CASSAVA AGRONOMY RESEARCH AND ADOPTION OF IMPROVED PRACTICES IN VIETNAM

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ABSTRACT

In the past few years, the economy of Vietnam has developed very rapidly, and in agriculture, food production has been quite successful, especially that of rice. At the same time cassava production has changed from being a crop providing food for humans to being a cash crop. The planting of new cassava varieties has increased the net income of farmers in some regions of Vietnam.

In the area of agronomy, research conducted in some regions of the north and south of Vietnam had the objective of increasing cassava yields and income for the farmer, while maintaining the productivity of the soil. This included:

- Soil research in South Vietnam showed that planting of cassava on the same land for many years reduced soil fertility more than with some other crops, trees or natural forest, resulting in soil degradation.
- In fertilizer trials, the response of cassava depends on the type of soil and the kind of fertilizers. In both north and south Vietnam cassava showed strong responses to application of N and K, while there was a response to P in only one site. In long-term NPK trials conducted in Thai Nguyen University and in Hung Loc Center the application of 80:40:80 and 160:80:160 kg/ha of N-P_2O_5-K_2O gave higher yields and higher economic returns than other treatments.
- In intercropping trials conducted on research stations and on farmers' fields with flat land, cassava intercropped with food crops and grain legumes increased income. In sloping areas cassava intercropping with peanuts or planting contour hedgerows of legume trees like *Tephrosia candida* or *Gliricidia sepium* reduced soil loss due to erosion and maintained or improved soil fertility.
- In order to reduce the cost of production, the use of pre-emergence herbicides to control weeds was very effective and controlled about 90% of the weeds for the first 3-4 months after planting, resulting in higher profits than when cassava was weeded by hand or when post-emergence herbicides were applied.

1. INTRODUCTION

In the past few years, the annual rate of economic development in Vietnam was about 4-6%. Among the various sectors, agriculture has been quite successful, especially the production of rice. Presently, Vietnam is the second largest rice exporting country in the world.

In the area of food crop production, cassava has remained important in providing food for poor people in the marginal areas, but the crop has changed from being a crop providing food for humans to being a cash crop. The planting of new cassava varieties has markedly increased the net income of farmers in some regions of Vietnam, especially in the Southeastern region.

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In the last decade of the 20th century, the area planted to cassava in Vietnam was around 250 thousand ha, comprising about 25% of the total area dedicated to food crop production; the cassava growing areas are rather evenly distributed over all regions of Vietnam. Because of the low value of cassava products, cassava is usually planted on sloping land and on poor soils, and in areas lacking investment, so that the cassava yield in Vietnam is still very low, with an average of around 8 t/ha.

Upto now, following the strategies of the National Root Crops Program and with technical and some financial support from CIAT, cassava breeding and agronomy research in Vietnam have strengthened significantly, and this has contributed to the increase in cassava yields and production in some regions of Vietnam.

2. RESULTS OF THE RESEARCH

2.1 Effect of Cassava Production on Soil Productivity

Research on the effect of cassava production on soil physical and chemical characteristics has been conducted in several regions of Vietnam (Cong Doan Sat and Deturck, 1998; Khanh, 1997; Nguyen Bich Thu, 1998). The results show that most of the soils used for long-term cassava growing in Vietnam had been degraded. The main reason for this deterioration of the soil is the lack of adoption of more sustainable technologies for cassava production. Thus, it is necessary to develop new technologies that can be adopted for cassava production and that will maintain soil fertility.

Results of a study about the sustainability of various cropping systems used on Haplic Acrisols in the uplands of South Vietnam (**Table 1**) indicate that different cropping systems had a differential long-term effect on pH, on macronutrient contents and on cation exchange capacity. Cassava cropping resulted in the lowest pH, the lowest levels of total N, total P and exchangeable K in the surface soil when compared with rubber or cashew cropping. The cation exchange capacity of the soil declined in the following order: sugarcane >forest >rubber >cashew >cassava (Hoang Van Tam, 1997).

Another report from North Vietnam (Thai Phien and Nguyen Cong Vinh, 1998) indicate that the reason for a reduction in production capacity of the soil when cassava was planted continuously in monoculture in the same site for many years is that at harvest time farmers usually remove both cassava roots and stems resulting in removal of about 60-153 kg N, 36-38 kg P_2O_5 and 56-122 kg K_2O/ha for one crop, while these nutrients are seldom returned in the form of fertilizers or manures.

