SUSTAINING CASSAVA FARMERS AND OUR EARTH: BACKGROUND OF THE NIPPON FOUNDATION PROJECT IN ASIA

Reinhardt H. Howeler[1]

ABSTRACT

In Asia, cassava is generally grown on gentle to steep sloping land, in areas with infertile soils and with low or unpredictable rainfall, where most other crops would not grow well. Because of its exceptional tolerance to drought, to high soil acidity and low levels of P, cassava is particularly well adapted to these marginal areas. The crop is therefore mostly grown by small-scale and poor farmers living in isolated areas with limited infrastructure. Fortunately, in Asia cassava suffers from few insect and disease problems and the crop can be grown almost continuously on the same land if soil fertility can be maintained and soil losses by erosion prevented.

During the past 30 years, research has shown that cassava will tolerate low levels of soil P, but requires relatively high inputs of N and K to maintain high yields. In general, a combination of inorganic fertilizers high in N and K and animal or green manures will give the highest yields and maintain or improve soil fertility. Also, while production of cassava tends to result in more erosion than other crops, many simple production and soil conservation practices have been identified that are highly effective in reducing erosion. However, all these practices may require some extra inputs of labor or money, while some may take a portion of the land out of production. The challenge is to develop a package of practices that fit well into the currently used production systems, that are effective in maintaining or improving the productivity of the land and which produce enough short-term financial benefits to the farmer that outway the extra inputs that may be required. The "right" combination of practices is highly site-specific, depending both on the soil and climatic conditions as well as the socio-economic circumstances in each site. These practices may also require trade-offs between short-term economic benefits and long-term sustainability. These choices can only be made by the farmers themselves. Thus, developing more sustainable practices can best be done with the full participation of farmers, while the dissemination of these improved practices can also best be done through farmer-to-farmer extension.

In 1994 the Nippon Foundation in Tokyo, Japan, agreed to fund a 5-year project that had as its main objective to develop and disseminate improved production practices that would increase cassava farmers' income while preventing soil degradation by nutrient depletion and soil erosion. To attain this objective it was proposed to develop and use a farmer participatory research (FPR) methodology, in which farmers would directly participate in the development of these practices by conducting FPR trials on their own fields. The first phase (1994-1998) was conducted in 2-3 pilot sites each in four countries, i.e. China, Indonesia, Thailand and Vietnam, in collaboration with national research and extension organizations in those countries. In 1998 a suitable FPR methodology had been developed, many improved practices had been identified by farmers, and some of these were already being adopted on a small scale.

The second phase (1999-2003) of the project aimed to develop a similar farmer participatory extension (FPE) methodology, that would enhance the dissemination and adoption of these farmer selected practices. The second phase is being conducted in over 20 sites in both Thailand and Vietnam, and in about ten sites in China, in collaboration with many research and extension organizations in those countries. Now, in the fourth year of the second phase, many sustainable production practices are already widely adopted by cassava farmers and the project is well on its way of meeting the target of benefiting at least 8000 farmers, while also protecting the soil, water and forest resources for the benefit of society at large and of future generations.

[1] CIAT Regional Cassava Office for Asia, c/o Field Crops Research Inst., Dept. of Agric., Chatuchak, Bangkok 10900, Thailand.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) originated in Latin America where it has been a staple food for the native Indian population for at least 4000 years. It was introduced to Asia on several occasions by European traders during the 17^{th} and 18^{th} Century. The crop was grown mainly as a food staple, and later, in some areas, for small-scale starch extraction. After the Second World War it became an industrial crop for production of animal feed and starch, mainly in Thailand, Malaysia and on Sumatra island of Indonesia, and later also in southern China, southern Philippines, Vietnam and Tamil Nadu state of India.

Because of its exceptional tolerance to drought, high levels of Al and low levels of P, the crop is mainly grown in areas of poor soils and with low or unpredictable rainfall. In eastern Asia cassava does not suffer from major disease or pest problems, so it is an easy and low-risk crop to grow. For that reason, it is often grown by poor farmers living in isolated and mountainous areas with marginal soil and climatic conditions. In some countries like Lao PDR and East Timor it is still grown under slash-and-burn agricultural systems, while in others it is grown as a continuous crop or in rotation with other crops, either in monoculture or in intercropping systems.

Long-term Effect of Cassava Cultivation on Soil Productivity

Many governments do not promote cassava cultivation because of the general perception that cassava will degrade the soil's productivity by exhausting the nutrient supply of the soil and by erosion. Thai Phien and Nguyen Tu Siem (1996) reported that the production of upland rice and cassava in many parts of Vietnam had turned once productive land into "waste lands", that were not suitable any more for agricultural production. Similarly, Cong Doan Sat and Pol Deturck (1998) concluded that soils in south Vietnam that had been under long-term cassava cultivation had deteriorated both chemically and physically, more so than similar soils under sugarcane, cashew, rubber or forest. Unfortunately, they did not compare cassava with other annual crops like maize, peanut or soybean, which also require annual land preparation and frequent weeding. It is well-known that any time a forest is cut and burned, and the land is prepared for growing annual crops, the soil is exposed to direct sunlight and rainfall splash, which will result in a steady decrease in soil organic matter (OM) content, leaching of nutrients and enhanced soil erosion. **Figure 1** shows that the productivity of soil declined under cassava, but it declined even more rapidly under upland rice. **Figure 2** also shows how cassava yields in three soil series in Thailand declined after many years of cassava cultivation without fertilizers. The decline in yields after continuous cassava cropping is due to soil nutrient depletion and/or excessive soil and nutrient loss by erosion. The question remains whether this is more serious in cassava than in other crops, and if so, what are the best ways to prevent this and make cassava cultivation more sustainable.

Effect of Cassava Cultivation on Soil Nutrient Depletion

Cassava has a reputation to degrade soils by excessive extraction and removal of soil nutrients, to the extent that no other crops can grow on these soils after cassava. However, comparing the removal of the major nutrients N, P and K, in cassava roots with those in the harvested products of other crops, it is clear that per tonne of dry matter (DM) produced cassava extracts much less N and P, and similar amounts of K as most cereals and much less nutrients than grain legumes and tobacco (Howeler, 1991). Similarly, in a comparative study of eight different crops grown during a 22-month period in Sri Racha, Thailand, the N and P removal per hectare was much lower for cassava grown for root production than for maize, sorghum, peanut, mungbean and pineapple, while the removal of K was similar to that of most of the other crops (**Table 1**). Nutrient removal by cassava is equal or higher than other crops only when root yields are extremely high or when leaves and stems are also removed from the field.

