manure+rice hulls, 400 kg/rai	30.42	26.2	34.98	2.50	17.15	17.83
3. Pelleted chicken manure, 100 kg/rai	26.70	21.1	30.71	2.00	15.39	15.32
4. 15-7-18 fertilizer, 50 kg/rai	29.68	24.1	34.13	2.66	16.73	17.40
5. 13-13-21 fertilizer, 50 kg/rai	32.22	27.4	37.05	3.13	17.89	19.16
6. 16-20-0 fertilizer, 50 kg/rai	26.08	25.9	29.99	2.50	15.61	14.38
7. 15-15-15 fertilizer, 50 kg/rai	30.36	26.9	34.91	2.81	17.07	17.84

[1)]1ha = 6.25 rai

[2)]Prices: cassava baht 1.15/tonne irrespective of starch content

[3)]Costs:

chicken manure		1.0/kg
pelleted chicken manure		3.20/kg
15-7-18		8.50/kg
13-13-21		10.0/kg
16-20-0		8.0/kg
15-15-15		9.0/kg
harvest + transport roots		270/tonne

cassava production without fertilizer or harvest 5,812/ha

Table 17. Results of an FPR green manure trial conducted by a farmer in Huay Faa village, Nikhom, Huay Phueng, Kalasin, Thailand in 2002/03.

Treatments[1)]	Root yield (t/ha)	Starch content (%)	Gross income[2)]	Product. costs	Net income	Farmers' preference (%)
			('000 baht/ha)			
1. No green manure	24.63	26.5	21.06	14.12	6.94	0
2. C+mungbean	26.00	27.8	23.24	14.43	8.81	12
3. C+*Crotalaria juncea*	32.00	27.5	28.32	16.04	12.28	0
4. C+*Canavalia ensiformis*	20.25[3)]	23.6	25.16	12.87	12.29	78

[1)] Green manures planted 1½ months after cassava, pulled up 1½ months later, except for *Canavalia* which was left to produce seed

[2)] Prices: cassava baht 0.96/kg fresh roots at 30% starch ; 0.03 baht reduction per 1% starch reduction
Canavalia 10/kg dry grain

[3)]Also 250 kg/ha of *Canavalia* seed

Table 18. Average results of three FPR intercropping trials conducted by farmers in Tran Phu commune, Chuong My district, Ha Tay, Vietnam in 2002.

Treatments	Yield (t/ha) Cassava	Yield (t/ha) Intercrop	Gross income[1)]	Seed costs	Product. costs	Net income	B/C	Farmers' preference (%)
			('000 dong/ha)					
1. Cassava monoculture	22.2	-	7,770	0	4,330	3,440	1.79	0
2. C+1 row peanut	25.0	0.884	13,170	480	5,810	7,360	2.27	35
3. C+2 rows peanut	24.0	1.916	17,980	960	6,290	11,690	2.86	85
4. C+mungbean	22.9	0	8,015	500	5,830	2,185	1.37	10
5. C+soybean	25.7	0.400	10,995	500	5,830	5,165	1.89	10

1) Prices:
- cassava — dong 350/kg fresh roots
- peanut — 5,000/kg dry pods
- peanut seed — 12,000/kg dry pods
- mungbean seed — 25,000/kg dry grain
- labor for cassava monoculture without fertilizers — 2.8 mil. dong/ha
- labor for intercropped cassava without fertilizers — 3.8 mil. dong/ha
- cost of fertilizers — 1.43 mil. dong/ha
- labor for fertilizer application — 0.1 mil. dong/ha

Table 19. Results of an FPR intercropping trial conducted by a farmer in Thung Krabam subdistrict, Law Khwan, Kanchanaburi, Thailand in 2002/03.

Treatments[1)]	Cassava yield (t/ha)	Starch content (%)	Intercrop yield (t/ha)	Gross income[2)] Cassava	Gross income[2)] Intercrop	Production costs	Net income	Farmers' preference (%)
				('000 baht/ha)				
C+monoculture	30.00	23.0	-	22.90	-	16.97	5.93	-
C+peanut	30.75	23.5	0.562	23.37	8.43	20.49	11.31	0
C+melon	24.00	23.2	0.250	18.10	1.25	16.11	3.24	0
C+pumpkin	32.13	23.8	1.250	24.61	12.50	18.30	18.81	10
C+sweet corn	31.00	24.5	1.250	24.18	3.13	17.87	9.94	5

1) C = cassava

2) Prices: cassava baht 0.89/kg fresh roots at 30% starch; 0.02 baht reduction per 1% starch reduction
- peanut 15/kg
- melon 5/kg
- pumpkin 10/kg
- sweet corn 2.5/kg

Table 20. Effect of increasing levels of ensiled cassava roots in pig feed on the average growth of nine pigs, on feed conversion ratio and feed costs in Huong Van commune, Huong Tra, Thua Thien Hue, Vietnam in 2002/03.

Treatments[1)]	No. pigs	Life weight (kg) initial	Life weight (kg) 3 months	LWG[2)] (g/day)	DFI[2)] (kg DM)	FCR[2)] (kg DM/kg gain)	Feed cost (VND/kg gain)	Feed cost %
Control diet[3)]	9	27.72	75.94	535.8	1.58	2.89	7,057	100
45% ECR	9	27.56	77.95	559.9	1.55	2.73	5,960	84.5
60% ECR	9	28.44	80.32	576.5	1.63	2.76	5,763	81.7

1) ECR = ensiled cassava roots
2) LWG = life weight gain; DFI = daily feed intake; FCR = feed conversion ratio
3) Control diet with rice bran, maize, fish meal and sweet potato vines

2.2 Adaptation

After 2-3 years of testing of various options in FPR trials, slowly narrowing down the number of best options, farmers started to adopt some of the tested varieties or practices on their bigger production fields. In some cases they made adaptations so as to make the practices more suitable on a larger scale. For instance, in Thailand farmers planted contour hedgerows of vetiver grass on their fields, but left enough space between hedgerows (usually 30-40 m) to facilitate land preparation by tractor. In some cases, especially in Vietnam, farmers planted hedgerows on plot borders rather than along contour lines. This reduces the amount of land occupied by hedgerows, but also reduces their effectiveness in controlling erosion.

While contour hedgerows of vetiver grass are usually the most effective in reducing soil losses by erosion in experiments and FPR trials conducted in small plots on a uniform slope, when this practice is scaled up to a larger production field the results are sometimes disappointing. In areas of rolling terrain large amounts of runoff water may accumulate and run down-slope in natural drainage ways. The force of the water is likely to wash out vetiver grass recently planted along the contour across the drainage way, and this may result in serious gully erosion. Attempts to repair these gullies by placing sand bags or other obstacles across them have usually failed as these obstacles too are washed away. Over the past few years farmers and project staff have experimented informally with ways to reduce the speed of water in these gullies. They found that it is most effective to place a row of soil-filled plastic fertilizer bags across the gully in line but slightly below the washed out vetiver hedgerow. The bags need to be secured in place by pounding bamboo stakes into the soil behind them (**Figure 5**). Once eroded soil is deposited in the gully above the soil bags, vetiver grass can be planted in this moist and fertile sediment. When the vetiver grass is well-established across the gully and in line with the rest of the hedgerow, this will further slow the speed of runoff water resulting in further deposition of sediments in the gully above the vetiver hedgerow. This allows weeds to reestablish in the gully bottom protecting the gully from further erosion. With the next plowing along the contours, parallel to the hedgerows, the gully will generally be filled up again with soil, while the hedgerow prevents further gully formation (**Figure 5**). In some sites in Thailand, terraces of up to a meter height were formed within two years by the placing of soil bags and planting of vetiver hedgerows across the gully. This local adaptation of the traditional contour hedgerow system markedly increased its effectiveness under real field conditions.

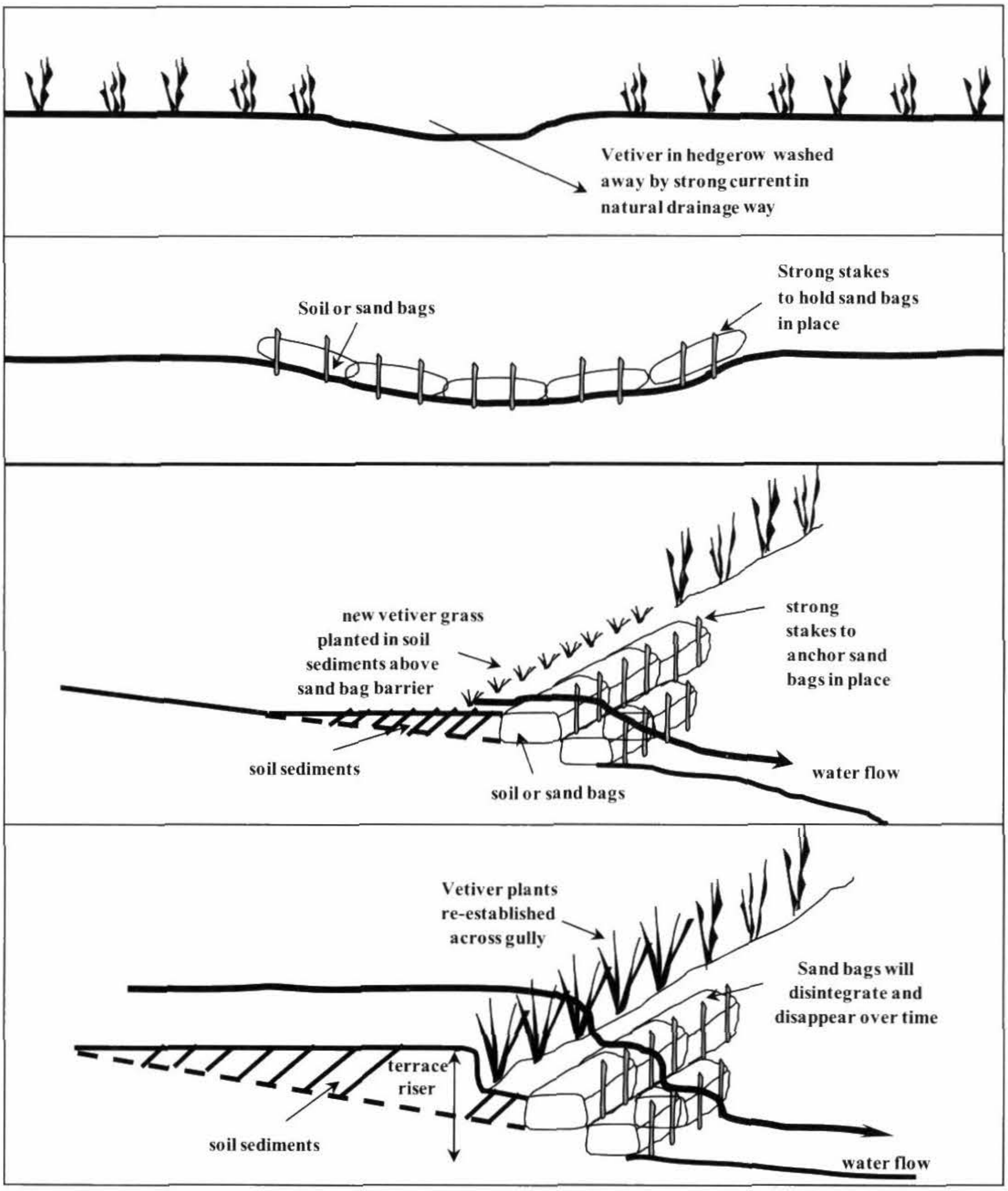

Figure 7. Simple and effective way to repair gullies by placing soil bags across gully and planting vetiver grass in the soil sediments accumulating above the barrier.

2.3 Training of Research and Extension Personnel and Farmers

a. FPR training courses

At the beginning of the project in 1994 none of the project staff, both from CIAT and in national programs, had any experience in farmer participatory methodologies. Thus, the project started with a one-week Training-of-Trainers (TOT) course on farmer participatory methodologies with staff from CIAT and others with more experience presenting their ideas. After lengthy discussions about methodologies, and practice sessions in the classroom and with farmers in the field, most participants felt more or less comfortable with this new approach and were willing to test it out in their own countries.

This initial course in English was followed by several TOT in-country courses for researchers and extensionists of national programs taught partially in English (with translation) and partially in the native language by resource persons from that country. Project staff that had participated in the first phase and had gained experience with the methodologies then served as resource persons in subsequent TOT courses for staff joining in the second phase. By that time, manuals on farmer participatory approaches had been prepared in Chinese, Thai and Vietnamese, making the teaching more efficient. **Table 21** shows the total number of training courses conducted during the first and second phase of the project.

Table 21. FPR training courses conducted as part of the Nippon Foundation project.

Country	Year	Type of training course	Location	Number of participants
China	1998	Researchers and extensionists	Danzhou	27
	2001	Researchers, Extensionists and farmers	Danzhou	32
	2003	Farmers and local extensionists	Yongning	100
				159
Indonesia	1998	Researchers and extensionists	Malang	31
Thailand	1994	Training-of-trainers in FPR methodologies	Rayong	29
	1997	Researchers and extensionists	Paakchong	28
	1999	Researchers and extensionists	Prachinburi	28
	2000	Farmers and local extensionists	Huay Bong	51
	2001	Researchers and farmers on vetiver grass	Khaw Hin Sorn	47
	2002	Researchers and extensionists of LDD	Huay Bong	30
	2002	Farmers and local extensionists	Khon Kaen	31
				244
Vietnam	1997	Researchers and extensionists	Thai Nguyen	28
	1999	Researchers and extensionists	Ho Chi Minh	29
	2000	Farmers and local extensionists	Thai Nguyen	29
	2001	Farmers and local extensionists	Ho Chi Minh	24
	2001	Farmers and local extensionists	Hue	29
	2002	Farmers and local extensionists	Van Yen	53
	2002	Farmers and local extensionists	Hue	34
	2003	Farmers and local extensionists	Nhu Xuan	66
				292
Total number of participants				**726**

After training of project staff in TOT courses, focusing mainly on tools and methodologies used in participatory diagnoses, in the implementation of FPR and FPE as well as in participatory monitoring and evaluation (PM&E), the emphasis shifted to training of local extension workers together with key farmers from each pilot site. By inviting one subdistrict extension worker together with two farm leaders from a project site in that subdistrict it was hoped that this three-man (or women) team could form a local "FPR team" that would work together in teaching others in the community to conduct FPR trials or adopt new technologies. Although these "FPR teams" were never formalized as such, the people that had participated in these FPR training courses would oftentimes lead the village as coordinators of the FPR trials or as officers on the Administration Committee of the "Cassava Development Villages".

