

FARMER PARTICIPATORY RESEARCH (FPR) ON SOIL EROSION CONTROL AND FERTILIZER USE FOR CASSAVA IN VIETNAM: 1999-2002

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ABSTRACT

In Vietnam, about 75% of the total land area are uplands, and most of these have a sloping topography. Of the 263,900 ha of cassava, 216,000 ha are planted on sloping land. For that reason, in many areas the soil for planting cassava is severely eroded. Soil erosion and inadequate fertilization are the two main causes of soil degradation leading to a reduction in cassava productivity. Based on the identification of the above mentioned constraints, a series of FPR trials on soil erosion control for land management, and balanced fertilization for cassava have been conducted by farmers in Vietnam. These trials were coordinated by six institutions, namely Thai Nguyen Univ. of Agric and Forestry (TUAUF), the National Inst. for Soils and Fertilizers (NISF), the Vietnam Agric. Science Inst. (VASI), Hue Univ. of Agric. and Forestry (HUAUF), Thu Duc Univ. of Agric. and Forestry (TDUAF) and the Inst. of Agric. Sciences (IAS) of south Vietnam.

From 1999 to 2002, a total of 103 experiments on soil erosion control have been conducted by farmers in 24 villages in the provinces of Thai Nguyen, Tuyen Quang, Yen Bai, Phu Tho, Ha Tay, Hoa Binh, Thua Thien-Hue, Ba Ria-Vung Tau, Dong Nai and Binh Phuoc provinces. Various plant species have been used as contour hedgerows for soil erosion control in most of these experiments. Planting of these hedgerows reduced the amount of eroded soil to only 2.5 to 48.8% of that in the check plot. Contour hedgerows of vetiver grass, *Paspalum atratum*, pineapple and *Tephrosia candida* minimized the amount of eroded soil. In some experiments conducted on less than 20-25% slope, intercropping cassava with peanut and taro, combined with hedgerows and adequate fertilization were found to be the most effective means of reducing erosion.

The combined use of chemical fertilizers and organic manures, intercropping, and the planting of contour hedgerows have been very effective in controlling soil erosion, retaining water and nutrients in the soil and improving the yield of cassava. All experiments were evaluated by farmers, and they have selected and adopted the planting of hedgerows of *Paspalum atratum*, vetiver grass and *Tephrosia candida*, and are now extending these practices to other cassava areas.

From 1999 to 2002, a total of 85 FPR fertilizer trials were conducted by households in the project pilot sites in the various regions. In Son Duong district of Tuyen Quang province, fertilizer treatments of 80 kg N + 40 P₂O₅ + 80 K₂O/ha increased the cassava yield by 77 % compared to the unfertilized check plot. In Phu Tho, the application of 60-80 kg N, 50-60 kg P₂O₅ and 80 kg K₂O/ha in addition to 10 tonnes FYM/ha increased yields 19-34% compared with applying only 10 tonnes FYM. In Ha Tay, the application of 60 kg N + 40 P₂O₅ + 80 K₂O/ha resulted in a cassava yield of 32.5 t/ha, 20% higher than the farmers' practice. Fertilizer experiments in the provinces of Ba Ria-Vung Tau, Dong Nai and Binh Phuoc showed that the application of 40 kg N + 40 P₂O₅ + 40-80 K₂O/ha in addition to 5 t/ha FYM increased the yield from 43-83% compared to the check plot without fertilizer application.

During the field-days at harvest time, farmers selected above-mentioned treatments for adoption and dissemination to other cassava production areas.

INTRODUCTION

Vietnam has a total natural area of 32,924,100 ha, about 75% of which are uplands, and most of these have a sloping topography. According to statistical data, of the 263,900 ha of cassava, about 216,000 ha are planted on sloping land. For that reason, in many areas the soil used for planting cassava is severely eroded. Soil erosion and inadequate

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fertilization are the two main causes of soil degradation leading to a reduction in cassava productivity. Since the availability of land in Vietnam is very limited, the expansion of land for cassava production is impossible. Therefore, measures to control soil degradation and intensify cassava production is the main goal at present.