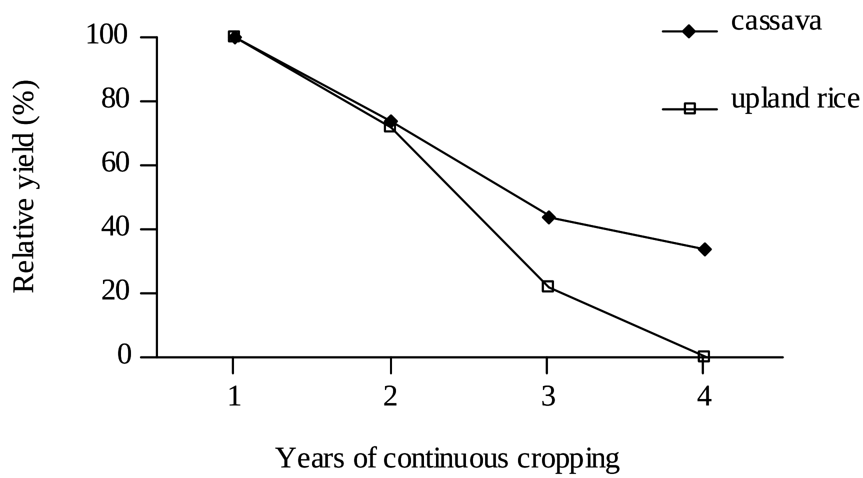

Figure 1. Yield reduction of upland rice and cassava due to fertility decline as a result of continuous cropping without fertilizer application. 100% corresponds to 18.9 t/ha of fresh cassava roots and 2.55 t/ha of rice.
Source: *adapted from Nguyen Tu Siem, 1992.*

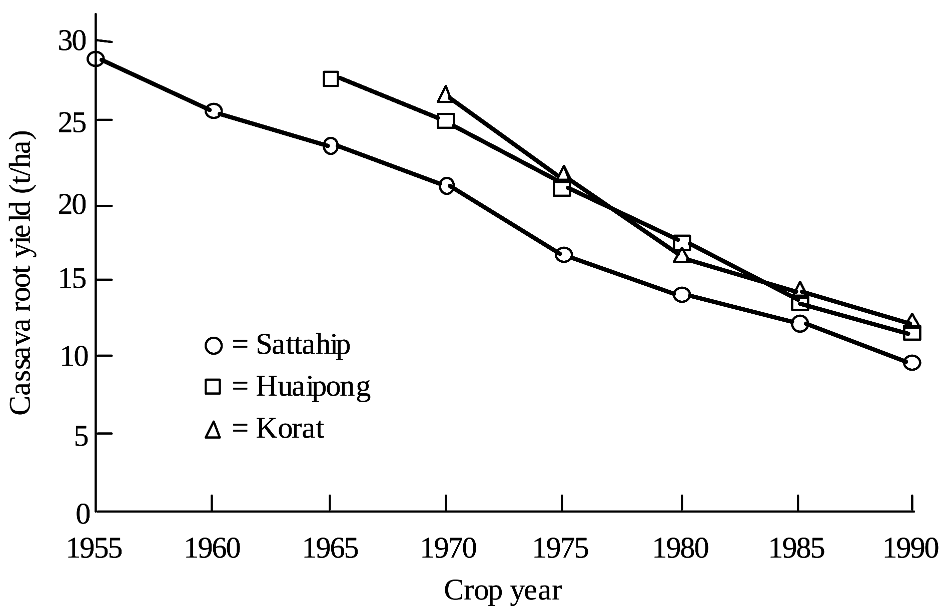

Figure 2. Decline in fresh root yields due to continuous cultivation without fertilizers in three soil series in Thailand.
Source: *Sittibusaya, 1993; Howeler, 1995.*

Table 1. Major nutrients removed in the harvested products and returned in the non-harvested products of various crops grown during 22 months in Sri Racha, Chonburi, Thailand in 1989-1991.

Crop	No. of crop cycles	Nutrients removed (kg/ha) N	P	K	Ca	Mg	Nutrients returned (kg/ha) N	P	K	Ca	Mg
Cassava for roots	2	48	7	60	14	6	236	46	132	154	35
Cassava for forage	1	363	43	240	162	62	17	4	16	24	5
Maize	2	118	44	87	6	11	101	13	269	34	28
Sorghum	2	79	25	51	10	9	147	27	304	51	37
Peanut	2	213	19	53	6	8	133	12	183	87	28
Mungbean	3	117	15	62	9	11	54	7	66	51	14
Pineapple	1	83	15	190	51	19	160	31	176	85	24

Source: *Putthacharoen et al., 1998.*

There is no doubt, however, that cultivation of cassava, like that of any other crop, will lead to nutrient extraction and this may result in nutrient depletion if the removed nutrients are not replaced in the form of chemical fertilizers, or animal or green manures. Numerous long-term fertilizers experiments have shown that application of adequate amounts of nutrients, especially N and K, can maintain soil productivity and sustain high yields of 20-30 t/ha for more than 15-25 years of continuous cassava cultivation (Nguyen Huu Hy *et al*., 2007; Wargiono and Ispandi, 2007, Nakviroj *et al*., 2007). The incorporation of cassava leaves and stems into the soil after harvest, as well as the combined application of chemical fertilizers with animal manures, compost or green manure residues will generally further increase cassava yields and maintain or improve the soils' chemical and physical characteristics (Nakviroj *et al*., 2007; Howeler, 2007)

Effect of Cassava Cultivation on Soil Erosion

Soil erosion trials conducted with twelve crops from 1943 to 1959 in Brazil indicate that castor bean, *Plaseolus* bean and cassava are the three crops causing most serious erosion and runoff (**Figure 3**). Similarly, Putthacharoen *et al*. (1998) reported that cassava grown for root production caused more than twice as much dry soil loss by erosion as mungbean, and three times more than maize, sorghum, peanut and pineapple. **(Table 2)**. Howeler (1998) also reported that in Lampung, Indonesia, one crop of cassava grown in monoculture resulted in more soil loss by erosion than two successive crops of maize, peanut or soybean or a rice-soybean rotation in the same 8-month cropping season, but that intercropping cassava with upland rice, maize and soybean as well as the application of fertilizers both markedly reduced erosion (**Table 3**). Thus, there is no doubt that when cassava is grown on slopes, it may cause more erosion than other crops. This is mainly due to the crop's wide plant spacing and slow early growth, which leaves a lot of soil exposed to the direct impact of rain drops during the first three months after planting (MAP), before the crop canopy is closed.