At the end of the project in 2003, about 726 people had participated in FPR training courses organized and funded by the project, of which about 200 were researchers and extensionists and about 400 were farmers and local extension workers (some people participated in more than one course). These training courses were extremely important to create a cadre of people with knowledge and experience in farmer participatory methodologies and to motivate people to work enthusiastically in extending the project to more and more sites. Similarly, the training of local extensionists and farmers was not only useful in extending knowledge about FPR and cassava production technologies, but also to motivate and empower local extension workers and key farmers to work together as a team for the benefit of members of the community.

b. Training manuals

To facilitate training in FPR methodologies and to hand out material that can serve as a reference for researchers, extensionists and farmers who have participated in these courses, the following training materials were prepared, mostly in the local language:

1. Video/CD: The use of farmer participatory research to develop and extend the use of soil conservation practices in cassava growing areas of Thailand (in Thai and English)
   by: Department of Agricultural Extension, Bangkok, Thailand
2. CD: Cassava resources development and research on preventing soil erosion and soil loss using cassava contour hedgerows in Honghe district, Yunnan, P.R. China (in Chinese)
   by: Honghe Regional Animal Husbandry Station, Mengzhe, Yunnan, China
3. Training Manual: Farmer Participatory Research; Methods and Tools; Planning FPR Trials (in Thai)
   by: Department of Agricultural Extension, Bangkok, Thailand
4. Training Manual: Farmer Participatory Research (in Vietnamese)
   by: Tran Ngoc Ngoan, Thai Nguyen Univ., Thai Nguyen, Vietnam
5. The Nippon Foundation Project to Control Erosion in Cassava Fields (in Vietnamese)
   by: Tran Ngoc Ngoan, Thai Nguyen Univ., Thai Nguyen, Vietnam
6. Cassava Varieties and Cultural Practices – FPR Project Training Manual (in Chinese)
   by: Li Jun, Guangxi Subtropical Crops Research Institute, Nanning, Guangxi, P.R. China

7. Several extension posters about the Control of Soil Erosion in Cassava, presented at End-of-Project Workshop, Thai Nguyen, Oct 2003.

c. Technical monographs

The intention was to prepare two technical monographs in English with possible translation in other languages on:

a. Cassava Production Technologies
b. Farmer Participatory Methodologies for the Development and Dissemination of New Cassava Technologies

Unfortunately, due to time constraints of the project coordinator, neither one has yet been written and published. The first one is still being written and may be published in 2008 as part of the *CIAT in Asia: Research for Development* Series. Some basic information for this Monograph has already been published entitled: "Cassava Agronomy Research in Asia: Has it Benefitted Cassava Farmers" by R.H. Howeler and published in the Proceedings of the 6^{th} Regional Cassava Workshop. This paper, as well as many others written by cassava agronomists in national programs, reviews cassava agronomy research conducted over the past 20-30 years in Asia. They are published in the same Proceedings.

The second monograph on FPR and FPE Methodologies used in the project, will probably not be published as the topic is rather similar to the recent publication "Developing Agricultural Solutions with Smallholder Farmers: How to Get Started with Participatory Approaches" by Peter Horne and Werner Stur, published as the third in the *CIAT in Asia: Research for Development* Series (ACIAR Monograph No 99). This publication has been translated into many Asian languages.

d. Project Website

Another effective way to disseminate knowledge about the farmer participatory methodology used in the project and the results obtained, is to launch a project website. This website was prepared in August 2002. Its web address is: www.ciat.cgiar.org/asia_cassava/index.htm. The website has numerous downloadable publications and serves as a general source of information on various cassava production aspects. The website is also linked to the Nippon Foundation website as well as that of CIAT in Asia: www.ciat.cgiar.org/asia/index.htm.

e. Scientific publications

Reports on various aspects of the project, both research results and about the FPR methodologies used, have been presented at many scientific meetings, workshops and symposia. Most of these were published. **Appendix 2** shows the list of publications resulting from the 2^{nd} phase of the project.

4. ADOPTION AND IMPACT

Adoption of new technologies is a gradual process; it is also influenced by the activities of various government and non-government organizations as well as by social, political and economic forces both within and beyond the village. For instance, the amount of fertilizers applied by Thai cassava farmers depends to a large extent on the cassava price received in the previous year; this price is determined by international markets for coarse grains and sugar, which are beyond the farmers' control. It is also difficult to measure adoption beyond the actual pilot sites (usually village or commune) and to know whether it was entirely or only partially a result of the project.

4.1 China

In China the first phase of the project, conducted only in Hainan province, concentrated on the testing of new varieties, erosion control and fertilization. In the second phase, the emphasis shifted to testing mainly new varieties and some erosion control (in Hainan and Guangxi provinces), and to the feeding of ensiled cassava leaves and roots (only in southern Yunnan province) **(Table 10).**

FPR variety trials conducted in Kong Ba village in Hainan in 1995-1998 resulted in the farmer selection of the breeding lines ZM 9057 and OMR 33-10-4 because of good adaptation, high yield and resistance to strong winds (typhoons). In 2002 these two lines were officially released as recommended varieties under the names of SC 5 and SC 6, respectively. In addition, CATAS in Hainan also released SC 8013 and SC 8002, both from crosses made at CATAS, while GSCRI in Guangxi released the high yielding varieties GR 891 and GR 911. Two other varieties, SC 124 released in the 1980s by CATAS, and Nanzhi 199, released in the early 1990s by the South China Institute of Botany (SCIB) in Guangdong, became popular new varieties in Guangxi.

Due to the rapid expansion of FPR variety trials to many sites in Hainan and Guangxi during the second phase, these new varieties are now spreading throughout the cassava growing regions of these two major cassava growing provinces. The importance of cassava in Guangdong province, once the major producer, has been declining and little is known about the area still being planted and the varieties used. Thus, **Table 22** is at best an estimate of the extent of adoption of new varieties in the five cassava growing provinces of China. According to these data, new varieties are now planted in about 30,000 ha or approximately 8% of the total cassava growing area in China. This is likely to increase substantially as cassava is becoming a major industrial crop in Guangxi and Hainan provinces.

Table 22. Estimated adoption of new cassava varieties in five provinces of China in 2003.

		Area under cassava	Area under new varieties	Percent under new varieties
Guangxi	GR 891 and GR 911	-	3,333	-
	SC 124 and Nanzhi 199	-	13,333	-
		260,000	16,666	6.4
Guangdong		<66,000	?	?
Yunnan	Mostly SC 124; some Nanzhi 188	27,000	12,000	44.0
Hainan	Mostly SC 5; some SC 6	20,000	1,333	6.7
Fujian		?	133	?
Total China		**<373,000**	**30,132**	**~8**

FPR erosion control trials conducted in Hainan from 1995 to 1998 showed mainly the effectiveness of vetiver grass hedgerows in reducing soil losses. Demonstration plots conducted for many years at CATAS also indicated the effectiveness of hedgerows of vetiver grass, *Clitoria ternateo, Cassia rotundifolia* and *Tephrosia candida* in reducing erosion and increasing cassava yields (Huang Jie *et al.*, 2008). Of these various options, only vetiver grass hedgerows were adopted by a few farmers and in a very limited area (less than 5 ha), mainly because of lack of planting material and the labor involved in transporting and planting the vegetative material. The search for cheaper solutions, such as seed-propagated hedgerow species, contour ridging and closer plant spacing should continue, as these options are more likely to be adopted.

While FPR fertilizer trials conducted in Kongba village in Hainan showed a substantial response to application of chemical fertilizers, few farmers in that village adopted this practice; they preferred to open new land for cassava on the higher slopes and leave the rest in fallow rotation or convert to rubber plantations. Both at CATAS in Hainan and at GSCRI in Guangxi long-term fertilizer trials indicated the importance of applications of K and N, respectively, for maintaining high cassava yields. It is not clear, however, to what extent improved fertilizer practices have been adopted by farmers.

Farmers in some parts of China have traditionally intercropped cassava with maize, peanut, and watermelons. To increase the yields of watermelon, many farmers started to cover the soil with plastic sheets to reduce weed growth, increase soil temperature in early spring and reduce evaporation. With cheap plastic available on the market this was a highly profitable practice. Now they have adopted the same practice for cassava grown in monoculture. In 2002, in one subdistrict (town) of Wuming county in Guangxi, about 25% of cassava was grown on plastic mulch. Apparently, the increased cassava yields obtained and the reduced need for weeding more than compensates for the cost of the plastic. This practice is now being investigated in replicated on-station trials – an example of farmer-to-researcher extension!

4.2 Thailand

In Thailand both the government and the private sector (through TTDI) are actively involved in cassava research and extension, including the training of cassava farmers. From 1993 to 2000 TTDI trained about 30,000 cassava farmers and distributed about 40 million stems of new varieties, free of charge to these farmers (Banyat Vankaew *et al.*, 2008). In addition, from 1993 to about 1998 the Thai government spent over US$1 million per year for the multiplication and distribution of new high-yielding cassava varieties. This has resulted in the rapid spread of new varieties; in 2002/03 these covered about 1 million ha or 98% of the total cassava area in the country (**Table 23**). Thus, in Thailand many farmers in the pilot sites had already adopted new varieties before the Nippon Foundation project started; but, they may have changed from one new variety to another as a result of FPR variety trials conducted as part of the project. For instance, in Baan Khlong Ruam in Sra Kaew province farmers in 1993 planted mainly Rayong 90 while presently they plant mainly Rayong 5 (**Table 24**) as the latter variety was only released in 1994 and tested as part of FPR trials from 1995 to 1998. Similarly, in Thaa Chiwit Mai, farmers in 1995 (before the project) planted mainly the local variety Rayong 1 but changed to KU 50 after testing in FPR trials. Data collected from a Participatory Monitoring and Evaluation (PM & E) conducted in four project sites in Aug 2002 (**Tables 24** and **25**) indicate that in 2002 one hundred percent of the cassava area in those four sites were planted with new varieties (Watananonta *et al.*, 2008). It is very difficult, however, to know to what extent the adoption of new varieties was due to the project, as new varieties were also adopted by farmers all over the country (see Section 5 on Impact Assessment below).

According to a survey conducted by DOAE, in 1992 only 46% of cassava farmers in Thailand applied chemical fertilizers. In 1999/2000 a similar survey of "advanced" cassava farmers conducted by TTDI indicate that between 44 and 80% of farmers applied chemical fertilizers to most fields. Recent data from the Dept. of Agric. Statistics of Thailand indicate that in 2001 66.4% of the cassava area was fertilized, but that this decreased to 56.2% in 2002. The PM&E project survey (**Table 24**) indicates that at the start of the project most farmers either did not apply chemical fertilizers or applied small amounts of 15-15-15 compound fertilizers. In 2002, however, according to the PM&E in four project sites, chemical fertilizers were applied in 79 to 100% of the cassava area in those sites (**Table 25**). In most sites this was still 15-15-15, but farmers also applied more and more 13-13-21 or other compound fertilizers high in N and K and low in P. These fertilizers are more appropriate for cassava, but are still not widely available on the market.

Table 23. Spread of new cassava varieties in Thailand from 1989/90 to 2002/03.

	Area (ha)							% in
Variety	1989/90	1991/92	1994/95	1995/96	1997/98	1999/00	2002/03	2002/03
Local variety[1)]	1,470,382	1,400,256	949,204	840,253	416,113	146,297	18,270	1.7
others	-	-	-	-	-	-	3,481	0.3
Rayong 3	17,158	50,283	135,421	14,953	NA	27,004	9,242	0.8
Rayong 60	-	-	125,049	207,589	206,057	216,897	38,297	3.6
Rayong 90	-	-	35,461	81,049	143,055	220,926	150,961	14.4
Kasetsart 50	-	-	322	17,846	149,270	410,852	465,951	44.3
Sri Racha 1	-	-	NA	NA	NA	4,125	NA	-
Rayong 5	-	-	NA	66,424	129,594	125,823	304,721	29.0
Rayong 72	-	-	-	-	-	-	60,444	5.8
Total new varieties	**17,158**	**50,283**	**296,253**	**387,861**	**627,976**	**1,005,627**	**1,029,616**	
Total cassava area	1,487,540	1,450,539	1,245,457	1,228,114	1,044,089	1,151,924	1,051,368	
% with new varieties	1.1	3.5	23.8	31.6	60.1	87.3	97.9	

[1)] >90% Rayong 1

Source: *Klakhaeng et al., 1995; Rojanaridpiched et al., 1998; Office of Agric. Economics, 2000; NE Tapioca Trade Assoc. 2003.*

Presently, more and more farmers are applying animal manures, mostly chicken manure as this is becoming more available as a result of the booming poultry industry (at least before the outbreak of bird flu in early 2004). But its use is still rather limited, probably no more than 10-20%. Farmers in some areas are also becoming interested in testing and planting green manures, such as *Canavalia ensiformis*, *Crotalaria juncea*, mungbean and cowpea. Some of these were tested in FPR trials (see **Table 17**). When the green manures are intercropped and planted at the same time as cassava, the yield of cassava is usually reduced due to strong competition (see **Table 3**). But when the green

Table 24. Change in the use of new cassava production technologies[1] in four pilot sites[2] in Thailand from 1995 to 2002[2] as a result of the Nippon Foundation project.

Technology	Baan Khlong Ruam			Thaa Chiwit Mai			Sapphongphoot			Huay Suea Ten		
component	1993	1995	2002	1995	1997	2002	1995	1997	2002	1995	1997	2002
Varieties	R90 (60%) R3 (30% R60 (10%)	R90 (60%) R5 (20%) KU50 (20%)	R5 (67%) R90 (19%) KU50 (12%) R72 (2%)	R1 (94%) R60 (3%) R5 (3%)	KU50 (41%) R60 (32%) R5 (22%) R90 (5%)	KU50 (81%) R5 (18%) R72 (1%)	R1 R60 R90	KU50 R5 R90	KU50 (91%) R90 (5%) R72 (3%) R5 (1%)	R1 R90 KU50	KU50 R5 R90	KU50 (54%) R5 (20%) R90 (15%) R72 (11%)
Chemical fertilizers	not apply	15-15-15 13-13-21	15-15-15 (35%) 13-13-21 (17%) 21-4-21 (13%) 14-4-24 (10%) 16-20-0 (5%) other (20%)	not apply	15-15-15	15-15-15 (50%) 13-13-21 (38%) other (12%)	not apply or 15-15-15 (little)	15-15-15 46-0-0	15-15-15 (44%) 46-0-0 (27%) 13-13-21 (4%) other (25%)	not apply or 15-15-15 (little)	15-15-15 and 16-8-8 mixed at 2:1 ratio	15-15-15 (47%) 16-8-8 (33%) 21-0-0 (12%) 46-0-0 (7%) 13-13-21 (1%)
Vetiver	not plant	46%	29%	not plant	3%	20%	not plant	70%	55%	not plant	32%	39%
Green manures	not plant	not plant	*Canavalia* (little) cowpea (little	not plant	not plant	*Canavalia* (little)	not plant	not plant	*Canavali a* (little) *Crotalaria* (little)	not plant	*Canavalia* (20%)	*Canavalia* (50%)

[1)]Date collected from Participatory Monitoring and Evaluation (PM&E) with farmers in Aug 2002; percentages are in terms of cassava area

[2)]Baan Khlong Ruam village, Wang Soombuun district, Sra Kaew province
Thaa Chiwit Mai village, Sanaam Chaikhet district, Chachoengsao province
Sapphongphoot village, Soeng Saang district, Nakhon Ratchasima
Huay Suea Ten village, Sahatsakhan district, Kalasin province

[3)]Nippon Foundation project started in these pilot sites around 1997, except in Baan Khlong Ruam where it started in 1995

Table 25. Extent of adoption[1)] of various cassava technology components in four pilot sites in Thailand in 2002 as a result of the Nippon Foundation project.

Technology component	Baan Khlong Ruam Sra Kaew		Thaa Chiwit Mai Chachoengsao		Sapphongphoot Nakhon Ratchasima		Huay Suea Ten Kalasin	
	(ha)	(%)	(ha)	%)	(ha)	(%)	(ha)	(%)
Varieties	480	100	469	100	396	100	228	100
Chemical fertilizers	480	100	469	100	364	92	180	79
Vetiver grass hedgerows	139	29	94	20	218	55	89	39
Green manures	72	15	0	0	0	0	114	50
Intercropping	0	0	0	0	0	0	0	0

1) Estimated by farmers in each site during Participatory Monitoring and Evaluation (PM&E) in Aug 2002
Source: *Watananonta et al., 2008.*

manures were planted one month after cassava and pulled up 1-2 months later, the competition was less and cassava yields sometimes (but not always) increased. **Tables 24** and **25** indicate that green manures were planted in only two of the four sites surveyed in 2002; in those sites green manures were planted in 15 and 50% of the cassava area and most farmers preferred *Canavalia* as it is well adapted to poor and acid soils, is drought tolerant, easy to plant and less competitive as compared to other species (see **Table 3**).

Although 23 FPR intercropping trials were conducted in Thailand in 2001 and 2002, this technology component was almost universally rejected by Thai farmers, mainly because it is too labor intensive, interferes with mechanized weed control, and intercrop yields are very much affected by either drought or excess rainfall; in addition, many intercrops have serious pest and/or disease problems. While the potential economic benefits from intercropping can be high (see **Table 19**), most farmers are not willing to spend the labor and money required and then risk crop failure. Intercropping with pumpkin might be attractive, but the marketing of large amounts becomes a serious problem.