Table 1. Long-term effect of various cropping systems on soil fertility parameters of Haplic Acrisols of Dong Nai province, Vietnam.

	Forest	Rubber	Sugarcane	Cashew	Cassava
pH	-	4.7	-	4.3	4.2
Total N (%)	0.058	0.054	0.039	0.034	0.024
Total P (%)	-	0.017	-	0.006	0.005
Exchangeable K (me/100 g)	-	0.129	-	0.089	0.063

Source: *Nguyen Bich Thu, 1998.*

2.2 Soil Fertility Maintenance through Fertilizer Application

To maintain or improve the productivity of soils used for cassava production, it is necessary to determine the response of cassava to NPK fertilizers and the level of macronutrient absorption by the crop. Many experiments, including both long-term and short-term NPK trials, have been conducted in various locations of Vietnam. It can be concluded that the response of cassava depended on the type and fertility of the soil.

In North Vietnam, at Thai Nguyen University, the response of cassava to N, P and K was already significant in the first year, and after ten years of continuous cassava cultivation without fertilizer application, the yield of two cassava varieties had decreased to only about 3 t/ha (**Figure 1**), while with adequate fertilization yields of 20 t/ha could be maintained. Application of K in the presence of N and P increased the yield of cassava, KM60 variety, from about 1.4 t/ha to 22 t/ha (Howeler and Thai Phien, 2000).

Other long-term NPK trials have been conducted on rather fertile Red Latosols at Hung Loc Agric. Research Center in Dong Nai province of South Vietnam. The results indicate that the response of cassava was not significant in the first four years and the yield could be maintained at about 15 t/ha without fertilizer application. However, in subsequent years yields increased significantly with fertilizer application. After the 8^{th} year of cropping there was a highly significant response to N and K, but no response to P as the yield without P was not significantly different to that obtained with P application. The available P of the soil remained much above the critical level, while the exchangeable K level had dropped to below the critical soil K-level during the last two years of cropping (**Figure 2**).

In the whole country, the best fertilizers for cassava were in the ratio 2: 1: 2 of N: P_2O_5: K_2O, and the optimum level varied from 80-40-80 kg/ha to 160-80-160 kg/ha. These levels gave the highest yields and economic returns (Nguyen Huu Hy *et al*., 1998).

Besides long-term NPK fertilizer trials, other short-term trials have been conducted in some regions of South Vietnam.

In the Central Highlands of Vietnam, the optimum level of N-P_2O_5-K_2O were about 100-100-150 kg/ha and 70-50-100 kg/ha (Nguyen Thanh Thuy, 1999; Lich and Oanh, 2000).

In the South Central Coastal Region, Nguyen Thanh Thuy (1999) found that cassava responded strongly to fertilizers on the grey podzolic soils, and the application of 80 kg N, 50 P_2O_5, 100 K_2O and 5 tonnes of manure/ha gave the highest net returns (**Table 2**).

However, in the Southeastern Region and on Haplic Acrisols, Tam (1997) found that the application of 120 kg N, 120 P_2O_5 and 180 K_2O/ha gave the highest yields (**Table 3**).

Nguyen Hong Linh (1999) reported that on peat soils with low pH and high organic matter content in the Mekong Delta, the application of N, P_2O_5, K_2O at 80-40-80 kg/ha gave the highest cassava yields and net income (**Table 4**).

To improve the soil's physical characteristics, results of a manure and green manure trial indicate that the application of manure and green manure can improve soil structure, reduce soil bulk density and maintain soil temperature and soil moisture more constant. Thus, applying manure and green manures can improve the soil's production capacity (Nguyen The Dang *et al*., 1998).