Based on the identification of the above mentioned constraints, with the support of the Nippon Foundation and CIAT, a series of FPR trials on soil erosion control for land management and balanced fertilization for cassava have been conducted by farmers in Vietnam. These trials were coordinated by six institutions, namely Thai Nguyen University of Agriculture and Forestry (TUAF), the National Institute for Soils and Fertilizers (NISF), the Vietnam Agricultural Science Institute (VASI), Hue University of Agriculture and Forestry (HUAF), Thu Duc University of Agriculture and Forestry (TDUAF) and the Institute of Agricultural Sciences of South Vietnam (IAS).

RESULTS

From 1999 to 2002 a total of 103 FPR trials on soil erosion control and 85 FPR fertilizer trials were conducted by households in ten provinces, i.e. Thai Nguyen, Tuyen Quang, Yen Bai, Phu Tho, Hoa Binh, Ha Tay, Thua Thien-Hue, Ba Ria-Vung Tau, Dong Nai and Binh Phuoc (**Table 1**).

Table 1. The number of FPR erosion control and fertilization trials conducted by farmers in 11 provinces in Vietnam during 1999 to 2002.

Province	Erosion control trials				Fertilization trials			
	1999	2000	2001	2002	1999	2000	2001	2002
Thai Nguyen	6	2	2	1	-	1	1	2
Tuyen Quang	1	2	4	4	-	1	4	3
Phu Tho	1	4	4	4	1	6	6	1
Yen Bai	-	-	-	2	-	-	-	-
Hoa Binh	3	4	4	4	-	3	5	-
Hay Tay	-	2	2	1	-	3	3	3
Thanh Hoa	-	-	-	1	-	-	-	-
Thua Thien-Hue	-	3	5	5	-	3	5	4
Ba Ria-Vung Tau	-	2	4	4	-	2	4	4
Dong Nai	-	-	-	-	-	4	3	3
Binh Phuoc	-	4	4	4	-	-	5	4
Total	11	23	29	30	-	23	36	24

Results of Research on Soil Erosion Control

In order to identify the most suitable experimental treatments, all farmers participating in the project have been 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, an FPR soil erosion control trial with five treatments has been conducted for two years by two households. The data in **Table 2** show that when cassava was intercropped with peanut, the amount of eroded soil was reduced to 77% 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 2. Average results of two FPR soil erosion control trials conducted by farmers in Minh Duc commune of Pho Yen district in Thai Nguyen province of Vietnam in 1999 and 2000.

Treatments ¹⁾	Dry soil loss (t/ha)			Yield (t/ha)				Farmers' preference (%)	
	1999	2000	Av.	cassava		peanut		1999	2000
				1999	2000	1999	2000		
1. Farmer's practice	32.55	21.30	26.92	15.75	13.12	-	-	0	0
2. C+P; no hedgerows	22.84	18.51	20.67	24.88	18.68	0.21	0.31	5	50
3. C+P; vetiver grass hedgerows	11.62	10.35	10.98	27.00	20.00	0.18	0.28	90	73
4. C+P; <i>Tephrosia candida</i> hedgerows	15.32	11.22	13.27	26.25	19.87	0.16	0.27	90	67
5. C+P; <i>Tephrosia</i> +vetiver hedgerows	12.01	9.87	10.94	28.88	21.81	0.15	0.27	100	97

¹⁾ Farmer's practice: 12 t/ha of FYM + 45 kg N+30 P₂O₅/ha

Treatments 2-5: 10 t/ha of FYM + 80 kg N+40 P₂O₅ + 80 K₂O/ha

Source: Nguyen The Dang, 1999, 2000.

In Hong Tien commune of Son Duong district of Tuyen Quang province, in addition to *Tephrosia* and vetiver grass, two species of forages, i.e. *Paspalum atratum* and *Panicum maximum*, were also used as hedgerows for erosion control. The two-year average data indicate that the eroded soil in treatment 3, 4 and 5 was only between 6 and 7% of that in the check plot without hedgerows (Table 3). The treatment with *Tephrosia candida* hedgerows reduced the dry soil loss to 14.1% of the check plot, and 63% of farmers during 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.

Table 3. Average results of three FPR soil erosion control trials conducted by farmers in Hong Tien commune, Son Duong district of Tuyen Quang province in 1999 and 2000.