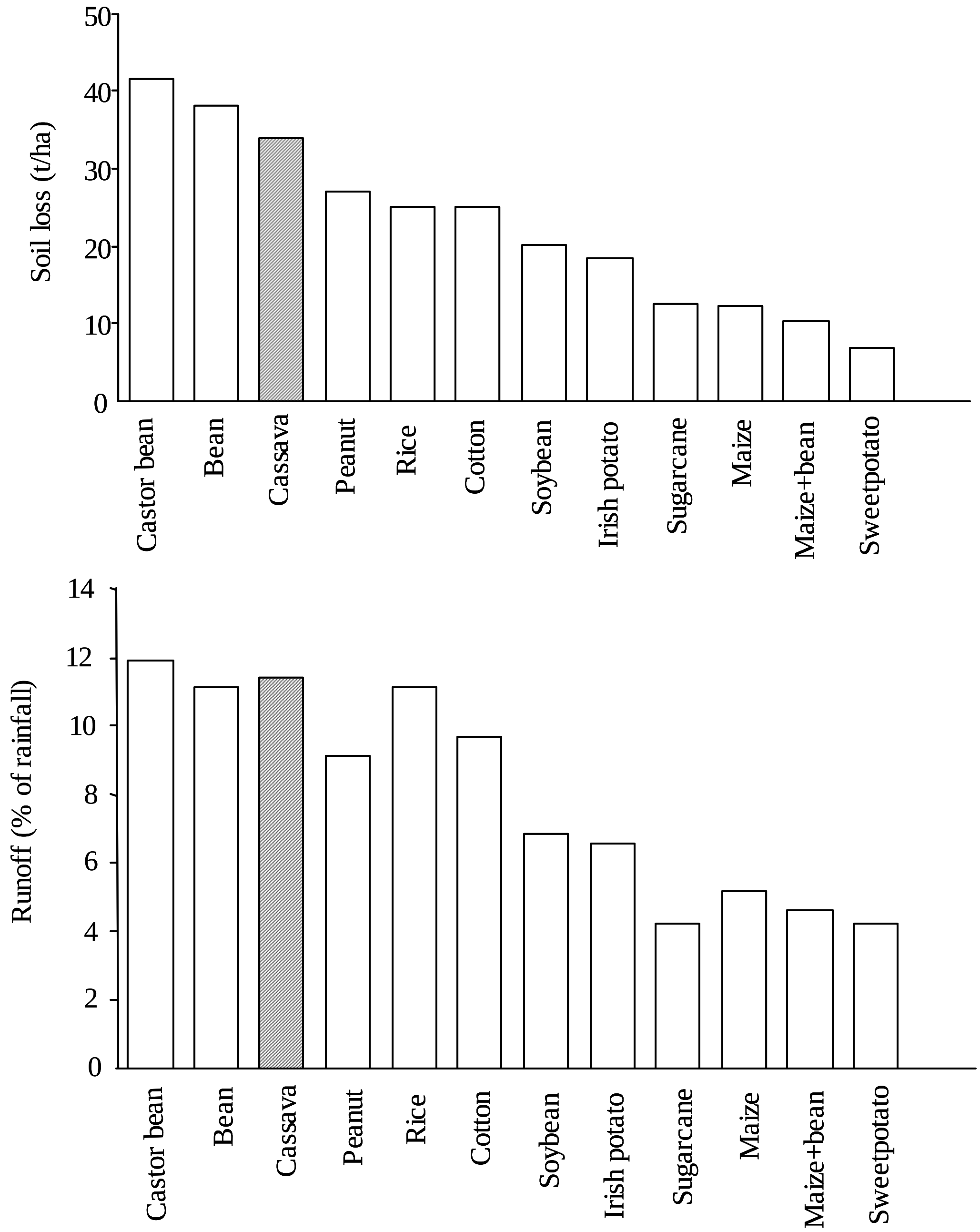

Figure 3. Effect of crops on annual soil loss by erosion (top) and on runoff (bottom). Data are average values (corrected for a standard annual rainfall of 1,300 mm) from about 48 experiments conducted from 1943 to 1959 on sandy, clayey and Terra roxa soils in Sao Paulo state of Brazil with slopes of 8.5-12.8%.
Source: *Quintiliano et al., 1961.*

Table 2. Total dry soil loss by erosion (t/ha) due to the cultivation of eight crops during four years on 7% slope with sandy loam soil in Sri Racha, Thailand, from 1989 to 1993.

	No. of crop cycles	First period (22 months)	Second period (28 months)	Total (50 months)
Cassava for root production	4	142.8 a	168.5 a	311.3
Cassava for forage production	2	68.8 b	138.5 ab	207.3
Maize	5	28.5 d	35.5 cd	64.0
Sorghum	5	42.9 c	46.1 cd	89.0
Peanut	5	37.6 cd	36.2 cd	73.8
Mungbean	6	70.9 b	55.3 cd	126.2
Pineapple[1)]	2	31.4 cd	21.3 d	52.7
Sugarcane[1)]	2	-	94.0 bc	-
F-test		**	**	
cv (%)		11.4	42.7	

[1)] Second cycle is ratoon crop; sugarcane only during second 28-month period

Source: *Putthacharoen et al., 1998.*

Table 3. Effect of various crops and cropping systems on dry soil loss due to erosion and on net income during an 8 month cropping cycle on 5% slope in Tamanbogo, Lampung, Indonesia. Data are average values for two years (1994-1996).

	Dry soils loss (t/ha)	Net income ('000 Rp/ha)
Without fertilizers		
Cassava	41.92	322
Rice-soybean	26.29	570
Maize-maize	30.64	159
With fertilizers		
Cassava	29.06	804
Rice-soybean	24.31	1,477
Maize-maize	24.98	892
Peanut-peanut	17.92	2,488
Soybean-soybean	27.61	2,031
Cassava+maize+rice-soybean	19.60	1,300

[1)] Net income = total crop value minus fertilizer costs.

Source: *Howeler, 1998.*

Erosion is particularly serious on steep slopes, but can be equally serious on gentle slopes if they have light-textured soils with low levels of OM. The latter soils are very susceptible to gully erosion due to their low aggregate stability, and the tendency to have a hard pan in the subsoil, which inhibits internal drainage. These light-textured soils are often used for cassava production, as soil fertility may be too poor for other crops.

Numerous erosion control experiments with cassava, conducted over the past 25 years in Colombia as well as in many parts of Asia, have shown that soil losses due to erosion can be markedly reduced by several agronomic and soil conservation practices, which may also increase yields. These practices include intercropping with peanut (Le Sy Loi, 2000), no tillage, contour ridging, closer plant spacing and fertilizer application (**Figure 4**) (Howeler, 1995), as well as contour hedgerows of various grasses, pineapple and leguminous species (Nguyen Huu Hy *et al*., 2001; Garrity *et al*., 2000; Howeler *et al*., 2001). Many of these practices require additional money or labor to establish, and some may initially reduce yields by taking part of the land out of production or by competition from intercrops or hedgerows. Thus, most of these practices have advantages and disadvantages and they may require trade-offs between maximizing economic benefits today and those in the future resulting from more sustainable production practices. These trade-offs can best be made by the farmers themselves. Moreover, soil conservation practices are highly site-specific, depending on the soil and climatic conditions as well as socio-economic factors. Thus, the most suitable practices for a specific location can best be developed by farmers on their own fields. And if farmers themselves select those practices they are more likely to adopt them.

The Nippon Foundation Cassava Project-First Phase (1994-1998)

In 1993 the Nippon Foundation in Tokyo, Japan, agreed to fund a 5-year project entitled "Improving the Sustainability of Cassava-based Production Systems in Asia". The main objective of this project was to enhance the adoption of soil conservation practices by those farmers growing cassava on slopes, so as to reduce soil erosion in cassava fields. The project was implemented by the CIAT Cassava Office in Asia in close collaboration with research and extension institutions in China, Indonesia, Thailand and Vietnam. It was proposed to develop the most suitable soil conservation practices together with farmers using a farmer participatory research (FPR) approach. Socio-economists and anthropologists at CIAT, in particular Jackeline Ashby and co-workers, had developed the principles and basic activities for the use of this approach (Ashby *et al*., 1987), and had used these successfully in several farming communities in Colombia. Borrowing ideas from this and other groups with experience in farmer participatory research, a regional training course was held in Rayong, Thailand, in July, 1994, to discuss the methodologies with researchers and extensionists from the collaborating countries, in order to develop work plans with activities adapted to the specific conditions in each country.