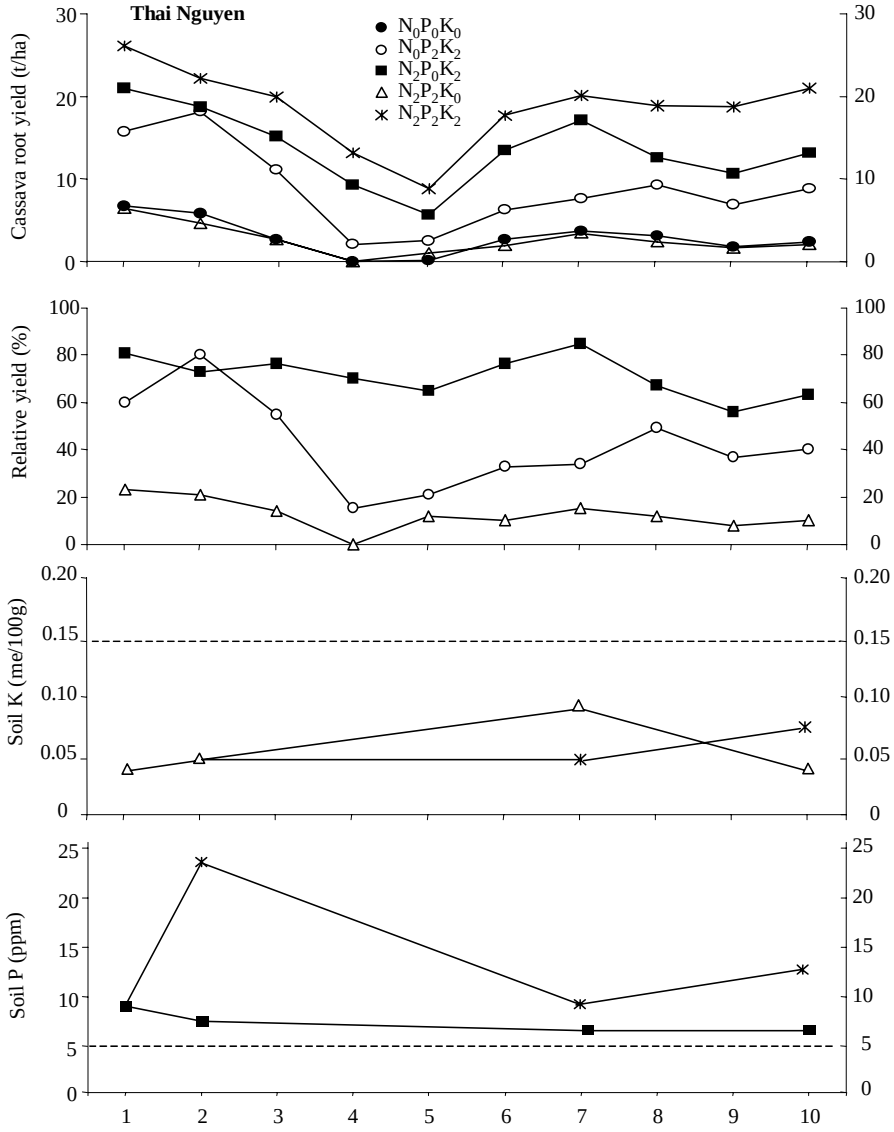

Figure 1. Effect of annual applications of N, P and K on cassava root yield, relative yield (yield without the nutrient over the highest yield with the nutrient) and the exchangeable K and available P (Bray 2) content of the soil during ten years of continuous cropping in Agro-forestry College of Thai Nguyen University, Thai Nguyen, Vietnam.