Treatments	Dry soil loss (t/ha)	Cassava yield (t/ha)	Gross income ---(mil. dong/ha)---	Net income	Farmers' preference (%)
1. Farmer's practice (check)	106.00	26.30	13.15	11.72	0
2. C+ <i>Tephrosia</i> hedgerows	15.00	28.70	14.35	12.92	63
3. C+vetiver grass hedgerows	7.10	27.00	13.50	12.07	0
4. C+ <i>Paspalum atratum</i> hedgerows	7.20	31.20	15.60	14.17	17
5. C+ <i>Panicum maximum</i> hedgerows	6.20	27.00	13.50	12.07	11

- NPK Hien Nong (7:4:7): 1,430 dong/kg (1,100 kg/ha)

- Cassava: 500 dong/kg

- Variety: KM 94

- Participants: 3 farmers

- Number of farmers participating in evaluation: 46

Source: Nguyen The Dang, 2000.

Results from an FPR trial conducted from 1996 to 2002 in Dong Rang, Hoa Binh province (**Table 4**) shows that the practice of intercropping cassava with taro or peanut, applying fertilizers and planting contour hedgerows of *Tephrosia candida* or vetiver grass markedly reduced erosion. In those treatments where cassava was intercropped with peanut, with hedgerows of *Tephrosia* or vetiver grass, the eroded soil loss decreased to only 2.2 to 4.5% of that in the treatment where cassava was intercropped with taro and grown without fertilizers or hedgerows. **Table 5** shows that both cassava and intercrop yields remained the same or increased over time; yields were higher when fertilizers were applied and contour hedgerows of either vetiver grass or *Tephrosia candida* were planted

Table 4. The effect of various treatments on dry soil loss by erosion in an FPR soil erosion control trial conducted by a farmer¹⁾ in Dong Rang commune, Luong Son district of Hoa Binh province from 1996 to 2002.

Treatments ²⁾	Dry soil loss (t/ha)							Av.
	1996	1997	1998	1999	2000	2001	2002	
1. C+T; without NPK; without hedgerows	43.14	12.54	25.66	15.10	3.40	16.27	12.40	18.36
2. C+T; with NPK; vetiver grass hedgerows	18.67	0.00	0.00	3.30	0.12	0.25	0.00	3.19
3. C+T; with NPK; <i>Tephrosia</i> hedgerows	15.95	0.86	0.38	3.15	0.40	0.12	0.00	2.98
4. C+P; with NPK; vetiver grass hedgerows	2.39	0.00	0.10	0.30	0.06	0.00	0.00	0.41
5. C+P; with NPK; <i>Tephrosia</i> hedgerows	3.99	0.15	0.00	0.70	0.12	0.40	0.40	0.82

¹⁾Farmer: Nguyen Van Tho

²⁾ C = cassava; T = taro; P = peanut
NPK = 40 kg N+40 P₂O₅+80 K₂O kg/ha
Source: Thai Phien et al., 1996-2002.

Table 5. The effect of various treatments on the yields of cassava and intercrops in a FPR soil erosion control trial conducted by a farmer¹⁾ in Dong Rang commune, Luong Son district of Hoa Binh province from 1996 to 2002.

Treatments ²⁾	Crop	Yield of cassava and intercrops (t/ha)							Av.
		1996	1997	1998	1999	2000	2001	2002	
1. C+T; without NPK; no hedgerows	C	9.00	12.50	12.10	18.05	12.58	8.91	8.75	11.70
	T	5.65	6.43	2.80	4.49	2.10	3.00	2.60	3.87
2. C+T; with NPK; vetiver grass hedgerows	C	13.02	15.39	14.81	20.00	14.45	15.19	16.87	15.67
	T	4.50	8.03	3.43	3.84	2.25	3.09	2.60	3.96
3. C+T; with NPK; <i>Tephrosia</i> hedgerows	C	14.09	15.93	16.10	23.30	15.94	17.15	15.30	16.83
	T	4.50	8.10	3.43	4.49	2.15	2.60	3.00	4.04
4. C+P; with NPK; vetiver grass hedgerows	C	15.66	14.86	14.81	21.67	16.70	14.23	15.30	16.18
	P	0.74	0.25	0.60	0.35	0.51	0.90	0.51	0.55
5. C+P; with NPK; <i>Tephrosia</i> hedgerows	C	14.29	14.79	15.43	21.67	15.58	14.94	14.63	15.90
	P	0.78	0.28	0.49	0.42	0.65	0.90	0.60	0.59

¹⁾Farmer: Nguyen Van Tho

²⁾ C = cassava; T = taro; P = peanut
NPK = 40 kg N+40 P₂O₅+80 K₂O kg/ha
Source: Thai Phien et al., 1996-2002.