Farmer Participatory Research (FPR)

The basic idea behind this approach is quite simple: to involve farmers directly in the development and testing of new technologies, and to let them make their own decisions about what they consider useful without making our own recommendations. The role of the researchers and extensionists changes from selecting and then recommending or transferring our selected technologies to being an equal partner with farmers in the quest for new technologies that are most useful in a particular area. Government officials become facilitators in the process of helping farmers diagnose their own problems, select some promising technologies that might solve those problems, and then help them test those technologies on their own fields in simple FPR trials. From these trials farmers select the best treatments; they may test those again before selecting the very best ones to be tried in larger areas of their production field, make some adaptations if necessary, and then adopt those practices considered most useful. **Figure 5** shows a schematic diagram of the whole process. The outstanding feature of this approach is that farmers participate in every step of the process and they make all the important decisions. While the exact execution of the activities differ somewhat from country to country, the basic approach is the same and may involve the following steps:

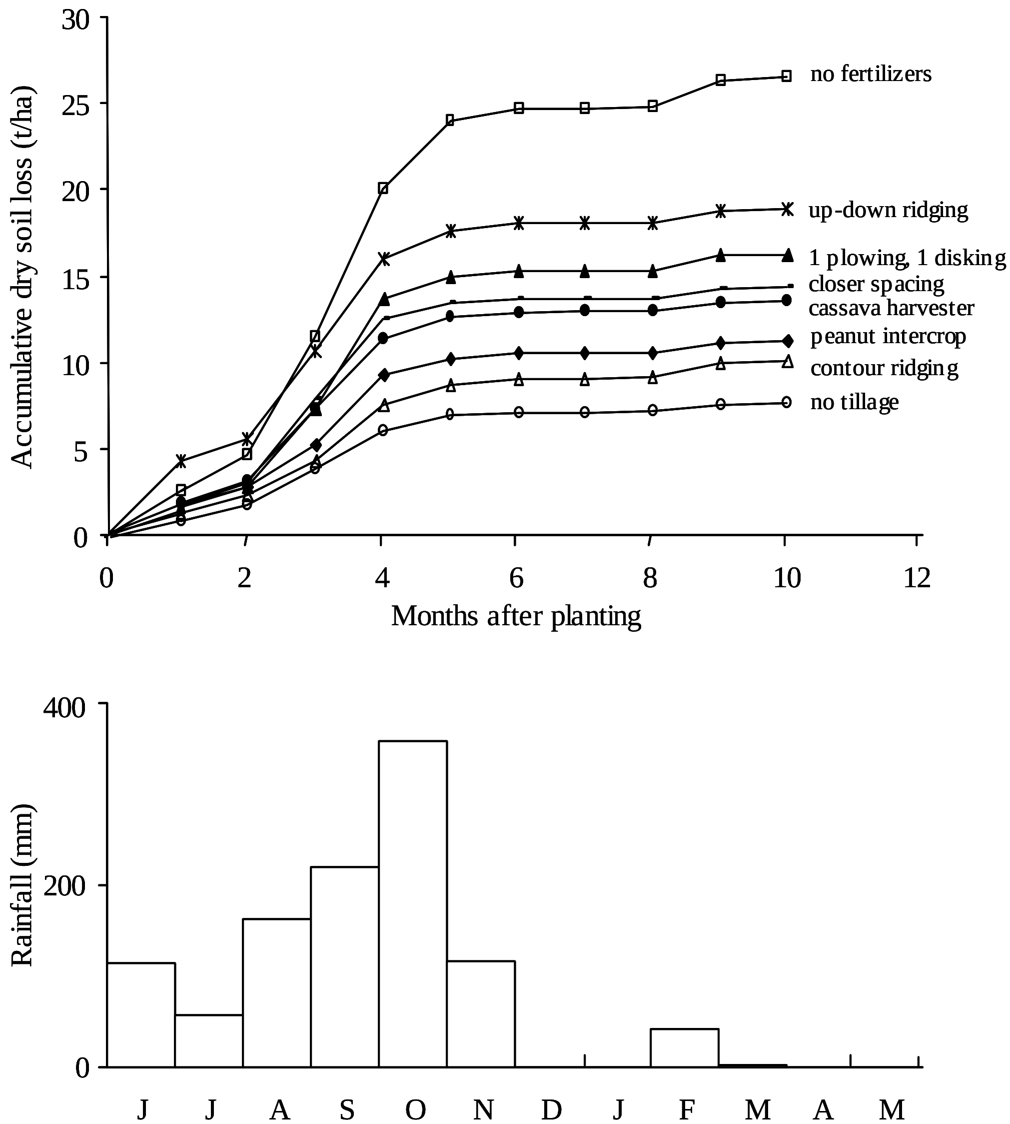

Figure 4. Effect of various crop and soil management practices on soill loss due to erosion during a 10 month cropping cycle of cassava on 4 % slope in Pluak Daeng, Rayong Thailand in 1990/01. Rainfall distribution is shown below. ***Source:*** *Anuchit Tongglum, FCRC, Rayong; Howeler, 1995.*

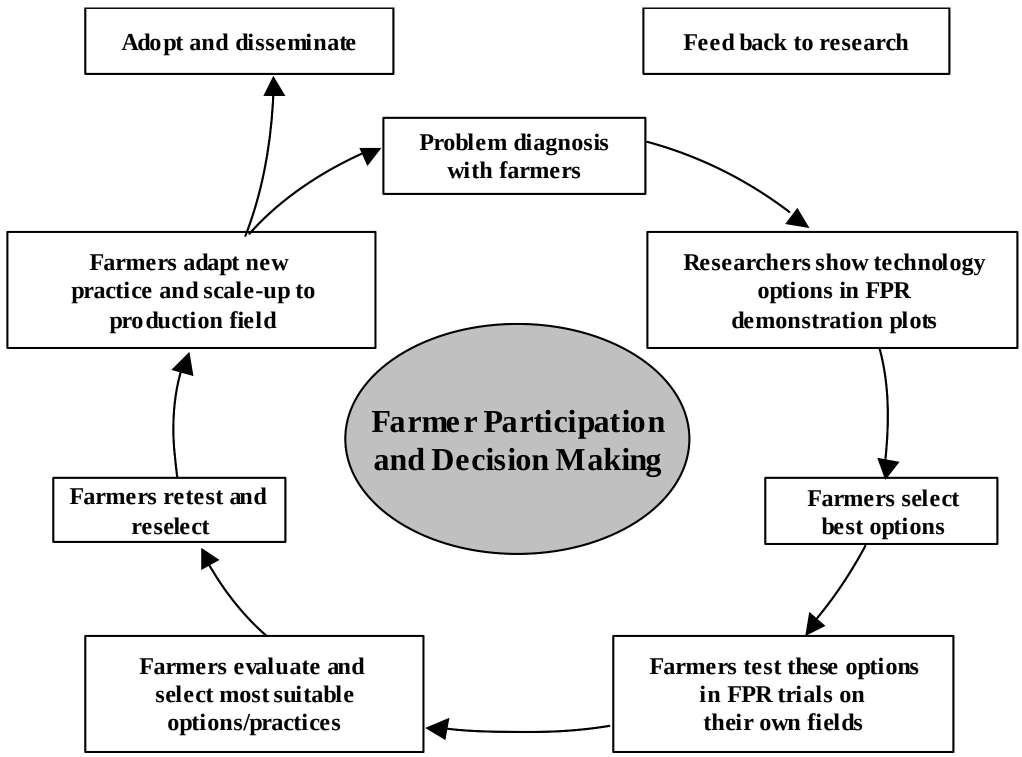

Figure 5. Farmer participatory model used for the development of sustainable cassava-based cropping systems in Asia.