As most cassava in Thailand is grown on very gentle slopes, usually between 0 and 10%, erosion would normally not be a problem. However, most cassava soils are very light textured (sandy loams or loamy sands) and are very low in organic matter (0-1%); these soils have thus poor aggregation, which makes them very susceptible to erosion. Moreover, yearly land preparation with disk plows has resulted in the formation of a very compacted plow layer at 20-25 cm below the soil surface, which impedes internal drainage. Thus, after heavy rains, the top soil becomes quickly saturated and excess water runs down the slope causing both sheet and gully erosion. Also, the large size of land holdings allows water to run freely over long distances resulting in water concentration and strong currents in natural drainage ways. This can result in very severe gully erosion.

In Thailand 33 FPR erosion control trials were conducted in the 1st phase and 41 in the second phase of the project (see **Table 10** and **Table 14**). After testing several ways to control erosion, farmers generally narrowed this down to contour hedgerows of either lemon grass or vetiver grass. While lemon grass has some commercial value, its marketing in large quantities is difficult; moreover, it is less drought tolerant than vetiver grass. Thus, almost 100% of farmers in Thailand selected vetiver grass hedgerows as the most suitable soil conservation practice. The fact that the Royal Family and most government organizations also promote the use of vetiver for soil and water conservation has certainly influenced that selection. In any case, many farmers in the project sites have adopted the planting of vetiver grass hedgerows, especially since the vegetative planting material was usually provided free of charge and LDD staff helped in setting out contour lines. **Table 24** indicate that there were no vetiver hedgerows planted before the start of the project, but that this soil conservation practice was used in 20-55% of the cassava area in the four sites surveyed in 2002. In Baan Khlong Ruam the area with vetiver hedgerows reached 46% in 1995 but decreased to only 29% in 2002; some had been destroyed by tractor drivers during land preparation, as these hedgerows interfere with straight-line and/or up-and-down land preparation. Nevertheless, the number of households adopting these soil conservation practices increased year by year (**Figure 6**). In 2003 about 145 km of vetiver hedgerows had been planted, covering about 580 ha in 20 project sites (Wilawan Vongkasem *et al.*, 2008). While this is a major accomplishment and far exceeds initial expectations, it still corresponds to less than 0.1% of the total cassava growing area in Thailand. Obviously, not all cassava areas have an erosion problem, but both low soil fertility and soil erosion were listed as some of the most serious problems in cassava cultivation by farmers participating in training courses at TTDI (Banyat Vankaew *et al.*, 2008).

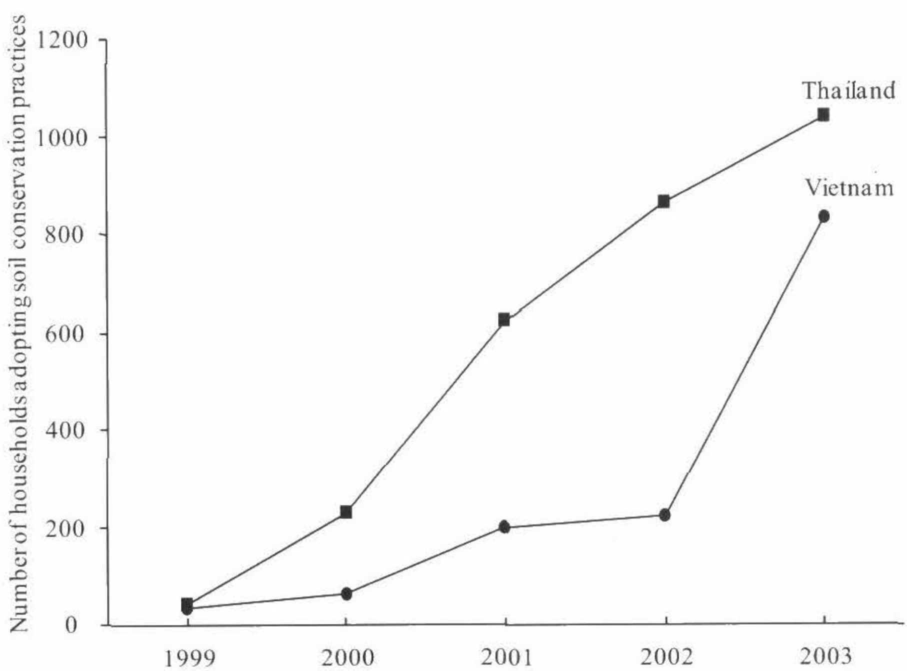

Figure 6. Number of farmers adopting soil conservation measures in their cassava fields in FPR pilot sites in Thailand and Vietnam from 1999 to 2003.

The strong government support for planting vetiver grass has no doubt contributed greatly to the relatively rapid adoption of this technology; however, it could well have impeded the search for, and adoption of, other soil conservation options that are almost equally as effective and cheaper to establish, such as contour hedgerows of seed propagated species like *Paspalum atratum, Brachiaria brizantha* and possibly *Tephrosia candida* (or other leguminous species). Using data from many erosion control experiments, demonstration plots and FPR trials conducted in Thailand from 1994 to 2003, it was found (**Table 26**) that on average hedgerows of vetiver grass and *Paspalum* were almost equally effective in reducing erosion (by 42 and 47%, respectively), while both reduced cassava yields about 10%. Closer plant spacing reduced erosion only slightly (12%), but increased yields by 16%, while contour ridging reduced erosion 31% and increased yields 8%. Lack of fertilizer application did not significantly reduce yields in FPR trials (only 4%) but markedly increased erosion by 140%. Thus, the adoption of more or better fertilizer use and closer plant spacing, almost universally adopted by farmers for economic reasons, may actually have contributed more to erosion control than any of the "soil conservation" practices adopted as a direct result of the project. In the future, it would be recommended to test the use of vetiver grass mainly for control and repair of gullies (**Figure 5**), and hedgerows of *Paspalum atratum* or *Brachiaria brizantha* variety Toledo for control of sheet erosion in the upper parts of the landscape (all except the drainage ways), all combined with contour ridging, closer plant spacing and the combined use of animal manures and chemical fertilizers high in N and K.

Table 26. Effect of various soil conservation practices on the average[1)] relative cassava yield and dry soil loss due to erosion as determined from soil erosion control experiments, FPR demonstration plots and FPR trials conducted in Thailand from 1994 to 2003.

	Soil conservation practices[2)]	Relative cassava yield (%)	Relative dry soil loss (%)
1.	With fertilizers; no hedgerows, no ridging, no intercrop (check)	100	100
2.	With fertilizers; vetiver grass hedgerows, no ridging, no intercrop**	90 (25)	58 (25)
3.	With fertilizers; lemon grass hedgerows, no ridging, no intercrop**	110 (14)	67 (15)
4.	With fertilizers; sugarcane for chewing hedgerows, no intercrop	99 (12)	111 (14)
5.	With fertilizers; *Paspalum atratum* hedgerows, no intercrop**	88 (7)	53 (7)
6.	With fertilizers; *Panicum maximum* hedgerows, no intercrop	73 (3)	107 (4)
7.	With fertilizers; *Brachiaria brizantha* hedgerows, no intercrop*	68 (3)	78 (2)
8.	With fertilizers; *Brachiaria ruziziensis* hedgerows, no intercrop*	80 (2)	56 (2)
9.	With fertilizers; elephant grass hedgerows, no intercrop	36 (2)	81 (2)
10.	With fertilizers; *Leucaena leucocephala* hedgerows, no intercrop*	66 (2)	56 (2)
11.	With fertilizers; *Gliricidia sepium* hedgerows, no intercrop*	65 (2)	48 (2)
12.	With fertilizers; *Crotalaria juncea* hedgerows, no intercrop	75 (2)	89 (2)
13.	With fertilizers; pigeon pea hedgerows, no intercrop	75 (2)	90 (2)
14.	With fertilizers; contour ridging, no hedgerows, no intercrop**	108 (17)	69 (17)
15.	With fertilizers; up-and-down ridging, no hedgerows, no intercrop	104 (20)	124 (20)
16.	With fertilizers; closer spacing, no hedgerows, no intercrop**	116 (10)	88 (11)
17.	With fertilizers; C+peanut intercrop	72 (11)	102 (12)
18.	With fertilizers; C+pumpkin or squash intercrop	90 (13)	109 (15)
19.	With fertilizers; C+sweetcorn intercrop	97 (11)	110 (14)
20.	With fertilizers; C+mungbean intercrop*	74 (4)	41 (4)
21.	No fertilizers; no hedgerows, no or up/down ridging	96 (9)	240 (10)

[1)] number in parenthesis indicates the number of experiments/trials from which the average values were calculated.
[2)] C = Cassava
** = most promising soil conservation practices; * = promising soil conservation practices

4.3 Vietnam

Table 27 shows how the number of households in the pilot sites adopting the various technology components increased over time, with most farmers adopting new varieties. This is partially due to the testing in FPR variety trials, but is also due to the planting of new varieties by non-participating farmers in or near the pilot sites.

Table 27. Trend of adoption of new cassava technologies in the Nippon Foundation project sites in Vietnam from 2000 to 2003.

	Number of households adopting			
Technology component	2000	2001	2002	2003
1. New varieties	88	447	1,637	14,820
2. Improved fertilization	64	123	157	1,710
3. Soil conservation practices	62	200	222	831
4. Intercropping	127	360	689	4,250
5. Pig feeding with cassava root silage	-	759	967	1,172

[1)]Number of project sites: 1999 = 9; 2000=15; 2001=22; 2002=25; 2003=34

Source: *Tran Ngoc Ngoan, 2008.*

Table 28 shows one example of the extent of adoption in 2002/03 of new varieties in five communes in Pho Yen district of Thai Nguyen province and in three communes in Son Duong district of neighboring Tuyen Quang province, both in north Vietnam. According to the RRA's conducted in 1994 in Pho Yen and in 1999 in Son Duong districts, the average cassava yields of the local variety Vinh Phu were 8.5 and 3.7 t/ha, respectively. In 2002/03 (**Table 28**), the average yield of the same variety but with improved practices were 24.5 and 18.4 t/ha in the project sites of the same two districts. With the adoption of new varieties, i.e. KM 95-3 and KM 98-7 in Pho Yen and KM 94 in Son Duong, yields further increased to 30.3 and 36.0 t/ha, respectively. Thus, in Son Duong the adoption of new varieties and improved practices (mainly more balanced fertilization) increased yields nearly ten times, while in Pho Yen yields increased about 3.5 times. In 2003/04, new varieties (KM 94) had been planted in 56.5 ha in seven communes in Son Duong district, out of a total of about 400 ha of cassava in the district, in Pho Yen in 2003 new varieties had been planted in 51.3 ha in six communes, out of a total of about 650 ha of cassava in the district (other communes may also have planted new varieties, but complete data is not available).

Tran Ngoc Ngoan (2008) reported that in Vietnam, KM 94 (= KU-50 from Thailand) is the most widely adopted new variety; it is by far the most popular variety in almost all regions of Vietnam except in parts of Thai Nguyen province where farmers have adopted KM 98-7 and KM 95-3, in Hue province where farmers prefer the more edible variety KM 98-1 (=Rayong 72 from Thailand), and in Binh Phuoc province where KM 94 is now being replaced by KM 98-5 which tends to produce higher yields.

Besides varieties, most farmers in the Vietnam pilot sites also adopted a more balanced fertilization, i.e. they combined the traditional practice of applying 5-10 t/ha of pig manure (FYM) with chemical fertilizers high in N and K (such as $40N\text{-}20P_2O_5\text{-}80K_2O$

or 80N-80K_2O) as these combinations usually produced highest yields and net income in the FPR fertilizer trials (see **Table 15**). Although the number of households applying fertilizers to cassava did not increase as much as expected (**Table 27**) as most farmers already applied FYM with some (mainly P) fertilizer, the level of application increased and the nutrient balance is now more appropriate as a result of the project. **Table 29** shows that adoption of more balanced fertilization on average increased yields from 21.4 to 30.5 t/ha, or a 43% increase over the traditional farmer's practice. The adoption of new varieties increased cassava yields more than the adoption of any other technology component, including improved fertilization.

Table 28. Extent of the dissemination of new cassava varieties in six communes of Pho Yen district, Thai Nguyen, and three communes in Son Duong district of Tuyen Quang province, Vietnam in 2002/03 and their effect on yield and gross income.

District	Commune	Variety	No. of farmers	Area (ha)	Cassava yield (t/ha)	Gross income[1] ('000 d/ha)
Pho Yen						
1.	Tien Phong	Vinh Phu (local)	18	0.64	25.4	12,700
		KM 95-3	50	1.60	32.3	16,150
		KM 98-7	50	3.56	34.3	17,150
2.	Dac Son	Vinh Phu (local)	6	0.27	25.1	12,550
		KM 95-3	5	0.22	28.3	14,065
		KM 98-7	11	0.49	30.5	15,250
3.	Minh Duc	Vinh Phu (local)	34	1.62	23.5	11,750
		KM 95-3	34	0.65	27.4	13,700
		KM 98-7	34	0.86	28.1	14,050
4.	Hong Tien	Vinh Phu (local)	12	0.61	25.4	12,700
		KM 95-3	16	0.58	31.1	15,550
		KM 98-7	28	1.42	32.3	16,150
5.	Nam Tien	Vinh Phu (local)	9	0.40	23.5	11,750
		KM 95-3	9	0.29	28.1	14,050
		KM 98-7	9	0.36	30.2	15,100
6.	Van Phai	Vinh Phu (local)	9	0.32	23.8	11,900
		KM 95-3	17	0.70	29.2	14,600
		KM 98-7	25	1.46	31.3	15,650
Son Duong						
1.	Am Thang	Vinh Phu (local)	14	2.57	19.8	9,900
		La Tre (local)[2]	10	3.65	16.1	8,050
		KM 60[3]	9	0.42	28.3	14,150
		KM 94[3]	23	5.06	36.3	18,150
		KM 95-3	13	1.05	27.1	13,550
		KM 98-7	3	0.14	30.0	15,000
2.	Hong Tien	Vinh Phu (local)	2	0.25	17.0	8,500
		La Tre (local)	26	11.39	15.4	7,700
		KM 94	30	4.29	36.1	18,050
		KM 98-7	1	0.14	28.0	14,000
3.	Cap Tien	La Tre (local)	20	12.25	19.6	9,800
		KM 60	20	0.20	29.4	14,700
		KM 94	20	0.28	35.7	17,850
		KM 98-7	20	0.20	30.0	15,000

[1]Price: cassava dong 500/kg fresh roots.
[2]La Tre = SC 205 introduced from China in 1967-1972.
[3]KM 60 = Rayong 60; KM 94 = KU 50, both introduced from Thailand in 1989-1991.

Table 29. Estimated increase in cassava fresh root yield due to the adoption of various new technology components in Vietnam in 2002/03[1].

Technology component	Cassava yield (t/ha) Farmers' practice[2]	Cassava yield (t/ha) With adoption of new technology component	New practice as % of farmers' practice[2]
1. New varieties	17.61	29.93	170
2. Improved fertilization	21.37	30.50	143
3. Soil conservation practices	20.60	25.48	124
4. Intercropping	29.95	28.94	97

[1] Based on results from 15 FPR sites where new technologies have been adopted by farmers.
[2] Farmers' practice usually includes most new technologies except the technology being tested
Source: *Tran Ngoc Ngoan, 2008*

Table 27 shows that the number of households adopting soil conservation practices – mostly the planting of contour hedgerows of *Tephrosia candida*, vetiver grass, *Paspalum atratum* and pineapple – increased from 62 in 2000 to 831 in 2003. These practices were used in 612 ha of cassava in the project pilot sites (**Table 30**). In some sites these hedgerows had been in place for 5-8 years, while in many others they had been recently established. Average results from many FPR trials and demonstration plots indicate that in Vietnam contour hedgerows of vetiver grass increased cassava yields about 13-15%, while those of *Tephosia* increased yields 5-10%; soil losses by erosion decreased 49-52% by vetiver grass and 36-51% by *Tephrosia* hedgerows (**Table 31**). Hedgerows of *Paspalum atratum* increased yields 12% and decreased erosion 50%, about the same as vetiver grass hedgerows; pineapple was also similarly effective in decreasing erosion (52-56%) but had basically no effect on yield. Contour ridging and intercropping with peanut both increased yields by about 6% and decreased soil losses by 30% and 19%, respectively.