In an FPR trial conducted on a 40% slope for eight years by seven farmers in Phuong Linh commune, Thanh Ba district of Phu Tho province, intercropping cassava with peanut and with vetiver grass hedgerows (T_6) reduced the eroded soil loss on average to 40% of that in the check plot (**Table 6**). The trapping of washed out soil and fertilizers by the hedgerows caused cassava yields in this treatment (T_6) to increase 23% as compared to the plot without hedgerows (T_3) (**Table 7**).

Table 6. The effect of various treatments on the dry soil loss (t/ha) by erosion in an FPR soil erosion control trial conducted by six farmers in Phuong Linh commune, Thanh Ba district, Phu Tho province from 1995 to 2002.

Treatments ¹⁾	Year								Av.	Compared to check (%)
	1995	1996	1997	1998	1999	2000	2001	2002		
1. C monocult.; with NPK; no hedgerows (check)	54.5	38.9	106.1	18.4	51.8	99.1	54.7	91.2	64.3	100
2. C+P, without NPK; no hedgerows	53.6	41.3	103.9	13.3	25.1	108.2	56.7	78.4	60.1	93
3. C+P; with NPK; no hedgerows	50.1	32.9	64.8	14.0	33.7	95.2	69.0	75.2	54.4	85
4. C+P; with NPK; <i>Tephrosia</i> hedgerows	45.3	37.9	40.1	5.3	6.2	34.2	16.3	28.0	26.7	42
5. C+P; with NPK; pineapple hedgerows	43.4	36.0	32.2	0.8	10.5	33.1	6.1	29.3	23.9	37
6. C+P; with NPK; vetiver hedgerows	42.9	36.8	32.0	3.1	8.0	39.2	14.3	28.2	25.6	40
7. C monocult.; with NPK; <i>Tephrosia</i> hedgerows	45.3	38.6	32.5	6.3	3.3	38.3	18.4	26.7	26.2	41

¹⁾ C = cassava; P = peanut

T_5 in 1995 had *Desmodium* hedgerows; T_4 in 2000, 2001 and 2002, and T_6 in 2001 and 2002 had cassava monoculture

NPK: 60 kg N + 40 P_2O_5 + 120 K_2O /ha; all plots received 10 t/ha of pig manure

Source: Thai Phien et al., 1995-2002.

In Suoi Rao commune in Chau Duc district of Baria-Vungtau province, two FPR erosion control trials were conducted by two households, using pineapple, *Paspalum atratum* and vetiver grass as hedgerows. **Table 8** shows that the use of any one of these hedgerows reduced the amount of eroded soil. Intercropping cassava with maize also decreased erosion to only 24% of that in the check plot without intercropping. However, the maize intercrop significantly reduced cassava yields and increased costs, resulting in a lower net income. Upon assessing these experimental results, most farmers selected a treatment with either vetiver grass or *Paspalum atratum* for adoption and dissemination in sloping land.

Another experiment, using two grasses (vetiver grass and *Paspalum atratum*) and two leguminous tree species (*Leucaena leucocephala* and *Gliricidia sepium*) was conducted by three households in Dong Tam commune in Dong Phu district of Binh Phuoc province (**Table 9**). In general, treatments with contour hedgerows were quite effective in reducing erosion, with the two grass species being more effective than the leguminous trees.

Table 7. The effect of various treatments on cassava and intercrop yields (t/ha) in an FPR soil erosion control trial conducted by six farmers in Phuong Linh commune, Thanh Ba district, Phu Tho province from 1995 to 2002.