1. Select suitable areas for new pilot sites.
2. Discuss the project and the FPR approach with local officials (often at the provincial, district and subdistrict levels) and village leaders.
3. Conduct Rapid Rural Appraisals (RRAs) to obtain information, and to select the most suitable sites.
4. Discuss details of the project with farmers in the selected sites and help them diagnose their own problems.
5. Take interested farmers from the pilot sites to see and evaluate 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 the specific treatments they want to test.
7. Help farmers set out the trails and establish the various treatments.
8. Farmers maintain their own trails 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, participating farmers and project personnel have

already harvested together the central part of each plot, leaving the harvested roots with a sign indicating the calculated yield 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 raising hands.

10. The preferred treatments may be retested in FPR trials the following year or tried out in small areas of their production fields.
11. After making some adaptations, if necessary, the selected variety or practice can be scaled up to larger areas and the new technologies can be disseminated to others during field days, cross-visits or informal talks with neighbors.
12. Once a new variety or improved practice has been identified, local officials can help to obtain the necessary planting material of new varieties or hedgerow species or help farmers obtain the most effective fertilizers.

Implementation of the Project During the First Phase (1994-1998)

The first phase of the project was implemented in collaboration with research and extension organizations in China, Indonesia, Thailand and Vietnam (**Table 4**). Some institutions were involved in conducting research in order to develop new technological options or to solve specific problems identified by farmers; others were mostly involved in the setting out of demonstration plots and in the testing with farmers of selected treatments in FPR trials.

Details of the actual implementation of the project in each country have been reported by Zhang Weite *et al*, (1998), Huang Jie *et al.* (2001), Utomo *et al.* (1998; 2001), Vongkasem *et al.* (1998; 2001) and by Nguyen The Dang *et al.* (1998; 2001). **Table 5** shows the types and number of FPR trials conducted during the first phase of the project. A total of 495 trials were conducted in the four countries over a 4-year period, mostly testing new varieties and erosion control practices, but also rates of fertilization, and in Vietnam intercropping. **Table 6** shows a typical example of an FPR erosion control trial conducted by farmers in Tien Phong and Dac Son villages in Vietnam in 1997. Farmers showed a clear preference for contour hedgerows of *Tephrosia candida* or vetiver grass due to their effectiveness in reducing erosion while also increasing cassava yields and net income.

During the first phase of the project, FPR trials were conducted in 2-3 pilot sites in each country in order to try out the farmer participatory methodologies being used. Once the methodology was more or less developed and people felt comfortable with this new approach, one-week training courses were held in each country in 1997 and 1998. **Table 7** shows that a total of 127 researchers and extension workers were trained in farmer participatory methodologies, while 155 farmers participated in the conducting of FPR trials. Towards the end of the first phase of the project, some farmers in pilot sites started to adopt some of the new technologies tested in the FPR trials, including new varieties, better fertilization practices, soil conservation measures and intercropping, as indicated in **Table 8**. The table clearly shows that farmers in different countries adopted different practices depending on the particular local conditions and farmers' traditional practices.

Table 4. Institutions collaborating with CIAT in the first phase of the Nippon Foundation cassava project in Asia.

Country - Province		Institution	Research	FPR
China	- Hainan	Chinese Acad. for Tropical Agric. Sciences (CATAS)	✓	✓
	- Guangxi	Guangxi Subtropical Crops Research Institute (GSCRI)	✓	
Indonesia	- E. Java	Brawijaya University in Malang (UNIBRAW)	✓	✓
	- E. Java	Research Inst. for Legumes and Tuber Crops (RILET)		✓
	- W. Java	Central Research Inst. for Food Crops (CRIFC)	✓	
Thailand	- Rayong	Field Crops Research Institute (FCRI) of Dept. Agriculture	✓	✓
	- Bangkok	Field Crops Promotion Div. of the Dept. Agric. Extension (DOAE)		✓
	- Bangkok	Kasetsart University (KU)	✓	
Vietnam	- Thai Nguyen	Thai Nguyen Univ. of Agric. and Forestry (TGUAF)	✓	✓
	- Hanoi	National Institute for Soils and Fertilizers (NISF)		✓
	- Ho Chi Minh	Institute of Agric. Science (IAS) in south Vietnam	✓	

Table 5. Number of FPR trials conducted in the 1st phase of the Nippon Foundation cassava project in Asia.

Country	Type of FPR trial	1995	1996	1997	1998	**Total**
China	Varieties	15	5	4	7	**31**
	Erosion Control	12	5	4	4	**25**
	Fertilization	10	4	4	-	**18**
		37	14	12	11	**74**
Indonesia	Varieties	6	-	1	10	**24**
	Erosion Control	19	9	13	10	**57**
	Fertilization	1	-	-	10	**20**
		26	9	14	30	**101**
Thailand	Varieties	12	9	9	7	**37**
	Erosion Control	15	15	3	15	**48**
	Fertilization	5	8	-	9	**22**
		32	32	12	31	**107**
Vietnam	Varieties	7	17	25	22	**71**
	Erosion Control	16	15	15	15	**61**
	Fertilization	5	13	13	15	**46**
	Intercropping	8	11	8	8	**35**
		36	56	61	60	**213**
Total		**131**	**111**	**99**	**103**	**495**

Table 6. Average results of five FPR erosion control trials conducted by farmers in Tien Phong and Dac Son villages of Pho Yen district, Thai Nguyen province, Vietnam, in 1997.