Table 30. Extent of adoption of soil conservation practices and the estimated increase in yield and gross income of farmers in the FPR pilot sites in Vietnam from 2000 to 2003.

Year	Number of farmers	Area with soil conser. (ha)	Cassava yield (t/ha) Farmers' practice[1]	Cassava yield (t/ha) With soil conservation	Percent yield increase	Increase in gross income (mil VND)[2] per ha	Increase in gross income (mil VND)[2] total	Increase in gross income (mil VND)[2] per household
2000	62	21.12	12.11	13.75	13.5	0.574	12.123	0.196
2001	200	59.87	16.50	19.95	20.9	1.112	66.596	0.333
2002	222	88.85	20.60	25.48	23.7	1.952	173.728	0.782
2003	831	612.00	20.60[3]	25.48[2]	23.7	1.561	955.699	1.150
Total	831	612.00					1,208.146	

[1] Farmers' practice includes most new technologies except soil conservation
[2] Fresh root price: in 2000 350 VND/kg
in 2001 350 VND/kg in north, 200 in central and 290 in south
in 2002 400 VND/kg
in 2003 320 VND/kg (estimated)
[3] Yields estimated from 2002
Source: *Tran Ngoc Ngoan, 2008*

Table 31. Effect of various soil conservation practices on the average[1] relative cassava yield and dry soil loss due to erosion as determined from soil erosion control experiments, FPR demonstration plots and FPR trials conducted in Vietnam from 1993 to 2003.

		Rel. cassava yield (%)		Rel. dry soil loss (%)	
	Soil conservation-practices[2]	Cassava monoculture	Cassava + peanut	Cassava monoculture	Cassava + peanut
1.	With fertilizers; no hedgerows (check)	100	-	100	-
2.	With fertilizers; vetiver grass hedgerows**	113 (17)	115 (23)	48 (16)	51 (23)
3.	With fertilizers; *Tephrosia candida* hedgerows**	110 (17)	105 (23)	49 (16)	64 (23)
4.	With fertilizers; *Flemingia macrophylla* hedgerows*	103 (3)	109 (4)	51 (3)	62 (3)
5.	With fertilizers; *Paspalum atratum* hedgerows**	112 (17)	-	50 (17)	-
6.	With fertilizers; *Leucaena leucocephala* hedgerows*	110 (11)	-	69 (11)	-
7.	With fertilizers; *Gliricidia sepium* hedgerows*	107 (11)	-	71 (11)	-
8.	With fertilizers; pineapple hedgerows*	100 (8)	103 (9)	48 (8)	44 (9)
9.	With fertilizers; vetiver+*Tephrosia* hedgerows	-	102 (7)	-	62 (7)
10.	With fertilizers; contour ridging; no hedgerows*	106 (7)	-	70 (7)	-
11.	With fertilizers; closer spacing, no hedgerows	122 (5)	-	103 (5)	-
12.	With fertilizers; peanut intercrop; no hedgerows*	106 (11)	100	81 (11)	100
13.	With fertilizers; maize intercrop; no hedgerows	69 (3)	-	21 (3)	-
14.	No fertilizers; no hedgerows	32 (4)	92 1(5)	137 (4)	202 (12)

[1] number in parenthesis indicates the number of experiments/trials from which the average values were calculated.
[2] IC = intercrop, HR = hedgerows
** = most promising soil conservation practices; * = promising soil conservation practices

Data in **Table 30** indicate that adoption of soil conservation practices in all sites in Vietnam increased yields from 13.5% in 2000 to 23.7% in 2002. **Table 30** also shows that the gross income, both per ha and per household, as a result of the adoption of soil conservation practices also increased very markedly over time. Results from both FPR trials and on-station research also indicate that the beneficial effect of contour hedgerows in terms of increasing yields and decreasing erosion increases over time (**Figures 3** and **4**). This is mainly because contour hedgerows, almost independent of the species used, will result in natural terrace formation, which over time reduces the slope and enhances water infiltration, thus reducing runoff and erosion. Well established hedgerows also become increasingly more effective in trapping eroded soil and fertilizers. Unfortunately, most FPR erosion control trials are conducted for only 1-2 years at the same site, so farmers do not quite appreciate the increases in beneficial effects that accrue over time. This, coupled with the fact that planting and maintaining hedgerows requires additional labor (and sometimes money for seed or planting material) while hedgerows take some land out of production and have initially little beneficial effect on yield, has hampered the more widespread acceptance and adoption of these soil conservation practices.

Nevertheless, adoption of soil conservation practices increased markedly from 2002 to 2003 (**Table 30**), partially because more farmers had seen the effectiveness of contour hedgerows in FPR trials, but also because the extension office in Van Yen district of Yen Bai province distributed 12 tonnes of free seed of *Tephrosia candida* and *Paspalum atratum* so as to encourage farmers to control erosion when planting cassava on steep slopes. Thus, in the spring of 2003 at least 500 km of double hedgerows of *Tephrosia* or *Paspalum* were planted in this district alone, covering 300-500 ha. This, combined with the use of new varieties (mainly KM 94), better fertilization (60N-40P_2O_5-80K_2O) and intercropping with peanut, increased average cassava yields in the district from about 10 t/ha to 30 t/ha.

Table 27 shows that the number of households adopting intercropping – mainly with peanut and, to a lesser extent, black bean (= black cowpea) – increased from 127 in 2000 to 4,250 in 2003. The very large increase in adoption from 2002 to 2003 is due to a marked increase in the number of project sites, but is also due to the rapid expansion of intercropped cassava in Van Yen district of Yen Bai province due to the distribution of seed of a new high-yielding peanut variety (LD-7) by the district extension office.

Although the small size of farm holdings and the abundance of labor in rural areas (especially in the north) of Vietnam favor very intensive crop production, including intercropping, this practice is still not so widespread. One reason is that intercropping oftentimes (but not always) decreases the yield of the main crop (**Tables 29** and **31**); secondly, it requires considerable extra labor for planting, harvesting and post-harvest handling as well as money for buying the seed (0.3 mil. VND/ha), while weather conditions as well as pests and diseases make intercropping very risky. While intercropping can markedly increase gross and net income (**Tables 18** and 19), many farmers are reluctant to invest in this practice because of the high risks involved.

Table 27 also shows that the number of households adopting cassava root and leaf silage for feeding pigs increased markedly from practically zero in 2000 to 1,172 households in 2003, mainly in the pilot sites of Hue province in central Vietnam. In 2003, 1,172 households adopted this practice raising 3,370 pigs, which resulted in additional gross income of 145.5 mil. VND (US$ 9,400), or 0.124 mil. VND ($8.00) per household. The use of cassava silage has mainly an effect on reducing feed costs (**Table 20**) and may thus increase net income more than gross income.

A good example of the extent of adoption of various technology components over time is shown in **Table 32** for Tien Phong commune in Pho Yen district of Thai Nguyen province, as well as the impact of this adoption on net income from cassava per ha and for the total community. This commune was selected as a suitable pilot site when the project commenced in 1994. At that time, according to the RRA, about 115 households planted cassava, cv Vinh Phu, on a total of 50 ha with an average yield of 8.5 t/ha. This produced a net income of 0.47 mil. VND/ha or 23.50 mil. VND for the whole commune. After conducting many FPR trials in 1995-1999 farmers started to adopt new varieties, intercropping, more balanced fertilization and soil conservation practices (in small areas only, as most fields are rather flat). Over the years, more and more households adopted these new technologies in ever larger areas resulting in marked increases in yields, both of the local variety Vinh Phu and the new varieties. In 2003 new technologies had been adopted in a total of about 32 ha with an average yield of 36 t/ha. Net income per ha increased from 0.47 mil. VND in 1994 to about 14 mil VND in 2003, while total net income from cassava in the community increased from 23.5 mil VND ($2,350) in 1994 to over 450 mil. VND ($29,200) in 2003. Thus, during the 10-year period, the net income from cassava in the community increased in dollar terms more than ten times even though the area under cassava may have decreased from 50 to about 32 ha. This has had a profound effect on the standard of living of farmers in this commune. The impact is probably less pronounced in other sites mainly because of a shorter duration of involvement in the project and thus less adoption of new technologies. With time similar beneficial effects can be expected in many other communities in Vietnam.

Table 32. Impact of the adoption of new cassava varieties and improved production practices on the livelihoods of farmers in Tien Phong commune, Pho Yen districtl of Thai Nguyen, Vietnam.

Year	Variety or practice[1)]	No. of farmers	Cassava area (ha)	Cassava yield (t/ha)	Peanut yield (t/ha)	Gross income[2)]	Production costs	Net income	Total net income (mil.dong)
						——	(mil. dong/ha)	——	
1994[3)]	Vinh Phu	115	50	8.5	-	3.40	2.93	0.47	23.50
	New varieties	0	-	-	-	-	-	-	-
			50						**23.50**
2000	Vinh Phu	NA[4)]	NA	21.5	-	NA	NA	NA	NA
	New varieties	25	1.31	30.9	-	15.45	4.36	11.10	14.54
	Intercropping	37	2.59	29.3	0.81	18.70	6.16	12.54	32.48
	Erosion control	4	0.20	24.7	-	12.35	4.66	7.69	1.54
			>4.10						**>48.56**
2001	Vinh Phu	61	2.17	22.7	-	11.35	4.36	6.99	15.17
	New varieties	122	4.70	29.0	-	14.50	4.36	10.14	47.66
	Intercropping	40	3.38	26.2	0.77	16.94	6.16	10.78	36.44
	Erosion control	4	0.20	NA	-	NA	NA	NA	NA
			10.45						**>99.27**
2002	Vinh Phu	18	0.64	25.4	-	12.70	4.33	8.37	5.36
	New varieties	100	5.16	33.7	-	16.85	4.33	12.52	64.60
	Intercropping	118	3.69	32.3	1.73	24.80	6.13	18.67	68.89
	Balanced fert.	48	2.95	33.4	-	16.70	4.83	11.87	35.02
	Erosion control	5	0.18	25.4	-	12.70	4.63	8.07	1.45
			12.62						**175.32**
2003	Vinh Phu	NA	NA	NA	-	NA	NA	NA	NA
	New varieties	225	17.00	36.8	-	18.40	4.33	14.07	239.19
	Intercropping	120	11.00	36.0	0.67	21.35	6.13	15.22	167.42
	Balanced fert.	54	3.40	33.6	-	16.80	4.83	11.97	40.70
	Erosion control	5	0.60	27.0	-	13.5	4.63	8.87	5.32
			>32.00						**>452.63**

[1)] In Tien Phong farmers traditionally grow mainly Vinh Phu variety but have now largely changed to KM 95-3 and KM 98-7; the new practices include intercropping with peanut, balanced fertilization of 10 t/ha of pig manure plus 80N-40P_2O_5-80 K_2O, and erosion control by contour hedgerows of *Tephosia candida*

[2)] Price of cassava in 1994: 400 VND/kg fresh roots
Price of cassava in 2000-2003: 500 VND/kg fresh roots
Price of peanut in 2000-3003: 5,000 VND/kg dry pods

[3)] Data from RRA at the start of project

[4)] NA = data not available

Table 33 summarizes the extent of adoption of new cassava technologies in 15 pilot sites in Vietnam in 2003 and the resulting expected increase in gross income due to higher yields obtained. Although balanced fertilization produced the highest yields, it was not adopted over a very wide area. New varieties were most adopted resulting in the greatest increase in gross income. The total increase in gross income due to new technologies was estimated at 2.2 million US dollars or $96.03 per household.

Table 33. Extent of adoption of new cassava production technologies in 15 FPR pilot sites in Vietnam in 2003/04, the effect on cassava yields, and the increase in gross income resulting from the yield increase in those sites.

Technology component	No. of households	Area (ha)	Cassava yield (t/ha) Farmers' practice[1)]	Improved technology	Increase in gross income ('000 US$)[2)]
1. New varieties	14,820	7,849	17.61	29.93	1,996
2. Balanced fertilization	1,710	607	21.37	30.50	114
3. Soil conservation practices	831	612	20.60	25.48	62
4. Intercropping	4,250	160	29.95	28.94	15 [4)]
5. Root and leaf silage for pig feeding	1,287	-[3)]	-	-	12
Total	**22,898**	**9,228**			**2,199**

[1)] Farmers' practice usually includes most new technologies except the technology being tested
[2)] based on an expected price of 320 VND/kg fresh roots in 2003/04; 1 US$ = 15,500 VND
[3)] 3,370 pigs
[4)] increase in gross income from the harvest of intercrops
Source: *adapted from Tran Ngoc Ngoan, 2008.*

4.4 Adoption of New Cassava Technologies and their Effect on Yield and Farm Income in Asia

The extent of adoption of specific technologies on a country-or continent-wide basis is almost impossible to determine. Nevertheless, surveys conducted in Thailand, Vietnam and China indicate the approximate extent of adoption of new varieties (**Table 34**). Information from RRAs, the Vietnam cassava survey of 1991/92 as well as published data in Thailand can give an average value for the area under cassava per household. Assuming that any one household has completely replaced their traditional cassava variety with new higher yielding varieties, we can get an idea about the minimum number of households in each country which planted new varieties. According to the data in **Table 34** at least 90,000 farmers in China, about 350,000 in Thailand and 718,000 in Vietnam or a total of at least 1.16 million farmers have benefited from planting new higher yielding varieties in these three countries. While it is impossible to say to what extent the Nippon Foundation project contributed to this rapid adoption of new varieties in Asia (**Figure 7**), it is probably fair to say that the project made a considerable contribution, either directly by conducting FPR trials with farmers, organizing field days and training courses, but also indirectly through the publication of booklets, pamphlets, as well as newspaper articles and TV. In Vietnam at least 15,000 farmers in 15 pilot sites have adopted new technologies, in Thailand at least 1000 farmers are members of "Cassava Development Villages" and in China over 700 farmers participated in FPR or regional training courses. Thus, it is likely that our target of benefiting at least 8000 farmers by this project was achieved, and probably surpassed by a considerable margin.

Another way of estimating the monetary benefits of adoption of new cassava technologies would be to look at the yield trends in the three countries where the Nippon Foundation project was most active. **Figure 8** shows the average cassava yields in India, Thailand, China, Indonesia and Vietnam from 1994 to 2003, i.e. the ten-year period corresponding to the Nippon Foundation project. Yields in all countries have increased, but the rate of increase was rather low in India, China and Indonesia, and very high in Thailand and Vietnam. From 1994 to 2003 yields in Thailand increased from 14.28 to 19.30 t/ha, a 40% increase corresponding to an annual rate of increase of 3.78%; during the same period yields in Vietnam increased from 8.44 to 14.28 t/ha, a 69% increase corresponding to an annual rate of increase of 6.02%, while in all of Asia yields increased from 12.93 to 16.61 t/ha or at an annual rate of 2.81%. In Thailand cassava yields have increased steadily since 1995, a few years after some of the high yielding varieties were released and started to be adopted (**Table 23**). In Vietnam the same thing happened but only about five years later. In China the process has barely started with only about 8% coverage of new varieties, *versus* about 50% in Vietnam and 100% in Thailand. Yields in China are expected to increase substantially, especially in Guangxi and Hainan provinces where the project has been quite active in developing and disseminating new varieties.

Table 34. Estimate of the area under new cassava varieties in China, Thailand and Vietnam in 2003 and the minimum number of households that planted these varieties.