Treatments ¹⁾	Crop	Year								Av.
		1995	1996	1997	1998	1999	2000	2001	2002	
1. C monocult.; with NPK; no hedgerows (check)	C	19.04	23.77	19.17	25.75	26.30	29.00	17.80	27.10	23.49
2. C+P, without NPK; no hedgerows	C	18.33	15.30	23.08	18.16	11.15	17.00	28.60	21.10	19.09
	P	0.96	0.88	0.70	0.47	0.45	0.59	0.77	0.54	0.67
3. C+P; with NPK; no hedgerows	C	17.50	14.64	19.23	20.32	18.60	15.00	32.10	29.70	20.89
	P	1.21	1.02	0.97	0.51	0.47	0.63	0.83	0.43	0.76
4. C+P; with NPK; <i>Tephrosia</i> hedgerows	C	14.81	15.14	14.67	21.60	23.80	20.00	21.40	16.10	18.44
	P	1.03	0.76	0.85	0.51	0.49	-	-	-	0.73
5. C+P; with NPK; pineapple hedgerows	C	17.60	21.63	19.39	23.33	24.00	20.00	16.10	18.80	20.11
	P	0.91	0.89	0.97	0.73	0.66	0.80	0.96	0.46	0.80
6. C+P; with NPK; vetiver hedgerows	C	18.11	21.96	23.71	26.52	33.80	32.00	25.00	25.30	25.80
	P	1.38	0.94	0.85	0.38	0.37	0.62	-	-	0.76
7. C monocult.; with NPK; <i>Tephrosia</i> hedgerows	C	17.60	26.18	23.33	25.05	21.70	23.00	30.30	28.00	24.39

¹⁾ C = cassava; P = peanut

T₅ in 1995 had *Desmodium* hedgerows; T₄ in 2000, 2001 and 2002, and T₆ in 2001 and 2002 had cassava monoculture;

NPK: 60 kg N + 40 P₂O₅ + 120 K₂O/ha; all plots received 10 t/ha of pig manure

Source: Thai Phien et al., 1995-2002.

Table 8. Average results of two FPR soil erosion control trials conducted by farmers in Suoi Rao commune, Chau Duc district, Ba Ria-Vung Tau province in 2000/01 and 2001/02.

Treatments ¹⁾	Dry soil loss (t/ha)		Yield (t/ha)				Farmers' preference (%)	
			Cassava		Intercrop			
	2000/01	2001/02	2000/01	2001/02	2000/01	2001/02	2000/01	2001/02
1. Cassava; no hedgerows	31.76	77.47	48.85	37.89	-	-	0	10
2. C; pineapple hedgerows	11.20	31.94	43.54	31.10	-	-	0	17
3. C; <i>Paspalum</i> hedgerows	15.49	21.87	40.54	34.54	-	-	71	43
4. C; vetiver hedgerows	13.15	40.43	47.16	30.99	-	-	100	43
5. C+maize intercrop	11.82	14.50	33.24	24.94	4.47	3.53	17	10

¹⁾ Fertilizer: 80 kg N + 40 P₂O₅ + 80 K₂O/ha

Source: Nguyen Thi Sam et al., 2000-2002.

Table 9. Average results of three FPR soil erosion control trials conducted by farmers in Dong Tam commune, Dong Phu district of Binh Phuoc province in 2000/01 and 2001/02.

Treatments	Dry soil loss (t/ha)		Cassava yield (t/ha)		Gross income ¹⁾ Net income (mil. dong/ha)				Farmers' preference (%)	
	00/01	01/02	00/01	01/02	00/01	01/02	00/01	01/02	00/01	01/02
	1. Cassava; no hedgerows	37.8	39.40	21.4	19.8	6.21	7.52	2.33	3.10	10
2. C; vetiver hedgerows	24.7	15.80	21.6	23.1	6.26	8.78	2.13	4.15	20	30
3. C; <i>Leucaena</i> hedgerows	33.6	21.80	22.0	21.8	6.38	3.28	2.25	3.66	20	0
4. C; <i>Gliricidia</i> hedgerows	34.8	28.10	23.4	21.2	6.79	8.06	2.66	3.43	25	0
5. C; <i>Paspalum</i> hedgerows	28.2	12.70	24.2	22.6	7.02	8.59	2.89	3.96	25	50

¹⁾ Prices: cassava dong 290/kg fresh roots in 2000/01, dong 380/kg in 2001/02.