Treatments[1)]	Dry soil loss[1)] (t/ha)	Yield (t/ha) cassava	peanut[2)]	Gross income[3)]	Production costs[4)]	Net income	Farmers' prefer. (%)
				(mil. dong/ha)			
1. Farmer's practice	7.73	11.77	-	5.89	4.05	1.84	0
2. C+P, contour ridges	5.39	17.47	0.36	10.54	5.64	4.90	0
3. C+P, contour ridges, vetiver hedgerows	3.94	19.05	0.37	11.38	5.92	5.46	67
4. C+P, contour ridges, *Tephrosia* hedgerows	3.02	19.00	0.39	11.45	5.92	5.53	83
5. C+P, contour ridges, *Tephrosia*+vetiver hedgerows	2.73	17.92	0.41	11.01	5.92	5.09	3

1) Farmer's practice: cassava monoculture, 11.4 t/ha of FYM+68 kg N+20 P_2O_5+50 K_2O/ha; all other plots received 10 t/ha of FYM+80 kg N + 40 P_2O_5 + 80 K_2O/ha
2) dry pods
3) Prices: cassava: dong 600/kg fresh roots
peanut: 5,000/kg dry pods
4) Costs FYM: dong 100/kg
urea (45%N): 2,500/kg
SSP (17% P_2O_5): 1,000/kg
KCl (60%K_2O): 2,500/kg
peanut seed: 6,000/kg; use 50 kg/ha
labor: 7,500/manday
1 US $ = 11.000 dong

Soure: *Nguyen The Dang et al., 2001.*

Table 7. Number of researchers/extension staff who participated in FPR training courses and number of farmers who participated in FPR trials from 1994 to 1998.

Country	Researchers and extension staff	Farmers
China	28	40
Indonesia	32	27
Philippines	2	-
Thailand	35	32
Vietnam	30	56
Total	**127**	**155**

Second Phase (1999-2003)

In 1998 the Nippon Foundation agreed to fund a second phase of the project in order to use the developed methodology to scale up to many more sites and to achieve more wide-spread adoption of soil conservation measures and other improved technologies that would benefit the cassava farmers and conserve the soil resources. The second phase of the project was entitled "Integrated Cassava-based Cropping Systems in Asia: Farming Practices to Enhance Sustainability". While the general objectives in the second phase were similar to those of the first phase, the emphasis changed from developing and implementing an FPR methodology to using that methodology in many more sites, while simultaneously developing a methodology for farmer participatory extension (FPE), so that the farmer-selected practices could be rapidly extended to more farmers in order to achieve more adoption and impact. The target during the second phase was to reach and benefit at least 8000 farmers.

Table 8. Technological components selected and adopted by participating farmers from their FPR trials conducted from 1994 to 1998 in four countries in Asia.

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

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

In order to concentrate the effort, the second phase is being implemented mainly in Thailand and Vietnam, with a smaller emphasis on China due to the limited number of cassava researchers in that country. As more people had already been trained in FPR methodologies in 1997 and 1998, more institutions wanted to join the project. Thus, the second phase of the project is being implemented by three research institutions in China, five research and extension institutions in Thailand, and six research institutes and universities in Vietnam (**Table 9**). **Figure 6** shows that in 2001 the project was being implemented in about nine sites in southern China, in 20 sites in eastern and central Thailand and in 21 sites in north, central and south Vietnam. Details of the implementation of the project in those countries are reported by Watananonta *et al.* (2007), Vongkasem *et al.* (2007), Nguyen The Dang (2007), Nguyen Thi Cach *et al.* (2007), Tran Thi Dung and Nguyen Thi Sam (2007), Tran Ngoc Ngoan and Howeler (2007), Li Kaimian *et al.* (2007) and Tian Yinong (2007).

Table 9. Institutions collaborating with CIAT in the second phase of the Nippon Foundation cassava project in Asia.

Country	- Province	Institution	Research	FPR	FPE
China	- Hainan	Chinese Academy for Tropical Agric. Sciences (CATAS)	✓	✓	✓
	- Guangxi	Guangxi Subtropical Crops Research Institute (GSCRI)		✓	✓
	- Yunnan	Animal Husbandry and Veterinary Station of Yunnan (AHVSY)		✓	✓
Thailand	- Rayong	Field Crops Research Institute (FCRI) of the Dept. of Agriculture (DOA)	✓	✓	✓
	- Bangkok	Field Crops Promotion Div. of the Dept. of Agric. Extension (DOAE)		✓	✓
	- Bangkok	Kasetsart University (KU)	✓		
	- Bangkok	Soil and Water Conservation Div. of the Land Development Dept. (LDD)		✓	✓
	-Korat	Thai Tapioca Development Institute (TTDI)		✓	✓
Vietnam	- Thai Nguyen	Thai Nguyen Univ. of Agric. and Forestry (TGUAF)	✓	✓	✓
	- Hanoi	National Institute for Soils and Fertilizers (NISF)		✓	✓
	- Hanoi	Root Crops Research Center of Vietnam Agric. Science Inst. (VASI)		✓	✓
	- Hue	Hue University of Agric. and Forestry (HUAF)	✓	✓	✓
	- Ho Chi Minh	Institute of Agric. Science (IAS) in south Vietnam	✓	✓	✓
	- Ho Chi Minh	Agric. and Forestry Univ. in Tu Duc		✓	✓

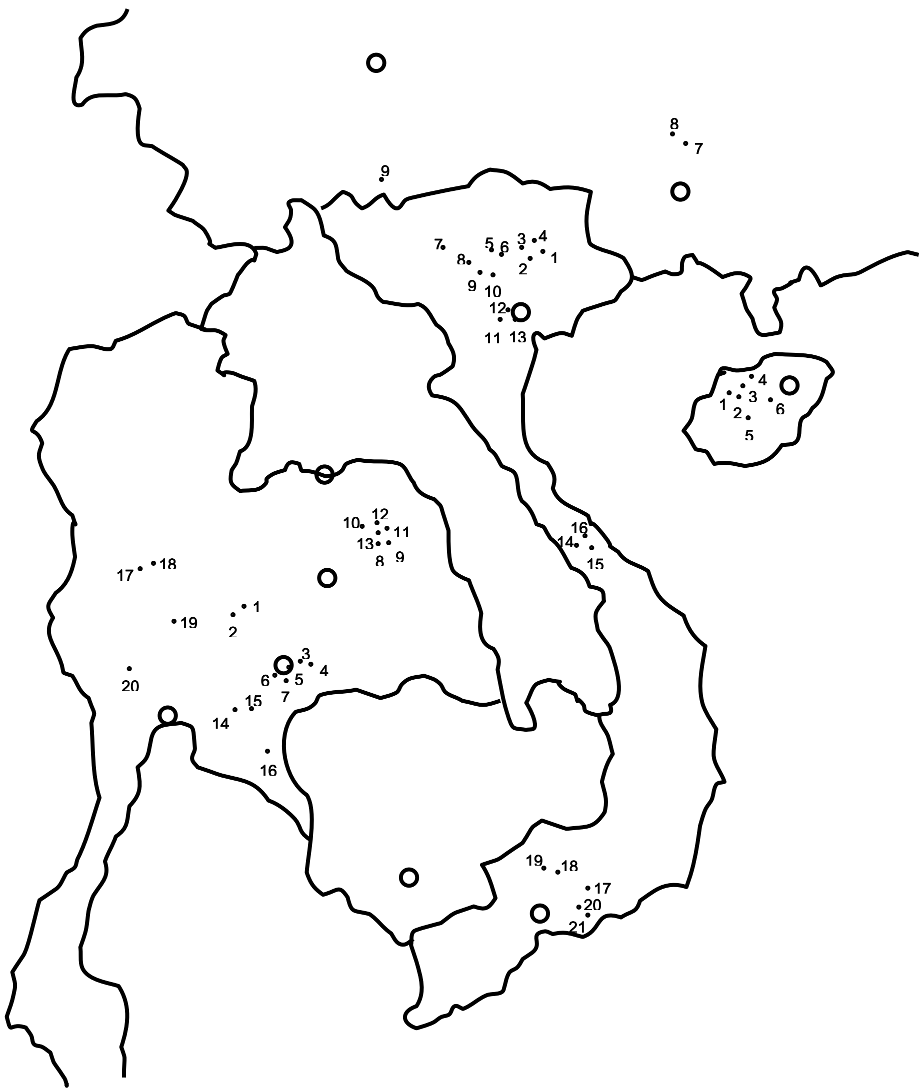
8
7
9
7 5 6 3 4
8 2 1
9 10
12
11 13
4
1 3 6
2
5
10 12 11
13 8 9
16 14 15
17 18
1
19
2
3
6 5 4
7
20
15
14
16
19 18
17
20
21

Figure 6. Location of FPR pilot sites in Thailand, Vietnam and China in 2001.