	Area under new varieties (ha)	Average cassava area per household (ha)[1)]	Average no. of farmers adopting new varieties[2)]
China -Guangxi	16,666	0.22	75,500
-Guangdong	~6,000	0.53	~11,320
-Hainan	1,333	0.53	2,500
Thailand	1,000,000	2.86	350,000
Vietnam	194,000	0.27	718,000
Total			**~1,157,820**

[1)] Data estimated from RRA in China in 1994 (Henry and Howeler, 1996) and the Vietnam Cassava Survey of 1991/92 (Pham Than Binh *et al.*, 1996) and Office Agric. Economics, Thailand (2002); Hoang Kim *et al.*, 2005

[2)] Assuming complete replacement of old by new varieties

Table 35 shows the impact of these yield increases on gross income in China, Thailand and Vietnam as well as for all of Asia, based on FAO data. During the past ten years yields in China increased 0.79 t/ha (our Chinese colleagues insist that those data are incorrect and that both the area under cassava and the yield increase is actually much higher), in Thailand 5.49 t/ha, in Vietnam 5.84 t/ha, and in all of Asia 3.68 t/ha. Considering the area under cassava in 2003 and the average price of fresh roots, it is possible to calculate the annual additional gross income from the increased cassava yields as compared to ten years ago. For China this was calculated to be 5.35 million, for Thailand 123.42 million and for Vietnam 54.30 million US dollars. In addition, Thai farmers received a price premium for planting varieties with higher starch content, which is not included in these calculations. For Asia as a whole the yield increase of 3.68 t/ha corresponds to an extra 318 million US dollars in the pockets of cassava farmers every year. If we estimate that there are about 8-10 million cassava farmers in Asia, this means that the increased cassava yields provided about $30-40 extra income per family as compared to ten years ago. In Thailand this may be as high as $350.-; in many countries it will be much less than $20.-. This is not insignificant considering that the net farm income in NE Thailand is $375.- per year; in other countries it is much lower. The economic benefits of the project continued to increase in subsequent years, as both cassava yields and area planted increased while in many countries in Asia the cassava root price nearly doubled between 2003 and 2007. **Table 1** in **Appendix 3** provides an estimate of the benefits achieved in 2005/06.

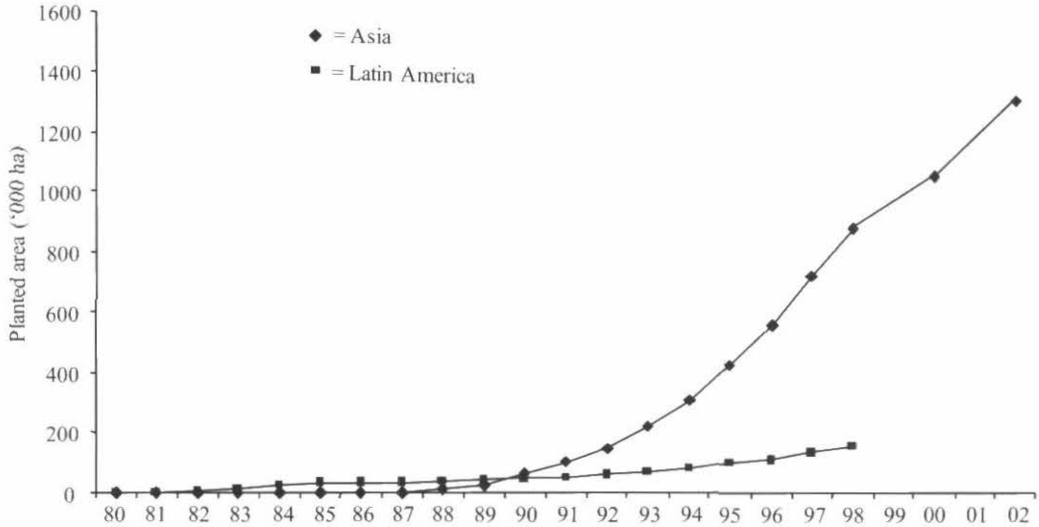

Figure 7. Adoption of CIAT-related cassava varieties in Latin America and Asia from 1980 to 2002.
Source. *C.H. Hershey; 2000-02 estimated by R. Howeler.*

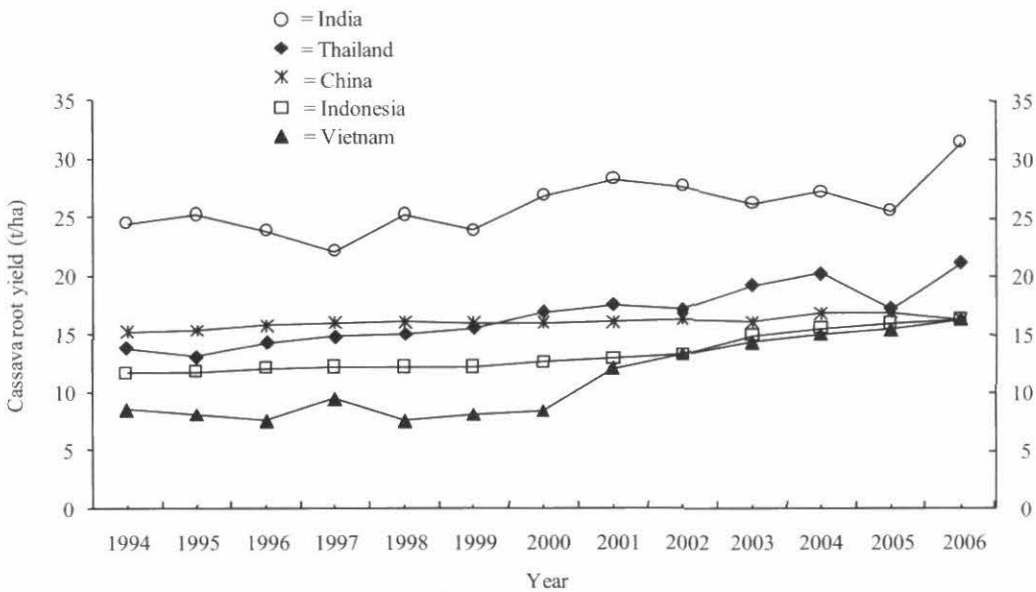

Figure 8. Change in cassava yield in five countries in Asia from 1994 to 2006.
Source: *FAOSTAT, 2008.*

Table 35. Estimated increase in gross income of cassava farmers in China, Thailand, Vietnam and in all of Asia as a result of increased cassava yields in 2003 as compared to 1994.

	Total cassava area (ha)[1]	Cassava yield (t/ha)[1]		Yield increase (t/ha)	Cassava price ($/tonne)	Increased gross income due to higher yields (mil. US$)
		1994	2003			
China	250,700	15.23	16.02	0.79	27	5.35
Thailand	1,021,840	13.81	19.30	5.49	22	123.42
Vietnam	371,900	8.44	14.28	5.84	25	54.30
Asia total	3,451,680	12.93	16.61	3.68	25	317.55

[1] Data from FAOSTAT in 2007

[2] In addition, farmers also benefited from higher prices due to higher starch content

In Vietnam the official government policy ten years ago was to maintain the area under cassava constant but increase yields. In fact, both area and yields have increased substantially, resulting in a 112% increase in cassava production since 1994. Ten years ago their were no medium- to large-scale starch factories and most cassava was used either for human consumption or on-farm pig feeding. In 2003 there were 24 medium- to large-scale factories in operation and another 18 in the planning or construction stage. In much of Asia cassava has been transformed from a food-security crop to an important industrial crop, used mostly for production of starch and animal feed, both for domestic use and export. Many national and provincial governments now consider cassava as an ideal vehicle for rural development: the crop is easy to grow, tolerates poor soils and long droughts, has no diseases or pests, requires little in terms of inputs or infrastructure and has multiple end-uses, providing both rural and urban employment. While many social, political and economic factors determined that change, the dedicated and hard work of our collaborators in the Nippon Foundation project - researchers, extension workers and farmers - surely contributed to this development. Moreover, without the sustained and generous financial support from the Nippon Foundation, as well as the technical and methodological support from CIAT this would not have been achieved. It is a case of many people working together towards a common goal: to enhance the sustainability of cassava cropping systems while increasing the livelihood of poor farmers.

5. IMPACT ASSESSMENT

In order to determine what impact the implementation of the Nippon Foundation project has had on the adoption of new cassava varieties and various production practices and the subsequent effect on cassava yields and income, an Impact Assessment study was conducted by an outside consultant, Dr. Tim Purcell, using funding generously provided for that purpose by SPIA (the CG's "Standing Panel on Impact Assessment"), in collaboration with the CG's System-wide Participatory Research and Gender Analysis (PRGA) program at CIAT. The study started in Oct 2003, coinciding with the End-of-Project Workshop, in order to discuss the methodology to be used with various project collaborators. Selection of appropriate and representative sites and the design of questionnaires were discussed between Tim Purcell, Nina Lilja of PRGA and Reinhardt Howeler, project coordinator. It was agreed that the study would collect data in four project sites each in Thailand and Vietnam, both from "participating" and "non-participating" farmers, in "project" and nearby (within 10 km) "non-project" villages[3]. Data would be collected from 1) government officials in the subdistrict; 2) from interviews of focus groups of about 20 farmers each in project and non-project villages; and 3) from a questionnaire filled out by farmers in the focus groups, both for their own family as well as for two neighbors. Thus, data were collected from officials in eight sites (in addition, similar data from subdistrict offices from all project sites was solicited by mail), from focus groups in 16 villages, and from survey forms from 832 households. The field work was conducted by Tim Purcell in collaboration with staff from DOAE and DOA in Thailand, and from IAS, TNUAF and NISF in Vietnam during Nov-Dec 2003. The final report entitled "Integrating Germplasm, Natural Resource, and Institutional Innovations to Enhance Impact: the Case of Cassava-Based Cropping Systems Research in Asia" was submitted to CIAT in April 2004. The 81 page report is supplemented with 215 tables and 26 figures for a total of over 500 pages. The Executive Summary is included in **Appendix 4**.

Tables 36 and **37** show the number of participating and non-participating farmers (out of 832) and the percentage of farmers, respectively, that had adopted specific technologies in the eight selected project sites in Thailand and Vietnam. The last three columns show whether there were *statistically significant* differences between "participating" and "non-participating" farmers. Some important conclusions are as follows:

1. Overall, chemical fertilizers were adopted by 84% of farmers, new varieties by 69%, contour ridging by 30%, contour hedgerows by 30%, and intercropping by 37% of surveyed farmers.
2. There were no statistically significant differences between participating and non-participating farmers in the adoption of new varieties, but there were highly significant differences in the adoption of contour ridging, planting of vetiver, *Tephrosia* (in Vietnam only) and *Paspalum* hedgerows, intercropping, and the application of chemical fertilizers and animal or green manures. In general, a larger percentage of participating than non-participating farmers had adopted new technologies, including new varieties (though the latter was not significant).
3. In Thailand, 100% of participating farmers and 87%[4] of non-participating farmers had adopted new varieties; in Vietnam, this was 48 and 45%, respectively.

[3] *Participating* farmers were mostly but not exclusively from the *project village* (pilot site) and *Non-participating* farmers were mostly but not exclusively from the nearby *non-project village*. *Participating* farmers are defined as those that have either conducted FPR trials and/or participated in FPR training courses. *Non-participating* farmers may have attended project field days, but had otherwise not been directly involved in the project.

[4] This figure seems low since nation-wide surveys indicate 98% adoption of new varieties; the 87% figure may refer to *new* varieties adopted since the project started in 1994. **Table 23** indicates that at that time 24% of the cassava area in Thailand was already planted with some of the earlier new varieties.

4. Since new varieties spread nearly equally among participating and non-participating farmers and well beyond the project sites (all over the country in case of Thailand), the use of an FPR approach may not be essential as standard training and extension approaches seemed to be equally effective. Still, testing new varieties in FPR trials is an excellent way to get farmers interested in testing other technologies as well. Moreover, from the results of FPR trials farmers may select certain "new" varieties that are particularly suitable for their own conditions, such as KM 98-7 and KM 95-3 in Pho Yen district in north Vietnam **(Table 28)**. In China, some of the officially released varieties now promoted by the extension service were actually selected by farmers from their FPR trials.
5. The use of an FPR approach seems to be particularly useful to enhance the adoption of practices with no- or little immediate benefits, such as erosion control measures and green manuring. The beneficial effects of these practices tend to accrue over time and are not clearly visible except when demonstrated in small plots side-by-side with the local practice.
6. Among soil conservation practices, about an equal percentage of farmers adopted contour ridging as contour hedgerows (of any type), while slightly over 50% of farmers did not adopt any soil conservation measures. The FPR project was particularly successful in enhancing the adoption of vetiver grass hedgerows in Thailand and *Tephrosia* or *Paspalum* hedgerows in Vietnam. However, it is also clear that these technologies did not spread widely beyond the immediate project sites indicating that the dissemination of these practices was not very successful. Adoption of vetiver grass in Thailand was partially a result of the promotion of this technology by the Royal Family and most government institutions. The adoption of *Tephrosia* and *Paspalum atratum* in Vietnam was also largely due to the distribution of free seed. Without these or other incentives it is unlikely that many farmers would have adopted these hedgerow technologies.
7. Fertilizers were widely adopted, but whether or not farmers adopt and how much fertilizer is applied depends largely on the economic status of the farmers; for that reason, adoption is not very different between participating and non-participating farmers (not significant in Vietnam).
   However, many participating farmers in both Vietnam and Thailand changed the *type* of fertilizers they applied, increasing the levels of N and K and decreasing that of P as a result of FPR trials.
8. Adoption of intercropping has been very limited, especially in Thailand; only in a few sites cassava is intercropped with maize or green manures. In Vietnam intercropping with peanut was the most widely adopted (35%) and this was significantly higher among participating than non-participating farmers.
9. Adoption of all technology components as well as changes in cassava yields over the course of the project were highly dependent on site characteristics.
10. Cassava yields increased significantly more for participants than non-participants (**Figure 9**); this change was mainly due to participation in FPR training courses. It is likely that the knowledge gained in these courses contributed to significant increases in cassava yields.

Table 36. Extent of adoption (number of households) of new technologies by participating and non-participating farmers in the Nippon Foundation project in Thailand and Vietnam in 2003.

	Participants			Non-Participants			Total		
Technologies adopted	Thailand	Vietnam	Overall	Thailand	Vietnam	Overall	Thailand	Vietnam	Overall
Varieties									
- >75% improved varieties	117	71	188	279	110	389	396	181	577
- about 50% improved varieties	0	50	50	1	51	52	1	101	102
- mainly traditional varieties	0	24	24	0	85	85	0	109	109
- no cassava	0	2	2	42	0	42	42	2	44
Soil conservation practices									
- contour ridging	62	46	108	71	71	142	133**	117	250**
- hedgerows - vetiver grass	72	17	89	31	9	40	103**	26**	129**
- *Tephrosia candida*	0	48	48	0	17	17	0	65**	65
- *Paspalum atratum*	1	17	18	0	5	5	1	22**	23**
- pineapple	0	4	4	0	2	2	0	6	6
- sugarcane	2	0	2	2	0	2	4	0	4**
- other hedgerows	4	11	15	1	4	5	5*	15**	20**
- no soil conservation	24	43	67	228	146	374	252**	189**	441**
Intercropping									
- with peanut	1	60	61	2	76	78	3	136*	139**
- with beans	0	35	35	0	67	67	0	102	102**
- with maize	12	4	16	9	9	18	21**	13	34
- with green manures	24	0	24	13	0	13	37**	0	37**
- other species	3	64	67	5	53	58	8	117**	125**
- no intercropping	84	30	114	291	117	408	375**	147**	522**
Fertilization									
- chemical fertilizers	115	117	232	272	197	469	387**	314	701**
- farm yard or green manure	66	96	162	82	136	218	148**	232	380**
- no fertilizer	0	24	24	40	35	75	40**	59	99**
Total	117	147	264	322	246	568	439	393	832

Households can adopt more than one type of technology simultaneously

Significant Difference between Participants and Non-Participants; *=95% Significance Level, **=99% Significance Level

Source: Impact Assessment (Time Purcell, 2004)

Table 37. Extent of adoption (percent of households) of new technologies by participating and non-participating farmers in the Nippon Foundation project in Thailand and Vietnam in 2003.