Based on the results of these FPR trials, most farmers in Vietnam have selected vetiver grass, *Tephrosia candida* and *Paspalum atratum* as the most useful practices to be adopted in their production fields. Up to 2002, a total of 222 households have adopted the use of vegetative contour hedgerows for erosion control in 99 ha of cassava land.

Results of 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 regarding the use of balanced fertilization have been conducted by farmers.

In Am Thang and Hong Tien communes of Son Duong district in Tuyen Quang province, FPR trials on NPK fertilization were carried out by four households between 2000 and 2001. The results (**Table 10**) indicate that applying only 40 kg N and 40 K₂O/ha increased cassava yields by 39%, while the application of 80 kg N, 80 K₂O and 40 P₂O₅/ha (treatment 4) increased the yield by 77% compared with the check without fertilizers. On the field days at harvest, almost all farmers selected these two treatments for adoption and dissemination to other cassava production areas.

Table 10. Combined results of four FPR fertilizer trials conducted by farmers in Am Thang and Hong Tien communes of Son Duong district, Tuyen Quang province in 2000 and 2001.

Treatments ¹⁾ (N, P and K in kg/ha)	Cassava yield (t/ha)				Compared to check plot (%)	Farmers' preference (%)	
	2000		2001			Am Thang	Hong Tien
	Am Thang	Am Thang	Hong Tien	Average			
1. Without fertilizer (check)	5.0	17.5	27.7	16.7	100	0	0
2. 40 N+40 K ₂ O	13.5	22.5	33.7	23.2	139	55	29
3. 40 N+20 P ₂ O ₅ +40 K ₂ O	13.8	28.7	27.7	23.4	140	4	9
4. 80 N+40 P ₂ O ₅ +80 K ₂ O	18.2	38.7	31.9	29.6	177	45	40

¹⁾ Variety: KM94

Source: Nguyen The Dang, 2000-2001.

In Phuong Linh, Thong Nhat and Bao Thanh communes in Phu Tho province, ten households conducted two trials on the use of various combinations of FYM and NPK fertilizers (**Tables 11 and 12**). In Phuong Linh, applying 10 t/ha of FYM combined with 60 kg N, 40-60 P₂O₅ and 80-120 K₂O/ha increased cassava yields on average by 21-30%. In Thong Nhat and Bao Thanh, using 10 t/ha of FYM plus 80 kg N, 40 P₂O₅ and 80 K₂O/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.

Table 11. Average results of five FPR fertilizer trials conducted by farmers in Phuong Linh commune, Thanh Ba district, Phu Tho province from 1996 to 2002.

Treatments (N, P and K in kg/ha)	Cassava yield (t/ha)							Av.	Compared to check (%)
	1996	1997	1998	1999	2000	2001	2002		
1. 10 t/ha FYM (check)	15.9	15.8	16.0	13.5	17.2	18.5	15.3	16.0	100
2. 10 t/ha FYM+60 N +60 P ₂ O ₅ +120 K ₂ O	19.3	20.2	18.2	19.1	20.9	21.4	16.7	19.4	121
3. 10 t/ha FYM+60 N +60 P ₂ O ₅ +80 K ₂ O	18.7	19.3	20.7	18.7	21.3	20.7	17.5	19.6	122
4. 10 t/ha FYM+60 N +40 P ₂ O ₅ +120 K ₂ O	21.9	17.6	17.7	19.1	23.4	23.2	22.4	20.8	130

Source: Thai Phien et al., 1999-2002.