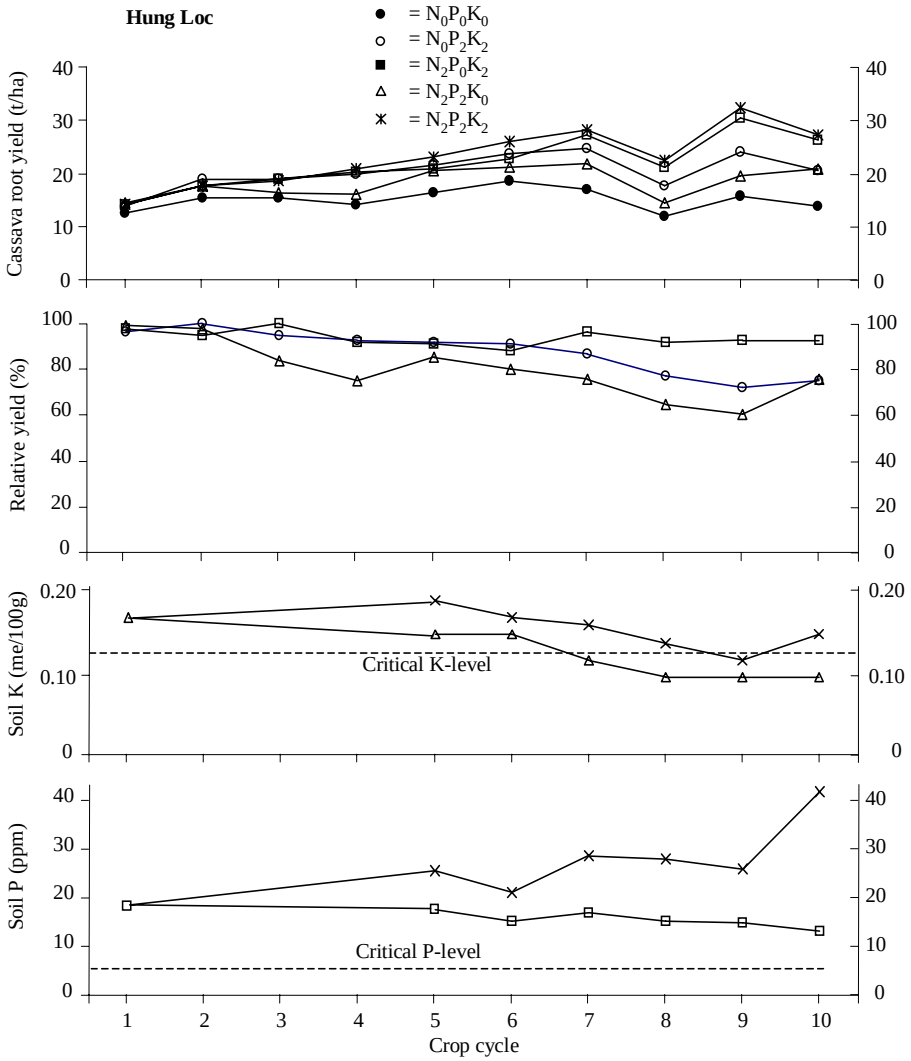

Figure 2. Effect of annual appplications of N, P and K on cassva root yield, relative yield (yield without the nutrient over the highest yield with the nutrient) and the exchangeable K and available P (Bray 2) content of the soil during eight years of continuous cropping in Hung Loc Agric. Research Center, Dong Nai, Vietnam.

Table 2. Effect of increasing levels of N on the root yield and economic returns of cassava grown in grey podzolic soil at Thinh Teo, Son Tinh, Quang Ngai province, Vietnam, in 1996/97.

Treatments (kg N-P_2O_5-K_2O/ha)[1)]	Root yield (t/ha)	Net income (mil. d/ha)
0-50-100	33.5 b	6.65
40-50-100	35.9 b	7.05
80-50-100	42.6 a	8.74
120-50-100	46.6 a	9.64
160-50-100	44.4 a	8.86
CV (%)	6.8	
LSD 0.05	5.03	

[1)]in addition to 5 tonnes manure/ha.
Source: *Nguyen Thanh Thuy. 1998.*

Table 3. Effect various rates of fertilizer application on root yield (t/ha) of cassava, KM94, planted on two Haplic Acrisols in the Southeastern Region of south Vietnam in 1995/96.

Treatments (kg N-P_2O_5-K_2O/ha)	Province	
	Tay Ninh	Dong Nai
0-0-0	12.31 c	15.04 c
30-30-45	18.75 b	22.14 b
60-60-90	19.49 b	23.44 b
120-120-180	26.35 a	28.00 a

Source: *Hoang Van Tam, 1997.*

Table 4. Effect of various rates of NPK application on the yield and income obtained from cassava grown on peat soil in Tri Ton, An Giang province, Vietnam, in 1998/99.