	Participants			Non-Participants			Total		
Technologies adopted	Thailand	Vietnam	Overall	Thailand	Vietnam	Overall	Thailand	Vietnam	Overall
Varieties									
- >75% improved varieties	100	48.3	71.2	86.6	44.7	68.5	90.2	46.1	69.4
- about 50% improved varieties	0	34.0	18.9	0.3	20.7	9.2	0.2	25.7	12.3
- mainly traditional varieties	0	16.3	9.1	0	34.6	15.0	0	27.7	13.1
- no cassava	0	1.4	0.8	13.0	0	7.4	9.6	0.5	5.3
Soil conservation practices									
- contour ridging	53.0	31.3	40.9	22.0	28.9	25.0	30.3**	29.8	30**
- hedgerows - vetiver grass	61.5	11.6	33.7	9.6	3.7	7.0	23.5**	6.6**	15.5**
- *Tephrosia candida*	0	32.7	18.2	0	6.9	3.0	0	16.5**	7.8
- *Paspalum atratum*	0.9	11.6	6.8	0	2.0	0.9	0.2	5.6**	2.8**
- pineapple	0	2.7	1.5	0	0.8	0.4	0	1.5	0.7
- sugarcane	1.7	0	0.8	0.6	0	0.4	0.9	0	0.5**
- other hedgerows	3.4	7.5	5.7	0.3	1.6	0.9	1.1*	3.8**	2.4**
- no soil conservation	20.5	29.3	25.4	70.8	59.3	65.8	57.4**	48.1**	53.0**
Intercropping									
- with peanut	0.9	40.8	23.1	0.6	30.9	13.7	0.7	34.6*	16.7**
- with beans	0	23.8	13.3	0	27.2	11.8	0	26.0	12.3**
- with maize	10.3	2.7	6.1	2.8	3.7	3.2	4.8**	3.3	4.1
- with green manures	20.5	0	9.1	4.0	0	2.3	8.4**	0	4.4**
- other species	2.6	43.5	25.4	1.6	21.5	10.2	1.8	29.8**	15.0**
- no intercropping	71.8	20.4	43.2	90.4	47.6	71.8	85.4**	37.4**	62.7**
Fertilization									
- chemical fertilizers	98.3	79.6	87.9	84.5	80.1	82.6	88.2**	79.9	84.3**
- farm yard or green manure	56.4	65.3	61.4	25.5	55.3	38.4	33.7**	59.0	45.7**
- no fertilizer	0	16.3	9.1	12.4	14.2	13.2	9.1**	15.0	11.9**
Total	100	100	100	100	100	100	100	100	100

Percentages may total more than 100 percent as households can adopt more than one type of technology simultaneously

Source: Impact Assessment (Time Purcell, 2004)

11. Among all surveyed farmers, cassava yields in Thailand increased from 20.11 t/ha before the project to 24.04 t/ha after the project. In Vietnam yields increased from 14.92 t/ha before the project to 22.35 t/ha after the project. These are significant yield increases obtained over a relatively short time (2-8 years) of participation (or not) in the project. However, in both Thailand and Vietnam cassava yields country-wide also increased significantly over the past five years[5] (**Figure 9**), indicating that the project may have had a direct effect on the yields of participating farmers as well as an indirect effect on yields nation-wide. But many other factors, such as site characteristics and wealth status of farmers were significant determinants of yield.
12. Univariate analysis indicate that yields increased significantly by the adoption of new varieties, soil conservation practices and intercropping; whether or not fertilizers had been adopted (not the level of fertilizers applied) had a significant effect only on cassava yields after the project but not on the change in yield. In multivariate analyses, however, the change in cassava yields was significantly determined only by site effects and participation in the project; among cassava technologies only the adoption of new varieties had a significant effect on yield after the project, while the effects of soil conservation practices, fertilizers or intercropping on yield were not significant as these effects are partially obscured by other factors such as site effects and wealth status of the household.

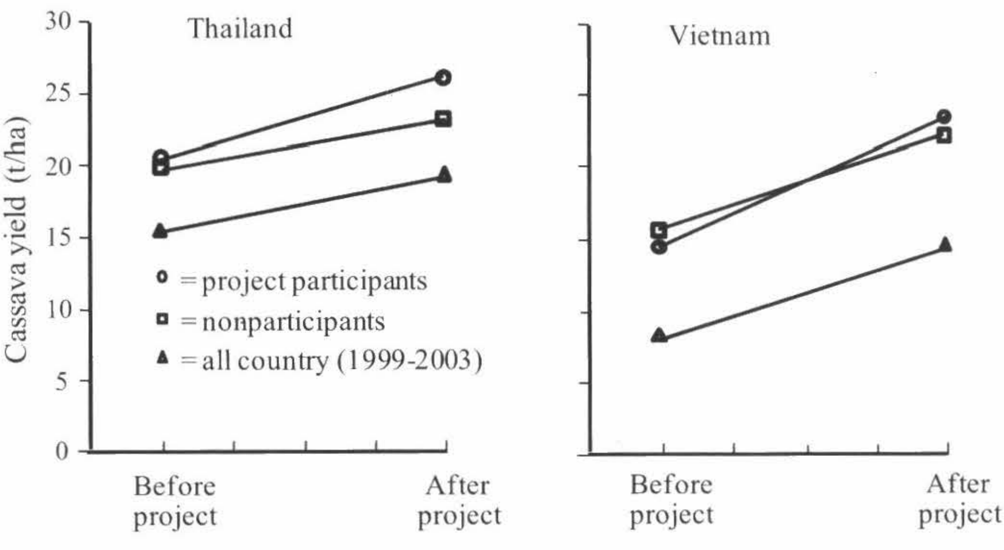

Figure 9. Average cassava yields of farmers participating in the Nippon Foundation cassava project or of nearby but non-participating farmers, before the project started and at the end of the project. Data are from PRRA census forms collected from 439 households in Thailand and 393 households in Vietnam. For comparison, the national average cassava yields in 1999 (before) and 2003 (after) are also shown.

[5] roughly corresponding to the same period between "before" and "after" the project

Thus, in general terms, participation in the project had a significant effect on the extent of adoption of soil conservation practices, intercropping and fertilizer use, but not on the adoption of "new varieties"; most likely it had an effect on the selection of a particular variety. Adoption of new varieties and chemical fertilizer use was widespread, but this was achieved mostly by traditional extension approaches used by various government institutions; fertilizer adoption was largely determined by the available financial resources of each household. Soil conservation measures and intercropping practices were not widely adopted beyond the pilot sites as the perceived benefits did not always justify the costs and labor involved.

Based on the results of the Impact Assessment a farm-level decision model was formulated by Dalton *et al.* (2005) to calculate the benefits of the project by type of beneficiary and by village. Also, the internal rate of return (IRR)) of the project was calculated at 20% during the project's implementation phase, and 34.1% if the benefits are extrapolated to an additional five years; if spillover effects are included, the IRR reached 49.2% (Dalton *et al.*, 2005).

Another study (Calkins and Vu Thi Thao, 2005) looked at the institutional impact of the Nippon Foundation Project in Thailand and Vietnam. While the authors concluded that the project was highly successful, both agronomically and institutionally, they showed quite marked differences among countries and institutions in the factors responsible for the perceived impacts of the FPR project.

6. CONCLUSIONS AND LESSONS LEARNED

From the implementation and results of the second phase of the Nippon Foundation project the following conclusions and lessons can be drawn:

1. To achieve widespread adoption of new technologies, as many farmers as possible should be involved in conducting FPR trials, participating in field days and in training courses; this can only be achieved by the active collaboration of many research institutions, universities, and extension offices, at national, provincial, district and subdistrict levels. This allows the project to extend rapidly to many sites. Active and enthusiastic participation of the local extension workers are crucial for the success of the project.
2. Training of project staff in FPR methodologies is not only essential to impart knowledge about the various tools and methods, but also to motivate people to work enthusiastically with and for the benefit of farmers.
3. Training of farmers and local extension workers together in FPR methodologies and cassava production technologies was an effective way to exchange knowledge and experiences between farmers from various regions, and to encourage farmers to experiment, to innovate and to draw their own conclusions.
4. The conducting of FPR erosion control trials on their own fields allowed farmers to see the actual soil losses as a result of erosion, and that simple agronomic practices can markedly reduce erosion. Participating in these trials and in training courses were the determinant factors in the adoption of soil conservation measures.
5. Most farmers are not aware or not concerned about soil erosion and may not be interested in conducting FPR erosion control trials. The simultaneous testing of other technology components such as new varieties, fertilizer practices and intercropping that are likely to have more immediate benefits is a good way to get

farmers involved in testing soil conservation measures as well. Only the whole package of "improved" practices (including soil conservation measures) will have an immediate beneficial effect on income.

6. The beneficial effects of various hedgerow technologies became apparent only after some time. As such, some erosion control experiments should be continued for many years to show the long-term effect on terrace formation and increased yields to visiting farmers and extension workers.
7. Besides hedgerows, there are other "soil conservation" measures, such as closer plant spacing, balanced fertilization (including animal and/or green manures) and contour ridging, that are effective in reducing erosion and may be more easily adopted by farmers.
8. Vetiver grass contour hedgerows is one of the most effective ways to control erosion and the grass never becomes a weed. However, its establishment from vegetative planting material is slow and costly. For that reason vetiver grass should be used strategically only in those areas where it is most needed, i.e. across natural drainage ways or gullies; this may require the use of sand bag barriers for initial establishment. Hedgerows of seed-propagated species such as *Palpalum atratum, Brachiaria brizantha* or *Tephrosia candida*, can be planted more quickly and cheaply, and these will serve well in the higher and convex parts of the landscape.
9. Every agricultural research and extension institution, both national and international, has its own areas of strength as well as weaknesses. By pooling their strength and working together they can become more effective in solving problems which contribute to the development of the country and will benefit poor farmers.

7. RECOGNITION

Mrs. Wilawan Vongkasem, principal collaborator from the Thai Department of Agric. Extension (DOAE) in the Nippon Foundation project, was honored with "the King of Thailand Vetiver Award" for her paper entitled "The Use of Vetiver for Soil Erosion Prevention in Cassava Fields in Thailand". Mrs. Wilawan received the award from HRH Princess Maha Chakri Sirindhorn during the International Vetiver Grass Conference held in Aug 10-15, 2003 in Guangzhou, China.

Reinhardt Howeler, Watana Watananonta and Tran Ngoc Ngoan received the "2006 International Service in Agronomy Award" from the American Society of Agronomy (ASA), as representatives of the "Cassava Team" comprising all people directly involved in the implementation of the Nippon Foundation funded FPR Cassava Project. Reinhardt Howeler received the award during the Annual Meeting of ASA on Nov 16, 2006 in Indianapolis, USA.

8. ACKNOWLEDGEMENT

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Appendix 1

List of Cooperators in the Second Phase of the Nippon Foundation Project

The second phase of the project has been implemented in collaboration with five research and extension organizations in Thailand, six institutions in Vietnam and three in China. The following people were directly involved in the project.

Within CIAT:

Reinhardt H. Howeler – Project Coordinator, stationed in Bangkok, Thailand
Peter Kerridge, Coordinator for Asia, Vientiane, Laos (1998-2002)
Rod Lefroy, Coordinator for Asia, Vientiane, Laos (2002-present)
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Guy Henry, CIAT, Cali, Colombia

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Mr. Chaipipop Yotachai, District Ext. Office, Huay Phueng, Kalasin, DOAE
Mr. Thinnakorn Withayakorn, District Ext. Office, Sahatsakhan, Kalasin, DOAE, Thailand
Mr. Nava Takraiklaang, District Ext. Office, Donchaan, Kalasin, DOAE, Thailand
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Appendix 2

List of Publications Resulting from the Second Phase of the Nippon Foundation Project

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Appendix 3

Table 1. Estimated increase in gross income of cassava farmers in China, Thailand and Vietnam and in all of Asia as a result of increased cassava yields in 2005/06 as compared to 1993/94.

	Total cassava area (ha)	Cassava yield (t/ha)		Yield increase (t/ha)	Cassava price ($/tonne)	Increased gross income due to higher yields (mil. US$)
		1994	2006			
China[1)]	265,800	15.23	16.25	1.02	45	12.20
Thailand	1,070,805	13.81	21.09	7.28	32	249.46
Vietnam	474,800	8.44	16.25	7.81	35	129.79
Asia total	3,673,235	12.93	18.24	5.31	36	702.18

[1)] Data from the Chinese Ministry of Agriculture indicate much higher yields and much greater area than the FAO data.

Source: *FAOSTAT, Feb 2008*

Appendix 4

Integrating Germplasm, Natural Resource, and Institutional Innovations to Enhance Impact: The Case of Cassava-Based Cropping Systems Research in Asia

Tim Purcell
April 2004

Executive Summary: CIAT-PRGA Impact Case Study

The CIAT Cassava Project, funded by the Nippon Foundation in Tokyo, Japan, was initiated in 1994. The objective of the project was to use Farmer Participatory Research (FPR) methodology to test and develop with farmers the best practices to control erosion and maintain soil fertility in cassava-based systems in Asia, and to enhance the adoption of these selected technologies. The first phase of the project (1994-1998) was conducted in Thailand, Viet Nam, China and Indonesia in close collaboration with various research and extension organizations in those countries. The second phase (1999-2003) was designed to build on the FPR methodologies developed in the first phase, and to use farmer participatory extension (FPE) methodologies to disseminate and enhance adoption of the best farmer selected practices. The second phase was implemented in collaboration with five research and extension organizations in Thailand, six institutions in Viet Nam and three in China.

At the end of the second phase in December 2003 the project was working in over 23 pilot sites in Thailand, 25 pilot sites in Viet Nam, and 15 pilot sites in China[6]. This is a considerable expansion from the 8 pilot sites across Thailand, Viet Nam, China and Indonesia at the end of 1998. In order to review the effectiveness of the project, an impact assessment exercise was carried out in 8 selected project sites in Thailand and Viet Nam; 4 in Thailand, 4 in Viet Nam, with an additional 8 adjacent non-project sites for comparison purposes. This report presents the results of that impact assessment exercise.

This impact assessment exercise examines the impact of the implemented FPR approaches on the adoption of cassava technologies by farmers in their own fields. Most importantly, this impact assessment exercise does not evaluate the impact of the FPR approaches on the adoption of (and results from) on-farm FPR trials, as this has been adequately covered by the Phase I evaluation report.

The impact study looks at three broad categories of impacts:

1. Adoption of
   a. new varieties
   b. fertilizers
   c. erosion control measures, and
   d. intercropping practices
2. Impact on income and sustainability of cropping system
3. Indirect/Non-productivity impacts (e.g. human capital, environment and poverty

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[6] another 36 sites had been recently initiated, mostly in 2003, and were too "new" to be considered in this study

impacts)

In addition to key informant interviews and focus group discussions, the field team surveyed 832 farm households across Thailand and Viet Nam using PRRA Survey forms.

Any impact assessment exercise is difficult due to the multitude of interaction effects and the difficulties in assigning causality and impact to any particular intervention. In the case of the CIAT cassava project it is made difficult due to the multiple paths of intervention that have been employed. The CIAT cassava breeding program from Cali has been working separately from the CIAT cassava project in S.E. Asia. Although germplasm from the breeding program has been distributed through the cassava project, it has also been disseminated directly and indirectly to national research institutions within S.E. Asia and then distributed through the various national extension agencies. While the cassava project has been working with some of these national research institutions and some of these national extension agencies, it has not been working with all of them, and not in all sites where these extension agencies are promoting cassava technologies.