Table 12. 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 (N, P and K in kg/ha)	Cassava yield (t/ha)			Gross income ¹⁾ ------(mil.dong/ha)-----	Product. costs (mil.dong/ha)	Net income (mil.dong/ha)
	Thong Nhat	Bao Thanh	Average			
1. 10 t/ha FYM+500 kg/ha NPK (5:10:3)	19.3	19.4	19.35	6.77	3.71	3.06
2. 10 t/ha FYM+40 N+20 P ₂ O ₅ +40 K ₂ O	21.0	21.8	21.40	7.49	3.58	3.91
3. 10 t/ha FYM+80 N+40 P ₂ O ₅ +80 K ₂ O	22.3	23.7	23.00	8.05	4.04	4.01
4. 10 t/ha FYM+80 N+40 P ₂ O ₅ +120 K ₂ O	22.7	21.3	22.00	7.70	4.21	3.49
5. 10 t/ha FYM+80 N+60 P ₂ O ₅ +120 K ₂ O	21.3	19.4	20.35	7.12	4.32	2.80

¹⁾ Prices: cassava 350/kg fresh roots
 NPK (5:10:3) 1,200/kg
 urea (45% N) 2,000/kg
 SSP (17% P₂O₅) 1,000/kg
 KCl (60% K₂O) 2,500/kg
 FYM 100/kg

Source: Thai Phien et al., 2001.

Another experiment on the use of NPK fertilizers was conducted in Thanh Hoa commune in Ha Tay province. The result indicate that the application of 60 kg N, 40 P₂O₅ and 80 K₂O/ha increased the yield by 20% in comparison with the farmer's traditional practice and markedly increased the farmers' net income. After evaluation, 90% of farmers selected this treatment for adoption and expansion in the area (**Table 13**).

In Thuong Long village in Thua Thien-Hue province, a fertilizer experiment consisting of three treatments was conducted by three households in 2000. Data in **Table 14** show that using a mixture of 60 kg N, 60 P₂O₅ and 120 K₂O/ha doubled the yield and increased net income 2.4 times as compared to the check without fertilizers.

Table 13. Average results of three FPR fertilizer trials conducted by farmers in Thach Hoa commune, Thach That district, Ha Tay, Vietnam in 2000/01.

Treatments (N, P and K in kg/ha)	Cassava yield (t/ha)	Gross income ¹⁾	Product. costs ²⁾	Net income	Farmers' preference (%)
1. Farmers' practice	27.1	8,130	3,308	4,822	10
2. 40 N+40 P ₂ O ₅ +0 K ₂ O	30.7	9,210	3,263	5,947	0
3. 40 N+0 P ₂ O ₅ +40 K ₂ O	29.3	8,790	3,156	5,634	0
4. 60 N+40 P ₂ O ₅ +80 K ₂ O	32.5	9,750	3,680	6,070	90
5. 80 N+40 P ₂ O ₅ +120 K ₂ O	32.3	9,690	3,938	5,752	0

¹⁾Prices: cassava dong 300/kg fresh roots
 urea (45% N) 2,200/kg
 fused Mg-phos. (15% P₂O₅) 1,000/kg
 KCl (60% K₂O) 2,400/kg

Table 14. Average results of three FPR fertilizer trials conducted by farmers in Thuong Long village, Hong Ha commune, A Luoi district, Thua Thien-Hue, Vietnam in 2000.

Treatments (N, P and K in kg/ha)	Cassava root yield (t/ha)	Gross income ¹⁾	Production costs ²⁾	Net income	Farmers' preference (%)
0 N+0 P+0 K	7.5	3,750	1,800	1,950	0
30 N+30 P ₂ O ₅ +90 K ₂ O	12.5	6,250	2,613	3,637	66
60 N+60 P ₂ O ₅ +120 K ₂ O	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% P₂O₅) 1,100/ kg
 KCl (50% K₂O) 2,200/ kg

²⁾Cost of cassava cultivation: 1.8 mil. dong/ha (120 mandays)
 Cost of fertilizer application: 0.03 mil. dong/ha (2 mandays)

In Suoi Rao commune in Ba Ria-Vung Tau province, the application of 5 t/ha of FYM together with 40 kg N, 40 P₂O₅ and 40 K₂O/ha increased the yield by 43% compared to the check plot without fertilizers; 100% of farmers selected this treatment for adoption (**Table 15**).

In An Vien commune in Dong Nai province, and in Dong Tam commune of Binh Phuoc province, the application of 80 kg N, 40 P₂O₅ and 80 K₂O/ha increased cassava yields by 44 and 55%, respectively, while the additional application of 5 t/ha of FYM further increased yields to 62% and 83%, respectively, compared with the check without fertilizers. The majority of farmers selected either one of these treatments for adaption in their cassava production fields (**Tables 16 and 17**).