Treatments (kg N-P_2O_5-K_2O/ha)	Root yield (t/ha)		Gross income		Production costs	Net income	
	KM60	KM94	KM60	KM94		KM60	KM94
					('000 dong/ha)		
0-0-0	11.67	9.52	3,380	2,760	1,300	2,080	1,460
40-20-40	19.37	16.07	5,620	4,660	1,750	3,870	2,910
80-40-80	23.33	20.77	6,770	6,020	2,300	4,470	3,720
60-60-120	22.14	20.47	6,420	5,940	2,520	3,900	3,420
100-100-0	19.49	17.59	5,650	5,100	2,530	3,120	2,570
40-100-100	18.30	16.40	5,320	4,760	2,640	2,680	2,120

[1)]Prices: urea: 2000 d/kg; DAP: 4000 d/kg; KCl: 2200 d/kg; cassava 290 d/kg fresh roots.
Source: *Nguyen Hong Linh, 1999.*

Comparing the response to manure and green manure with that of chemical fertilizers it was concluded that the response of cassava to chemical fertilizers was faster than to manures and green manures (Dinh Ngoc Land and Nguyen The Dang, 2000).

2.3 Soil Fertility Maintenance by Intercropping

In Vietnam, farmers usually intercrop cassava with other food crops, especially grain legumes. The results of trials conducted at research stations and in farmer participatory research (FPR) trials indicate that cassava intercropping with maize and peanut or mungbean in fertile soils, and with peanut or black bean in poor soils, can increase net income and maintain soil fertility (Hoang Kim, 1991; Nguyen Huu Hy *et al*., 1995; 1998; Nguyen The Dang *et al*., 1998; Le Sy Loi, 2000).

Others concluded that intercropping or crop rotations also improve soil fertility through the return of crop residues of the intercrop to the surface soil; this practice can also reduce soil losses by erosion and increase income when cassava is grown on sloping land (**Tables 5** and **6**). Cassava intercropping with grain legumes has become very important for many farmers because the cassava production area is often far from the home; in that case the application of chemical fertilizers is minimal or the transport of fertilizers is a problem.

When intercropping or planting hedgerows of legume trees, the prunings can be used for mulching; also, some other materials, such as straw, residues of cassava peel or cassava leaves and stem can be used to improve the soil's chemical and physical conditions (Howeler and Thai Phien, 2000).

2.4 Soil Erosion Control

In tropical regions the degradation of soil is often a serious problem in agricultural production. Ernst and Fairhurst (1997) concluded that the loss of the soil surface and the decrease in soil fertility by human activity when no nutrients are returned to the soil is the biggest challenge facing agricultural production in the future.

Table 5. Effect of intercropping and alley cropping on soil chemical characteristics[1)] after four years of consecutive cassava planting on red Latosols at Hung Loc Agric. Research Center in Dong Nai, Vietnam, in 1992-1996.

Treatments	pH	OM (%)	P (ppm)	Ca	Mg (me/100 g)	K
Soil before planting (1992)	5.0	2.1	5.0	1.68	0.54	0.28
Soil after four years (1996)						
-Cassava monoculture	4.6	2.5	9.3	1.70	0.58	0.24
-Cassava + peanut intercrop	4.6	2.9	10.2	1.50	0.51	0.27
-Cassava + cowpea intercrop	4.4	3.0	11.3	2.80	0.69	0.32
-Cassava + *Canavalia* intercrop	5.1	2.7	9.7	1.80	0.65	0.27
-Cassava + *Leucaena* hedgerows	4.7	3.0	19.2	2.10	0.75	0.38
-Cassava + *Gliricidia* hedgerows	4.7	2.9	11.3	1.90	0.72	0.37

[1)]Data from IAS soil testing laboratory, HCM city, Vietnam.

Table 6. Effect of intercropping cassava with various grain legumes on the yield of crops, on gross and net income, as well as on dry soil loss due to erosion when grown on 10% slope at Agro-forestry College of Thai Nguyen Univ., Thai Nguyen, Vietnam in 1997.