As such, there are impacts due directly to the CIAT cassava project, directly to the CIAT cassava breeding program, and directly to the national research institutions and extension agencies. Acting in concert with these direct impacts is an overarching network of collaboration between the different agencies and with the CIAT cassava project.

While this occurs with the physical technologies being promoted (varietal as well as hedgerow material), it is also the case with the "knowledge" technologies being promoted (fertilizer use, nutrient requirements, soil conservation concepts, cassava management methods etc), as well as with the mechanism of transfer and extension; the FPR and FPE approach.

It is important to note that this study does not evaluate the impact of the CIAT Cassava breeding program, the national research and extension institutions, or the CIAT Cassava Project operating as a capacity building and network-facilitating institution. ***The sole purpose of this study is to evaluate the direct impact the CIAT Cassava Project has had on the adoption of cassava technologies by farmers in the project sites.***

In the context of the multitude of impact sources, it is difficult to evaluate the impact of the approaches and the technologies being promoted when the non-project villages are also potentially benefiting from improved extension techniques and improved technologies through the actions of the national extension services. Nevertheless, there are several broad "conclusions" that come out of the impact assessment exercise; see the tables below:

The adoption of new cassava varieties has been widespread; both due to the actions of the CIAT cassava project as well as through national research and extension organizations acting in concert with the project as well as through their own extension programs. The fact that the adoption of the new varieties has occurred through standard extension programs, and using standard extension methodologies, calls into question the necessity of the FPR and FPE approaches in promoting the adoption of new varieties *per se*. Farmers are well aware of the "benefits" arising from increased yields and will always choose a higher yielding variety – everything else being equal.

However, the use of FPR and FPE approaches is still valid and necessary for other purposes, and should not be discounted.

Firstly, it is rare that two varieties differ only in their yields. There are other factors such as starch content, growth habit, suitability for different uses (food or starch) as well as processing characteristics (such as thickness of peel, number of roots, ease of harvesting, breakability of the root, etc.). Farmers may prefer one variety in one site due to their management practices and yet reject that variety in another site precisely for the same characteristics that made it desirable in the first site.

Secondly, FPR and FPE approaches are necessary to demonstrate intangible benefits, or non-productivity benefits arising from particular cultivation practices; soil erosion control and green manure intercropping are good examples of these. Due to the long gestation periods between intervention and impact in the case of soil erosion control, farmers may not appreciate the extent of soil loss and the effect on soil fertility that comes with particular unsustainable practices.

The yields from improved varieties have been substantially above those of traditional varieties. However, on-station research trials have indicated that the yield potential of both types is not all that different. This contrasts greatly with the results of FPR trials which demonstrate vast differences in yields. There are two main reasons for this.

Firstly, it is unclear that varietal trials have been done in isolation of improved management versus traditional management. Too often results are presented showing differences in yields between traditional varieties and traditional practices versus improved varieties and improved practices. This is a false comparison and does nothing to identify the critical factors underlying yield changes.

Secondly, when attempts have been made to compare varietal differences with the same management system (represented often by the same level of fertilizer application), the results show that the yields of the traditional varieties are significantly below the improved varieties. Again, this result is different from that obtained by yield potential trials on research stations; given enough inputs traditional varieties have the potential to produce just as high a yield as improved varieties. It is clear that the yield response curves for improved and traditional varieties are different, however, data on what those response curves are is seriously lacking. Ultimately, the true comparison of profitability of cassava production from local versus improved varieties should be carried out by comparing returns to investment, not comparing yields at identical costs.

On an aggregate basis, soil conservation adoption has been rather high; given that not all sites have steep enough slopes to warrant soil conservation measures. Adoption is significantly higher amongst participants compared to non-participants (particularly those who have attended training courses and field days). However, the types of soil conservation measures adopted are not really indicative of the impact of the project on conservation technology adoption; while the project emphasized hedgerow technologies in FPR demonstration plots and training courses, farmers chose to adopt contour ridging as the predominant form of soil conservation measure.

While the number of soil conservation technologies adopted has been greater in Viet Nam than in Thailand, most farmers have either adopted vetiver grass hedgerows or contour ridging. In the case of the former, this has mainly been in Thailand rather than Viet Nam (who have adopted *Tephrosia candida* hedgerows instead), and the sustainability of hedgerow adoption appears to be weak. Vetiver hedgerows have had more adoption in Thailand due to non-project effects – notably the promotion of vetiver by the Royal Family. In terms of contour ridging the adoption of this technology appears to be stronger, as there is less labor involved in this compared with establishing and maintaining hedgerows, as well as land not having to be set aside for hedgerows.

While theoretically hedgerows require less labor once they have been established (compared with contour ridging which must be done every year at land preparation stage), PRA interviews suggest that in practice this is not the case. Farmers invariably need to continually maintain and re-establish hedgerows which are destroyed during harvesting (when the cassava is planted too close to the hedgerow), or destroyed by fire during the fallow period, or eaten by livestock (e.g. *Paspalum atratum* and other palatable hedgerows). When the cost of labor and the reduction in yield due to reduced density is taken into consideration, many farmers prefer to adopt contour ridging in preference to hedgerows.

While the results are mixed, and vary across sites, there is no real evidence to suggest that (as a general statement) soil conservation adoption has had any effect on yields in farmers' fields. Soil conservation would be expected to reduce the rate of soil loss (and maintain soil fertility) so that while it would not be expected that there is an increase in yields, it would be expected that participants would have higher yields than non-participants (everything else being equal). However, there is no evidence from multivariate analysis that the yields between the two groups are significantly different.

While it is evident from FPR trials that soil conservation adoption has an effect on soil retention and soil fertility over the longer term, these effects have not been evident (in terms of their effect on yields) when examining farmer adoption on their own plots. Unless there are significant yield effects arising from soil conservation adoption, the sustainability of the adoption process (for soil conservation technologies) is at best weak. One argument is that these effects need significant time lags in order to become evident, but the counter to that is that the project has been working in some sites for over 10 years and that if there had been effective adoption of soil conservation measures then this would have shown up in the analysis.

Project training courses have had a significant impact on intercropping adoption. However, the level of intercropping adoption has been limited, particularly in Thailand but less so in Viet Nam. Despite higher returns from an intercrop system, most farmers do not wish to reduce their cassava yields in return for increased benefits from intercropping. The labor effort and cost of establishing intercrops, while on a partial budget basis economical, does not counter the increased risk from intercrop failure and the seasonal labor constraints impacting on labor availability for intercrop establishment. In Viet Nam the results are slightly different, with more farmers adopting intercropping technologies, particularly groundnut and beans. With limited land area, farmers in Viet Nam are more willing to undertake intercropping than their Thai counterparts.

Fertilizer adoption has been quite high, both in terms of chemical fertilizer as well as organic fertilizer (farm yard manure and green manure). In Thailand more project participants have adopted fertilizer than non-participants, while in Viet Nam there is no significant difference in the number of people adopting fertilizer. The actual quantities of fertilizer used in Viet Nam are higher for participants, while in Thailand the opposite is true. Given the widespread adoption of fertilizer, there is some concern as to the impact of the project on fertilizer adoption. While the analysis does seem to indicate that being a participant in the project does mean that you are more likely to apply fertilizer, discussions with farmers indicated that the primary motivation has been increasing incomes. Considering the high level of fertilizer adoption amongst non-participants, and the general increase in incomes for all farmers over time (particularly in Viet Nam), there is a concern that the impact of the project on adoption of fertilizer may not be all that significant (in comparison with an income effect). This is not to deny that the project has had a significant impact on fertilizer adoption – it clearly has – but rather to question the relative importance of such an impact.

While there is a question as to the relative importance of the project impact on adoption of fertilizer, and the level of fertilizer applied compared with an income effect, it is clear that the project has had some significant effect on the type of fertilizer applied. Until farmers were educated as to the appropriate nutritional balance needed for cassava, they were happy to apply increasing quantities of phosphate-based fertilizers, or compound NPK fertilizers, rather than taking into consideration cassava requirements for nitrogen and potassium as well as micronutrients such as zinc. In terms of extension of this knowledge, it is unclear whether conventional extension services could have achieved success due to the limited number of cassava specialists amongst national extension services.

Poverty and gender play a role in the adoption of cassava technologies and changes in land area and cassava yields. Although the cassava project was not aimed at gender equality or poverty alleviation per se, the differential adoption of cassava technologies does illustrate that wealthier households are more likely to adopt new technologies (whether they be cassava or any other crop) than their poorer counterparts. Richer households and male-headed households are likely to have higher yields. If the project had exclusively targeted poor female farmers the indications are that there would have been less impact than has been observed. Critically, the FPR approach self-selects farmer-researchers who are more willing to take risks and experiment, and have enough land to set aside for trials. This group of farmers is less likely to be found amongst the poorer and disadvantaged sections of the community.

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China

Photo 1. Serious sheet and rill erosion after slopes were prepared by tractor for large-scale cassava production in Fangcheng county, Guangxi, China.

Photo 2. Poor cassava growth on eroded slopes in Fangcheng county, Guangxi, China.

Photo 3. Much of cassava in Wuming county, Guangxi, China, is now grown on alternating strips of plastic mulch to reduce weeding and increase yields.

Photo 4. Plastic mulch laid out along the contour may also help to reduce soil erosion in Wuming county, Guangxi, China.

Photo 5. Ye Jianqiu of CATAS explains to farmers how to plant vetiver grass contour hedgerows to control erosion.

Photo 6. Huang Jie of CATAS shows farmers the importance of fertilizer application to increase cassava yields.

Photo 7. Li Kaimian of CATAS extablished an excellent relationship with farmers in Kongba village, Hainan, which resulted in the selection and release of two new high-yielding varieties.

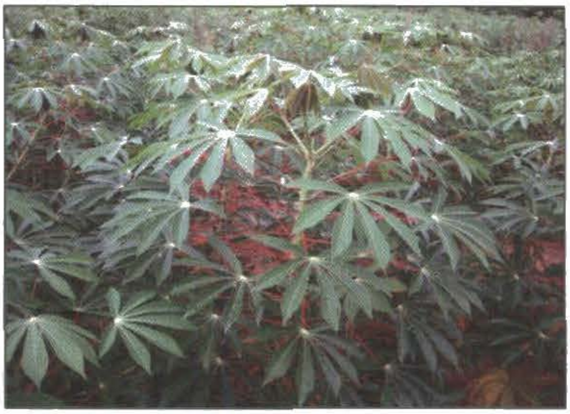

Photo 8. OMR 33-10-4, selected by farmers in Kongba village, was later released by CATAS as SC 6.

Photo 9. Large-scale planting of the newly released variety SC 5 in Tunchan county Hainan, China.

Photo 10. A vetiver grass hedgerow planted on a farmer's field in Kongba village, Hainan, China, resulted in terrace formation one year after planting.

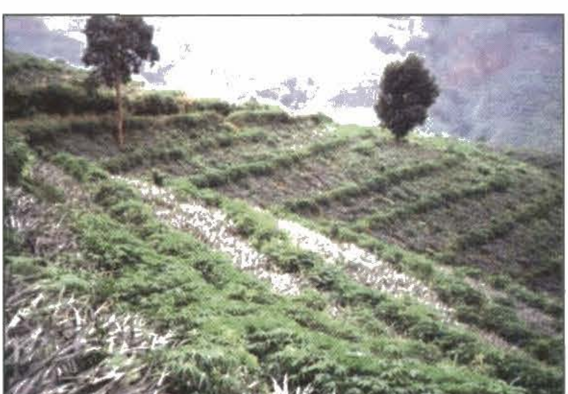

Photo 11. In pineapple plantations on steep slopes in southern Yunnan, China, contour hedgerows of closely spaced cassava are used to control erosion. Only cassava tops are harvested regularly for silage making and pig feeding.

Photo 12. Cassava tops are chopped up in a simple electric chopping machine before ensiling for pig feed in Pingbian county, Yunnan, China.

Photo 13. Mr. Ohno and Mr. Kentaro Ogiue of the Nippon Foundation visit cassava experiments at CATAS in January 2003.

Photo 14. Farmers are very happy with the high yields obtained with the new variety SC 7.

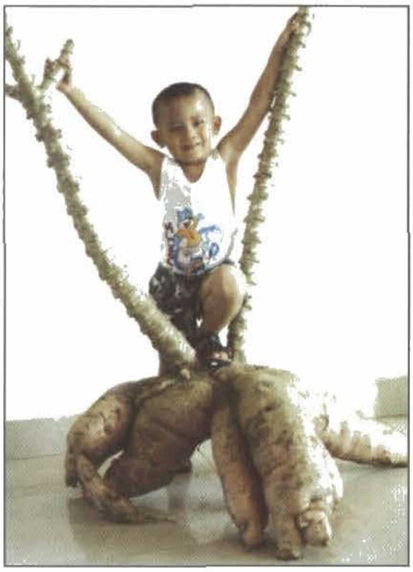

Photo 15. This farmer prefers SC 5.....100% !

Photo 16. Farmers and researchers are dancing together to celebrate the national holiday..........and their high cassava yields.

Thailand

Photo 1. Landscape of rolling hills in Wang Nam Yen district, Sra Kaew, Thailand with only green cassava fields during the dry season.

Photo 2. Serious sheet and gully erosion after heavy rains at TTDI Research and Development Center in Huay Bong, Thailand.

Photo 3. Gully erosion remains a serious problem in cassava fields at TTDI Center in Huay Bong, due to poor water infiltration through a compacted subsoil.

Photo 4. Severe erosion in sandy soils of Phoochai district, Roy Et, Thailand, washed out a large part of the cassava field.

Photo 5. Gully erosion starts when excess runoff breaks or goes around vetiver barriers planted without protection across natural drainage ways.

Photo 6. Incredible gully erosion in cassava fields in Panglagore, Sri Kiew, Nakhon Ratchasima, Thailand.

Photo 7. Cassava intercropped with jackbean *(Canavalia)* used as green manure in FPR demonstration plots in TTDI, Huay Bong.

Photo 8. *Tephrosia candida* hedgerows are a new option shown in demonstration plots at TTDI Research and Development Center in Huay Bong, Thailand.

Photo 9. Farmers form Nong Kae village in Kanchanaburi evaluate the treatments in erosion control demonstration plots at TTDI, Huay Bong, Nakhon Ratchasima.

Photo 10. Farmers and project staff listen to a farmer explaining his treatments in an FPR erosion control trial in Baan Poong district of Ratchaburi.

Photo 11. FPR erosion control trial showing severe soil loss in the check plot in Say Yook district, Kanchanaburi.

Photo 12. A farmer in Thammarat village, Chonburi, shows visiting farmers and project staff his FPR erosion control trial.

Photo 13. Another farmer in Thammarat village, Chonburi, shows the response to fertilizers in his FPR fertilizer trial.

Photo 14. A farmer harvests pumpkins from one of her plots in an FPR erosion control trial in Phoochai district, Roy Et, Thailand.

Photo 15. Rayong 72 in an FPR variety trial in Phuu Khaw Thong village in Roy Et.

Photo 16. Field day at harvest of FPR trials in Huay Pueng district of Kalasin, Thailand.

Photo 17. Farmers evaluating treatments in FPR trials during a field day in Law Khwan, Kanchanaburi, Thailand.

Photo 18. The deep and extensive root system of vetiver grass provides excellent anchorage to withstand strong runoff currents and to trap eroded sediments.

Photo 19. A well-established contour hedgerow of vetiver grass trapped large amounts of eroded soil sediments in Kaeng Dinso, Prachinburi.

Photo 20. A vetiver grass contour hedgerow trapped enough sediments to result in a 50 cm high natural terrace in Kaeng Dinso subdistrict of Prachinburi.