REFERENCES

Ashby, J., C. Quiros and Y. Rivera. 1987. Farmer participation in on-farm trials. Discussion Paper 22. Overseas Development Inst. Agric. Administration (Research and Extension) Network.

Cong Doan Sat and P. Deturck. 1998. Cassava soils and nutrient management in south Vietnam. *In:* R.H. Howeler (Ed.). Cassava Breeding, Agronomy and Farmer Participatory Research in Asia. Proc. 5th Regional Workshop, held in Danzhou, Hainan, China. Nov 3-8, 1996. pp. 257-267.

Garrity, D., A. Mercade, R.H. Howeler and S. Fujisaka. 2000. Participatory methods in research and extension for using forages in conservation farming systems: Managing the trade-off between productivity and resource conservation. *In:* W.W. Stur, P.M. Horne, J.B. Hacker and P.C. Kerridge (Eds.). Working with Farmers: The Key to Adoption of Forage Technologies. Proc. Intern. Workshop, held in Cagayan de Oro city, Mindanao, Philippines. Oct 12-15, 1999. ACIAR Proceedings No. 95. Canberra, Australia. pp. 254-272.

Howeler, R.H. 1991. Long-term effect of cassava cultivation on soil productivity. Field Crops Research 26:1-8.

Howeler, R.H. 1995. Agronomy research in the Asian Cassava Network – Towards better production without soil degradation. *In:* R.H. Howeler (Ed.). Cassava Breeding, Agronomy Research and Technology Transfer in Asia. Proc. 4th Regional Workshop, held in Trivandrum, Kerala, India. Nov 2-6, 1993. pp. 368-409.

Howeler, R.H. 1998. Cassava Agronomy Research in Asia – An Overview 1993-1996. *In:* R.H. Howeler (Ed.). Cassava Breeding, Agronomy and Farmer Participatory Research in Asia. Proc. 5th Regional Workshop, held in Danzhou, Hainan, China. Nov 3-8, 1996. pp. 355-375.

Howeler, R.H., 2007. Production technologies for sustainable cassava production in Asia. *In:* Proc. 14th Symposium of the Intern. Soc. Tropical Root Crops, held in Thiruvananthapuram, Kerala, India. Nov 20-26, 2006. (in press)

Howeler, R.H., C.G. Oates and A.C. Costa Allem. 2001. Strategic Environmental Assessment: An Assessment of the Impact of Cassava Production and Processing on the Environment and Biodiversity. Proc. of the Validation Forum on the Global Cassava Development Strategy, held in Rome, Italy. April 26-28, 2000. Vol. 5. 137 p. FAO/IFAD, Rome, Italy.

Huang Jie, Li Kaimian, Zhang Weite, Lin Xiong and R.H. Howeler. 2001. Practices and progress in farmer participatory research in China. *In:* R.H. Howeler and S.L. Tan (Eds.). Cassava's Potential in Asia in the 21st Century: Present Situation and Future Research and Development

Needs. Proc. 6th Regional Workshop, held in Ho Chi Minh city, Vietnam. Feb 21-25, 2000. pp. 413-423.

Le Sy Loi. 2000. Intercropping cassava with legume crops in the northern mountainous region of Vietnam. *In:* Cassava Research and Extension in Vietnam. Proc. National Workshop, held in Ho Chi Minh city, Vietnam. March 16-18, 1999. pp. 160-170. (in Vietnamese)

Li Kaimian, Ye Jiangqiu, Huang Jie and R.H. Howeler. 2007. Farmer participatory research (FPR) in Hainan province of China. *In:* R.H. Howeler (Ed.). Cassava Research and Development in Asia: Exploring New Opportunities for an Ancient Crop. Proc. 7th Regional Workshop, held in Bangkok, Thailand. Oct 28-Nov 1, 2002. (this Proceedings)

Nakviroj, C., K. Paisancharoen, O. Boonseng, C. Wongwiwatchai and S. Roongruang. 2007. Cassava long-term fertility experiments in Thailand. *In:* R.H. Howeler (Ed.). Cassava Research and Development in Asia: Exploring New Opportunities for an Ancient Crop. Proc. 7th Regional Workshop, held in Bangkok, Thailand. Oct 28-Nov 1, 2002. (this Proceedings)

Nguyen Huu Hy, Nguyen The Dang and Pham Van Bien. 2001. Cassava agronomy research and adoption of improvement practices in Vietnam. *In:* R.H. Howeler and S.L. Tan (Eds.). Cassava's Potential in Asia in the 21st Century: Present Situation and Future Research and Development Needs. Proc. 6th Regional Workshop, held in Ho Chi Minh city, Vietnam. Feb 21-25, 2000. pp. 216-227.

Nguyen Huu Hy, Nguyen The Dang, Pham Van Bien, Tran Thi Dung, Nguyen Thi Cach and Thai Phien. 2007. Cassava agronomy research in Vietnam. *In:* R.H. Howeler (Ed.). Cassava Research and Development in Asia: Exploring New Opportunities for an Ancient Crop. Proc. 7th Regional Workshop, held in Bangkok, Thailand. Oct 28-Nov 1, 2002. (this Proceedings)

Nguyen The Dang. 2007. Farmer participatory research (FPR) on soil erosion control and fertilizer use for cassava in Vietnam: 1999-2002. *In:* R.H. Howeler (Ed.). Cassava Research and Development in Asia: Exploring New Opportunities for an Ancient Crop. Proc. 7th Regional Workshop, held in Bangkok, Thailand. Oct 28-Nov 1, 2002. (this Proceedings)

Nguyen The Dang, Tran Ngoc Ngoan, Dinh Ngoc Lan, Le Sy Loi and Thai Phien. 2001. Farmer participatory research in cassava soil management and varietal dissemination in Vietnam – Results of Phase 1 and plans for Phase 2 of the Nippon Foundation Project. *In:* R.H. Howeler and S.L. Tan (Eds.). Cassava's Potential in Asia in the 21st Century: Present Situation and Future Research and Development Needs. Proc. 6th Regional Workshop, held in Ho Chi Minh city, Vietnam. Feb 21-25, 2000. pp. 383-401.