Intercropping treatments	Yield (t/ha)		Gross income[1)]	Costs fert. +seed[1)]	Net income	Dry soil loss
	cassava	intercrop	(mil. d/ha)			(t/ha)
1. Cassava monoculture	18.67	-	7.47	6.22	1.25	31.24
2. C+peanut	16.50	1.08	12.00	8.77	3.23	24.03
3. C+soybean	18.42	0.15	8.27	7.98	0.29	28.50
4. C+mungbean	20.83	0.27	10.49	7.84	2.65	28.61
5. C+black bean	17.92	0.35	9.62	7.94	1.68	28.64
6. C+cuoc bean	17.67	0.17	7.92	7.87	0.05	28.14

[1)]Prices:

cassava:	d 400/kg fresh roots		
peanut:	5000/kg dry pods	peanut seeds:	d 7000/kg dry pod
soybean:	6000/kg dry grain	soybean seeds:	7000/kg dry grain
mungbean:	8000/kg dry grain	mungbean seeds:	8000/kg dry grain
black bean:	7000/kg dry grain	black bean seeds:	7000/kg dry grain
cuoc bean:	5000/kg dry grain	cuoc bean seeds:	5000/kg dry grain

Source: *Le Sy Loi, 2000.*

In Vietnam mountainous areas occupy about 75% of the total area. According to a farm-level survey conducted in 1990-1991 of over 1100 households in 45 districts of the major cassava growing regions of Vietnam (Pham Van Bien *et al*., 1996), 59% of cassava is grown on sandy soils, 3.9% on loamy soils, 11.7% on clayey soils and 25.3% on rocky soils; also, about 45% of cassava is grown on sloping land.

To develop measures to control soil erosion, erosion control trials have been conducted in both North and South Vietnam. The results of these trials indicate that soil loss and runoff can be reduced by intercropping and by the planting of contour hedgerows. Intercropping with peanut was generally more effective in reducing erosion than intercropping with other crops (**Tables 7** and **8**). Contour ridging and no- or reduced-tillage as well as adequate fertilization are also effective practices to reduce erosion (**Figure 3**).

2.5 Chemical Weed Control

In order to reduce the cost of cassava production, chemical weed control trials have been conducted in the red Latosols at Hung Loc Agricultural Research Center in Dong Nai province. Results of the trials show that when the pre-emergence herbicide metolachlor (Dual) was used to control weeds from planting to three months after planting, better yields and net income were obtained than weeding by hand or using post-emergence herbicides. The treatment with 2.4 l Dual/ha gave the highest yield and net income compared with other treatments. This result is important when cassava is planted in regions where there is a lack of labor or where cassava production is done on a large scale (**Table 9**). However, when using chemicals to control weeds one needs to consider the potential pollution of the environment.

Table 7. Effect of intercropping and hedgerows on cassava yield and soil loss due to erosion in cassava planted on about 8% slope in Hung Loc Agric. Research Center in Dong Nai province, Vietnam, in 1998/99.

Treatments	Root yield (t/ha)	Stem yield (t/ha)	Root starch content (%)	Dry soil loss (t/ha)
Cassava monoculture	36.51 c	21.61 c	29.8	23.3
Cassava + mungbean intercrop	35.84 c	23.60 bc	30.0	22.5
Cassava + peanut intercrop	39.51 bc	23.54 bc	29.8	19.3
Cassava + vetiver grass hedgerows	51.78 a	28.44 ab	29.8	22.7
Cassava + *Gliricidia* hedgerows	45.67 ab	30.22 a	30.9	18.5
Cassava + *Leucaena* hedgerows	45.06 ab	30.89 a	29.8	19.4
CV (%)	8.61	10.66		
LSD 0.05	7.61	5.86		NS

Table 8. Effect of intercropping on cassava yield and soil loss when cassava was grown on yellow-red soil at Thai Nguyen University in Thai Nguyen province, Vietnam, in 1998.

Treatments[1)]	Yield (t/ha)		Gross income[1)]	Production costs[3)]	Net income	Dry soil loss
	cassava	peanut	(mil. d/ha)			(t/ha)
1. Cassava monoculture	17.96	-	8.98	1.25	7.73	24.1
2. C+peanut intercrop	21.72	0.39	12.81	1.67	11.14	13.3
3. C+peanut+*Tephrosia*	22.38	0.27	12.54	1.67	10.87	5.6
4. C+peanut+vetiver grass	21.50	0.30	12.25	1.67	10.58	5.4
5. C+peanut+V+T	21.04	0.38	12.42	1.67	10.75	5.2

[1)] T = *Tephrosia candida*
V = vetiver grass
[2)] Prices: cassava dong 500/kg fresh roots
peanut 5000/kg dry pods
[3)] Production cost = fertilizer cost + cost of grain legume seed
Source: *Dinh Ngoc Lan and Nguyen The Dang, 2000.*

3. FUTURE DIRECTION

Considering the results obtained during the past decade, future cassava agronomy research in Vietnam will focus on the following research topics:

- Maintenance of soil fertility by intercropping and fertilizer application, and erosion control in cassava areas with sloping land in various parts of the country.
- Using FPR methods to develop practical agronomic practices and enhance the adoption of these practices by other farmers.