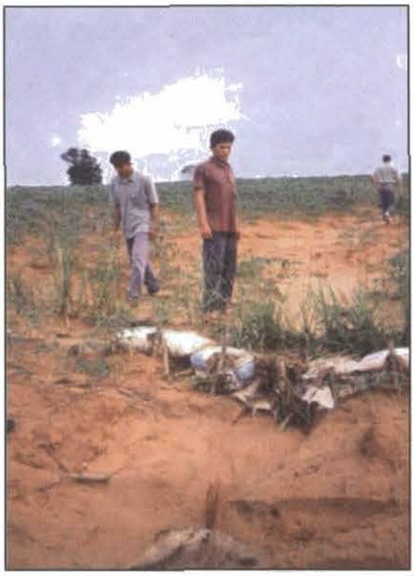

Photo 21. Soil bags anchored with sticks and placed across the gully trap soil allowing the replanting of vetiver grass in the sediments.

Photo 22. Farmers and an extensionist in Nadi show how the sandbag plus vetiver system has trapped soil in a former gully about 1½ years after establishment.

Photo 23. Farmers are desperately looking for simple and effective ways to prevent gully erosion in their cassava fields in Nong Kungsri, Kalasin.

Photo 24. One year after the construction of a soil bag barrier and the subsequent planting of a vetiver grass hedgerow has resulted in natural terrace formation within the gully in Nong Kungsri, Kalasin.

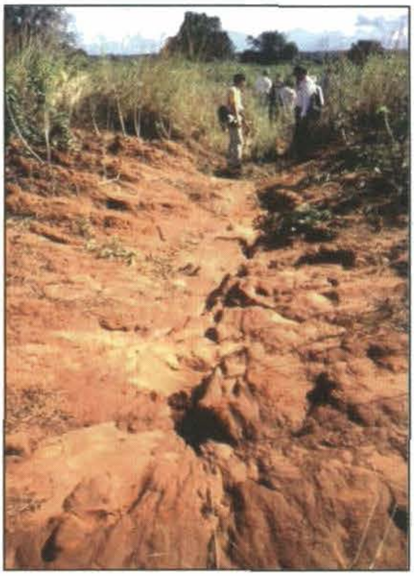

Photo 25. Runoff water concentrated in a natural drainage way has completely removed all topsoil exposing an infertile and compacted subsoil in Khut Dook village, Nakhon Ratchasima, Thailand.

Photo 26. Repair of gully in Khut Dook, one year after placing soil bags across gully and planting vetiver in eroded sediments accumulated above the barrier.

Photo 27. Vetiver hedgerow planted across former gully above the soil bag barrier now helps to trap large amounts of eroded soil, slowing water flow and reducing erosion.

Photo 28. Excellent growth and yield of cassava in Nadi, Prachinburi, through active collabaration between farmers and the local extensionist.

Photo 29. Over one thousand farmers, school children and government officials attended a project field day in Khut Dook village, Thailand.

Photo 30. School children admire and take notes about sustainable cassava production and utilization during a field day in Khut Dook, Thailand.

Photo 31. During the field day a farmer from Khut Dook village explains the results of his FPR trials to other visiting farmers.

Photo 32. The president of the "Cassava Development Village" in Khut Dook welcomes farmers from a new site during a cross-visit.

Photo 33. Vetiver grass contour hedgerows to control erosion in Khut Dook, Nakhon Ratchasima province, Thailand.

Photo 34. Cassava fields in Khut Dook, Nakhon Ratchasima, with vetiver hedgerows to reduce erosion.

Photo 35. Cassava fields (in background) with contour hedgerows of vetiver grass to control erosion in Wang Sombuun district, Sra Kaew, Thailand.

Photo 36. Excellent growth of new cassava varieties for stem multiplication in Say Yook district, Kanchanaburi, Thailand.

Photo 37. *Canavalia ensiformis* is intercropped between widely spaced cassava in Wang Nam Yen, Sra Kaew. *Canavalia* is grown as green manure and for sale of seed.

Photo 38. Members of "Cassava Development Village" in Law Khwan, Thailand, with researchers and extensionists during field day.

Photo 39. Video, CD and various training manuals and extension booklets produced as part of the Nippon Foundation project.

Photo 40. Mrs. Wilawan Vongkasem receives the King of Thailand Vetiver Award from HRH. Princess Maha Chakri Sirindhorn in Aug 2003.

Vietnam

Photo 1. Cassava after slash-and-burn in Binh Phuoc province, southwest Vietnam.

Photo 2. Well-managed cassava grown on slopes in An Binh commune, Yen Bai province of north Vietnam.

Photo 3. Before the start of the project, cassava was grown in monoculture on steep slopes leading to severe erosion in Kieu Tung commune of Phu Tho province.

Photo 4. Looking uphill. Serious sheet and rill erosion in cassava grown on 40% slope in Kieu Tung, Phu Tho, Vietnam.

Photo 5. Poor cassava and serious sheet and rill erosion in fields where improved practices have not yet been adopted in Thong Nhat commune of Phu Tho province.

Photo 6. Well managed erosion control experiment in Hung Loc Center in Vietnam. Vetiver hedgerows provide *in-situ* mulch, protecting the soil from rainfall splash.

Photo 7. Weed control trial using plastic mulch at Hung Loc Agric. Research Center, Dong Nai, in south Vietnam.

Photo 8. Farmers from a new pilot site visit FPR erosion control demonstration plots at Thai Nguyen University.

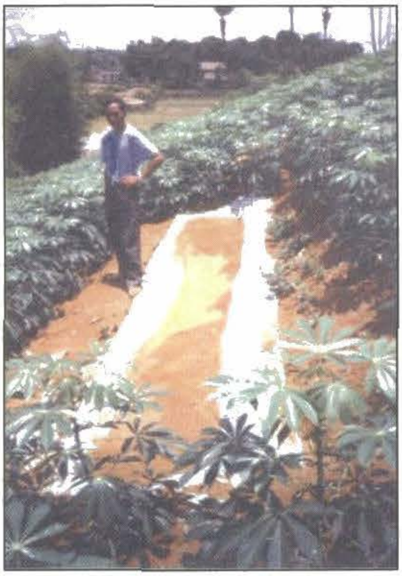

Photo 9. Farmers become aware of the seriousness of soil losses by erosion once they see the eroded soil in check plots of FPR erosion control trials.

Photo 10. FPR erosion control trial in Baria-Vungtau. Severe erosion in check plot (front); little erosion with vetiver hedgerows (back).

Photo 11. A farmer in Yen Binh district of Yen Bai province shows his FPR erosion control trial with KM 94, intercropped with peanut and hedgerows of vetiver grass and *Paspalum atratum* (in back).

Photo 12. FPR erosion control trial in Dong Rang, Hoa Binh, using cassava intercropped with peanut and contour hedgerows of vetiver grass and *Flemingia macrophylla* (on lower slope).

Photo 13. FPR erosion control trial in Dong Rang, Hoa Binh province. Without hedgerow (front) there are serious soil losses; almost none with vetiver hedgerows (back).

Photo 14. Contour hedgerows of vetiver grass provide *in-situ* mulch and trap eroded soil sediments to form natural terraces in Dong Rang commune, Hoa Binh.

Photo 15. An all-women farmers group in Nhu Xuan district, Thanh Hoa province, conduct an FPR soil erosion control trial.

Photo 16. Terrace formation by soil accumulating above a contour hedgerow of pineapple+vetiver grass in an FPR erosion control trial in Hong Ha commune in Thua Thien-Hue.

Photo 17. After conducting nine years of this FPR erosion control trial, contour hedgerows of *Tephrosia candida* have resulted in one-meter high terrace risers in Kieu Tung village of Phu Tho province.

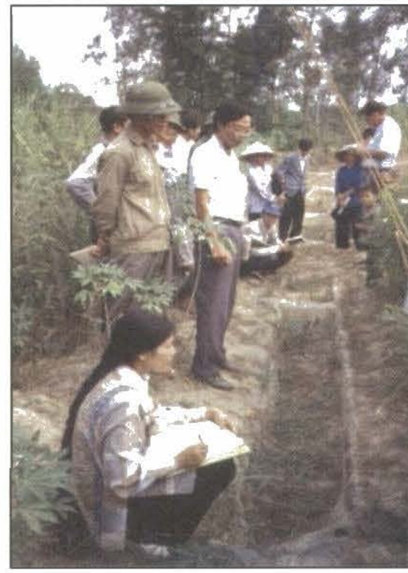

Photo 18. Researchers, extensionists and farmers observe the soil loss by erosion in each treatment of an FPR erosion coutrol trial in Pho Yen district, Thai Nguyen.

Photo 19. Farmers evaluate treatments in an FPR erosion control trial in Thong Nhat commune, Phu Tho, Vietnam.

Photo 20. After visiting all FPR trials in Kieu Tung, Phu Tho, farmers discuss results during the field day at harvest.

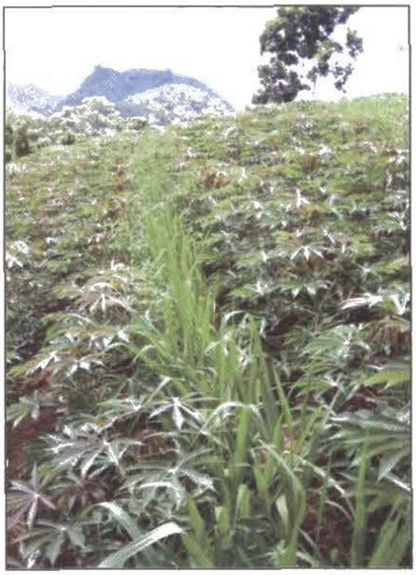

Photo 21. A young contour hedgerow of *Paspalum atratum* in Thuong Am commune of Son Duong district, Tuyen Quang, Vietnam.

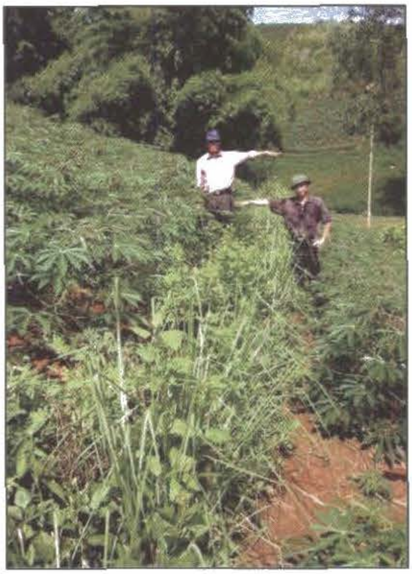

Photo 22. Two years after establishment, a mixed hedgerow of vetiver and *Tephrosia* has resulted in significant terrace formation in Son Duong, Tuyen Quang, Vietnam.

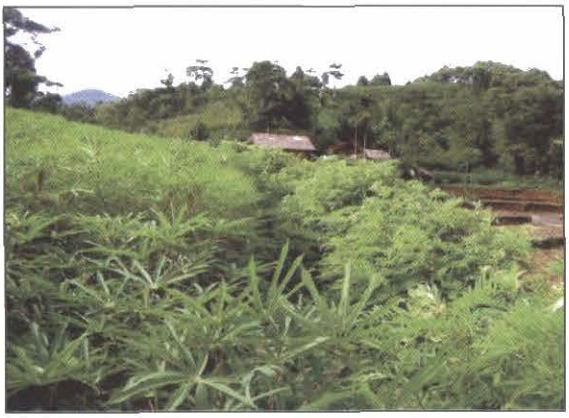

Photo 23. In Van Yen district of Yen Bai province over 1000 ha are now planted with new cassava varieties and double hedgerows of *Tephrosia candida* to control erosion.

Photo 24. In Van Yen district of Yen Bai province cassava is grown on very steep slopes with contour hedgerows of *Tephrosia candida*.

Photo 25. Excellent growth of KM 94 on very steep slopes with contour hedgerows of *Tephrosia candida* in Mau A commune, Van Yen district of Yen Bai.

Photo 26. Farmers in Nhu Xuan district of Thanh Hoa province selected pineapple hedgerows to control erosion as it also provides salable fruits.

Photo 27. Adoption of two new high-yielding cassava varieties in Thach That district of Ha Tay province.

Photo 28. Minority people that used to harvest about 10 t/ha are now getting 30 t/ha with new varieties, fertilization, intercropping with peanut and contour hedgerows in Van Yen district, Yen Bai.

Photo 29. Large-scale multiplication field of KM 94 in Lac Son district of Hao Binh province where a new cassava starch factory will be built.

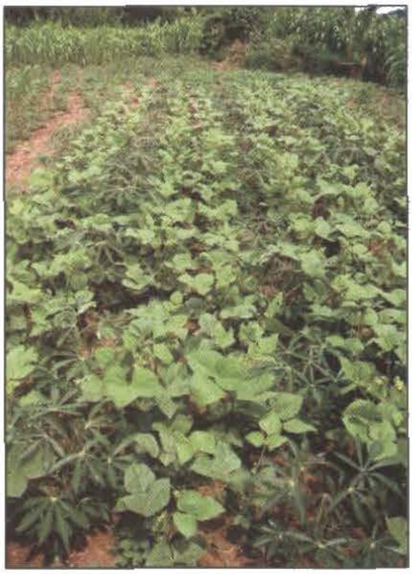

Photo 30. Intercropping cassava with black bean in Suoi Rao commune, Baria-Vungtau, Vietnam.

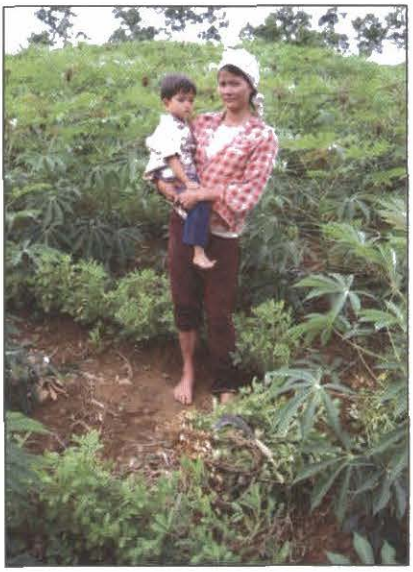

Photo 31. A farmer in An Binh commune in Van Yen, Yen Bai, harvesting peanuts intercropped in her cassava field.

Photo 32. A farmer in An Binh commune, Yen Bai, carries home peanuts intercropped in cassava and *Paspalum* forage cut from contour hedgerows to feed her family and water buffalo.

Photo 33. Many farmers in Huong Van commune in Hue have adopted the feeding of pigs with ensiled cassava leaves as a protein source.

Photo 34. Young pigs in Huong Van *commune* in Hue being fed with ensiled cassava leaves. In back, the underground tank to convert pig manure into biogas.

Photo 35. A farmer participating in the FPR trials is interviewed for TV in Son Duong district, Tuyen Quang, Vietnam.

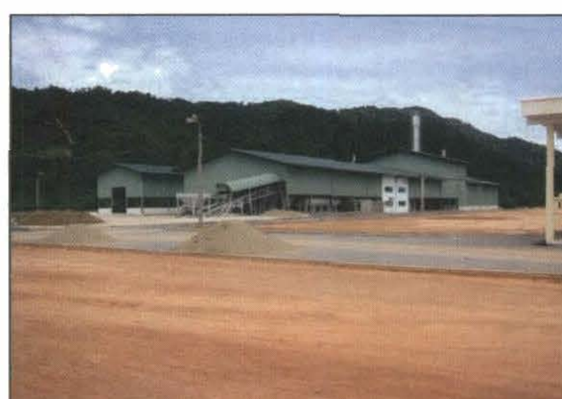

Photo 36. New cassava starch factories are being built all over Vietnam to supply the increasing demand for starch and starch-derived products.

Photo 37. Additional income from higher yields of cassava allow farmers in Thong Nhat commune in Phu Tho to buy new motorcycles and construct new homes.

Photo 38. A farmer in Thong Nhat district of Dong Nai province dries his cassava chips in front of his new "cassava house".

Photo 39. With the adoption of new varieties in Nam Dong district of Hue there is a lot more cassava to carry.

Photo 40. Mr. Kentaro Ogiue of the Nippon Foundation addresses the participants of the End-of-Project Workshop in Thai Nguyen in Oct 2003.