Nguyen The Dang, Tran Ngoc Ngoan, Le Sy Loi, Dinh Ngoc Lan and Thai Phien. 1998. Farmer participatory research in cassava soil management and varietal dissemination in Vietnam. *In:* R.H. Howeler (Ed.). Cassava Breeding, Agronomy and Farmer Participatory Research in Asia. Proc. 5th Regional Workshop, held in Danzhou, Hainan, China. Nov 3-8, 1996. pp. 454-470.

Nguyen Thi Cach, Trinh Thi Phuong Loan, Huang Van Tat, Tran Ngoc Ngoan, Nguyen The Dang, Nguyen Viet Hung, Hoang Kim, Pham Van Bien, Nguyen Huu Hy, Vo Van Tuan, Thai Phien, Tran Thi Dung and Nguyen Thi Sam. 2007. Farmer participatory variety trials conducted in Vietnam. *In:* R.H. Howeler (Ed.). Cassava Research and Development in Asia: Exploring New Opportunities for an Ancient Crop. Proc. 7th Regional Workshop, held in Bangkok, Thailand. Oct 28-Nov 1, 2002. (this Proceedings)

Nguyen Tu Siem. 1992. Organic matter recycling for soil improvement in Vietnam. Proc. 4th Annual Meeting IBSRAM-Asialand Network.

Putthacharoen, S., R.H. Howeler, S. Jantawat and V. Vichukit. 1998. Nutrient uptake and soil erosion losses in cassava and six other crops in a Psamment in eastern Thailand. Field Crops Research. 57: 113-126.

Sittibusaya, C. 1993. Progress report of soil research on fertilization of field crops 1992. Annual Cassava Program Review, Jan 19-20, 1993. Rayong, Thailand. (in Thai)

Quintiliano, J., A. Marques, J. Bertoni and G.B. Barreto. 1961. Perdas por erosão no estado de S. Paulo (Soil loss by erosion in Sao Paulo State). Brigantia 20(2): 1143-1182.

Thai Phien and Nguyen Tu Siem. 1996. Management of sloping lands for sustainable agriculture in Vietnam. *In:* A. Sajjapongse and R.N. Leslie (Eds.). The Management of Sloping Lands in Asia. (IBSRAM/ASIALAND) Network Doc. #20. IBSRAM. Bangkok, Thailand. pp. 275-314.

Tian Yinong, Li Jun and Liu Jianping. 2007. Farmer participatory research (FPR) in Guangxi and Yunnan provinces of China. *In:* R.H. Howeler (Ed.). Cassava Research and Development in Asia: Exploring New Opportunities for an Ancient Crop. Proc. 7th Regional Workshop, held in Bangkok, Thailand. Oct 28-Nov 1, 2002. (this Proceedings)

Tran Ngoc Ngoan and R.H. Howeler. 2007. The adoption of new technologies and the socio-economic impact of the Nippon Foundation cassava project in Vietnam. *In:* R.H. Howeler (Ed.). Cassava Research and Development in Asia: Exploring New Opportunities for an Ancient Crop. Proc. 7th Regional Workshop, held in Bangkok, Thailand. Oct 28-Nov 1, 2002. (this Proceedings)

Tran Thi Dung and Nguyen Thi Sam. 2007. Farmer participatory research (FPR) trials on cassava intercropping in Vietnam. *In:* R.H. Howeler (Ed.). Cassava Research and Development in Asia: Exploring New Opportunities for an Ancient Crop. Proc. 7th Regional Workshop, held in Bangkok, Thailand. Oct 28-Nov 1, 2002. (this Proceedings)

Utomo, W.H., Suyamto, H. Santoso and A. Sinaga. 1998. Farmer participatory research in soil management in Indonesia. *In:* R.H. Howeler (Ed.). Cassava Breeding, Agronomy and Farmer Participatory Research in Asia. Proc. 5th Regional Workshop, held in Danzhou, Hainan, China. Nov 3-8, 1996. pp. 471-481.

Utomo, W.H., Suyamto H. and A. Sinaga. 2001. Implementation of farmer participatory research (FPR) in the transfer of cassava technologies in Indonesia. *In:* R.H. Howeler and S.L. Tan (Eds.). Cassava's Potential in Asia in the 21st Century: Present Situation and Future Research and Development Needs. Proc. 6th Regional Workshop, held in Ho Chi Minh city, Vietnam. Feb 21-25, 2000. pp. 424-435.

Vongkasem, W., K. Klakhaeng, S. Hemvijit, A. Tongglum, S. Katong and D. Suparhan. 1998. Farmer participatory research in soil management and varietal selection in Thailand. *In:* R.H. Howeler (Ed.). Cassava Breeding, Agronomy and Farmer Participatory Research in Asia. Proc. 5th Regional Workshop, held in Danzhou, Hainan, China. Nov 3-8, 1996. pp. 412-437.

Vongkasem, W., K. Klakhaeng, S. Hemvijit, A. Tongglum, S. Katong, D. Suparhan and R.H. Howeler. 2001. Reducing soil erosion in cassava production systems in Thailand – A farmer participatory approach. *In:* R.H. Howeler and S.L. Tan (Eds.). Cassava's Potential in Asia in the 21st Century: Present Situation and Future Research and Development Needs. Proc. 6th Regional Workshop, held in Ho Chi Minh city, Vietnam. Feb 21-25, 2000. pp. 402-412.

Vongkasem, W., K. Klakhaeng, K. Srakaew, R. Sawatasai, W. Watananonta and R.H. Howeler. 2007. Farmer participatory extension (FPE) methodologies used in the cassava project in Thailand. *In:* R.H. Howeler (Ed.). Cassava Research and Development in Asia: Exploring New Opportunities for an Ancient Crop. Proc. 7th Regional Workshop, held in Bangkok, Thailand. Oct 28-Nov 1, 2002. (this Proceedings)

Wargiono, J. and A. Ispandi. 2007. Cassava agronomy research and its contribution to a secure food system in Indonesia. *In:* R.H. Howeler (Ed.). Cassava Research and Development in Asia: Exploring New Opportunities for an Ancient Crop. Proc. 7th Regional Workshop, held in Bangkok, Thailand. Oct 28-Nov 1, 2002. (this Proceedings)

Watananonta, W., W. Vongkasem, K. Klakhaeng and R.H. Howeler. 2007. Farmer participatory research activities in the Nippon Foundation cassava project in Thailand. *In:* R.H. Howeler (Ed.). Cassava Research and Development in Asia: Exploring New Opportunities for an Ancient Crop. Proc. 7th Regional Workshop, held in Bangkok, Thailand. Oct 28-Nov 1, 2002. (this Proceedings)

Zhang Weite, Lin Xiong, Li Kaimian, Huang Jie, Tian Yinong, Lee Jun and Fu Quohui. 1998. Cassava agronomy research in China. *In:* R.H. Howeler (Ed.). Cassava Breeding, Agronomy and Farmer Participatory Research in Asia. Proc. 5th Regional Workshop, held in Danzhou, Hainan, China. Nov 3-8, 1996. pp. 191-210.