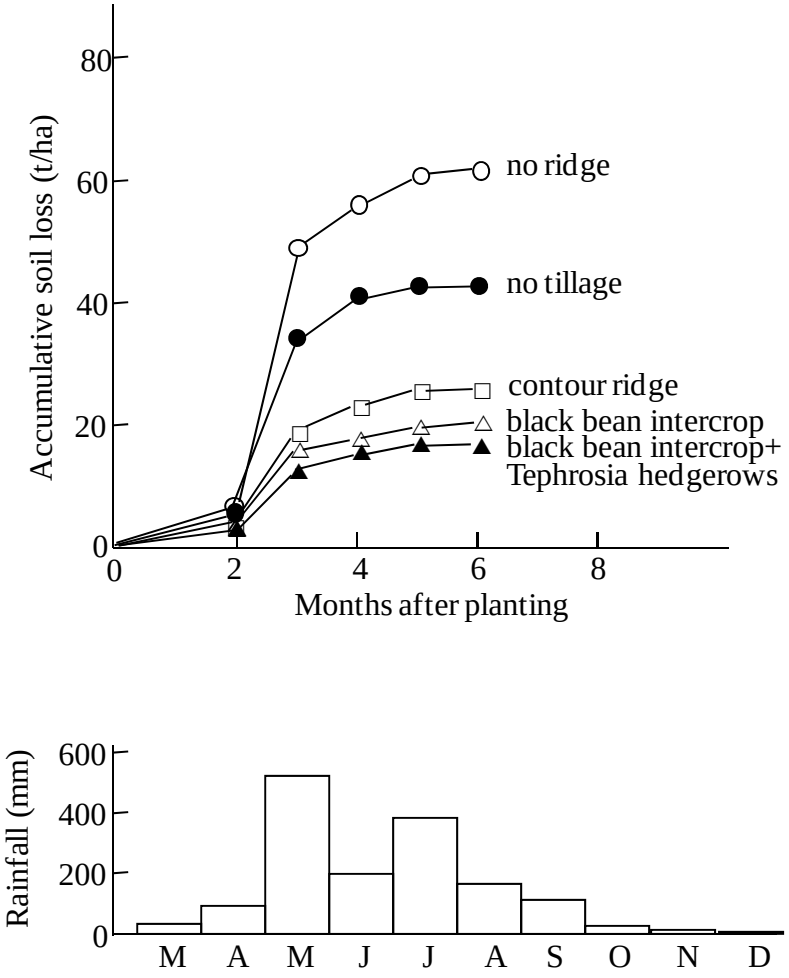

Figure 3. Effect of various soil/crop management practices on dry soil loss due to erosion in cassava planted on about 10% slope in Agro-forestry College of Thai Nguyen University, Thai Nguyen, Vietnam, in 1993.

Table 9. Effect of various weed control practices on cassava yield and economic return when cassava was grown on red Latosols at Hung Loc Agric. Research Center in Dong Nai province of Vietnam in 1997/98.

Treatments	Cassava yield (t/ha)	Gross income[1)]	Cost for weeding	Total production costs	Net income	MBCR
		('000 d/ha)				
Hand weeding	21.22	8,488	1,200	3,215	5,272	-
Dual (0.8 l/ha)	22.61	9,044	0,270	2,685	6,359	4.0
Dual (1.6 l/ha)	24.23	9,692	0,390	2,805	6,887	4.1
Dual (2.4 l/ha)	27.53	11,012	0,510	2,925	8,087	5.5
Roundup (2 l/ha)	24.38	9,752	0,414	2,829	6,923	3.9
Gramoxone (2 l/ha)	21.61	8,644	0,382	2,797	5,847	1.5

[1)]cassava price: 400 d/kg fresh roots.

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