According to our surveys, until 2002 at least 157 households in the FPR pilot sites in Vietnam are applying these selected treatments to achieve a more balanced fertilization in 26 ha of cassava.

Table 15. Average results of two FPR fertilizer trials conducted by farmers in Suoi Rao village, Chau Duc district, Ba Ria-Vung Tau, Vietnam in 2000/01.

Treatments (N, P and K in kg/ha)	Cassava yield (t/ha)	Gross income ¹⁾ —————	Product. costs ¹⁾ (‘000 dong/ha)	Net income —————	Farmers’ preference (%)
0 N+0 P+0 K	38.61	11,583	5,700	5,883	0
80 N+40 P ₂ O ₅ +80 K ₂ O	50.21	15,063	6,535	8,528	0
40 N+40 P ₂ O ₅ +80 K ₂ O	49.03	14,709	6,375	8,334	50
40 N+40 P ₂ O ₅ +40 K ₂ O+5 t FYM/ha	55.36	16,608	7,335	9,273	100
Prices: cassava	dong 300/kg	FYM	dong 200/kg		
urea (45% N)	1,800/kg	fertilizer applic.	40,000/ha		
SSP (17% P ₂ O ₅)	1,000/kg	manure applic.	80,000/hg		
KCl (60% K ₂ O)	1,800/kg	labor	20,000/manday		

Table 16. Average results of three FPR fertilizer trials conducted by farmers in An Vien village, Thong Nhat district, Dong Nai, Vietnam in 2000/01.

Treatments (N, P and K in kg/ha)	Cassava root yield (t/ha)	Gross income ¹⁾ —————	Product. costs ¹⁾ (‘000 dong/ha)	Net income —————	Farmers’ preference (%)
0 N+0 P+0 K	19.66	5,701	3,350	2,351	10
80 N+40 P ₂ O ₅ +80 K ₂ O	28.37	8,227	4,329	3,898	50
40 N+40 P ₂ O ₅ +80 K ₂ O +5 t FYM/ha	31.96	9,268	4,779	4,489	40

¹⁾Prices: cassava dong 290/ kg fresh roots
 urea 2,300/ kg
 SSP 1,000/ kg
 KCl 2,300/ kg
 FYM 120/ kg
 labor 25,000/ manday

Table 17. Average results of three FPR fertilizer trials conducted by farmers in Dong Tam village, Dong Xoai district, Binh Phuoc, Vietnam in 2000/01.

Treatments (N, P and K in kg/ha)	Cassava yield (t/ha)	Gross income ¹⁾ —————	Production costs ¹⁾ (‘000 dong/ha)	Net income —————	Farmers’ preference ²⁾ (%)
0 N+0 P+0 K	16.6	4,482	2,900	1,582	20
80 N+40 P ₂ O ₅ +80 K ₂ O	25.8	6,966	3,879	3,087	50
80 N+40 P ₂ O ₅ +80 K ₂ O+5t FYM/ha	30.4	8,208	4,429	3,779	30

¹⁾Prices: cassava dong 270/ kg fresh roots
 urea (46% N) 2300/ kg
 SSP (18% P₂O₅) 1000/ kg
 KCl (60% K₂O) 2300/ kg
 FYM 100/ kg

²⁾Number of participating farmers: 24

CONCLUSIONS

1. The use of contour hedgerows of vetiver grass, *Paspalum atratum* and *Tephrosia candida* reduced the amount of eroded soil to 2.2 to 49% compared to the check plots without hedgerows.
2. The combined use of chemical fertilizers and organic manures, intercropping and planting of contour hedgerows have been very effective in controlling soil erosion, retaining water and nutrients in the soil, and improving the yield of cassava; this also increased the net income of farmers.
3. Applying 60-80 kg N, 40-50 P₂O₅ and 80-120 K₂O/ha increased cassava yields by 20 to 100% compared to the check plots without fertilizers.
4. After our field days at harvest time, participating farmers generally selected the above-mentioned treatments for adoption and dissemination to other cassava production areas.

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