## OUTPUT 13

## Integrated cassava-based cropping systems in Asia: Widespread adoption of farming practices that enhance sustainability

The overall objective of this output is to increase the income and agricultural sustainability in less favored upland areas by developing, together with farmers, efficient and effective integrated cassava-based cropping and livestock production systems that optimize total farm productivity, improve livelihoods and contribute to the long-term sustainability of cassava-based cropping systems in Asia.

### *Activity 13.1 Soil fertility maintenance through the application of chemical fertilizers, or the use of intercropping, green manuring, alley cropping and crop rotations.*

#### Rationale

Because of the near absence of diseases and pest problems in Asia, cassava is often grown continuously on the same land for many years. But, most cassava soils have a low inherent fertility. The opening up of land for cultivation of annual crops leads to exposure of the soil surface to high temperatures resulting in rapid decomposition of organic matter, while the direct impact of rainfall on the soil surface may destroy soil aggregates and lead to runoff and erosion. Continuous cropping with the removal of cassava roots (and sometimes stems and leaves as well) will lead to depletion of soil nutrients. Unless these nutrients are replaced in the form of chemical fertilizers, animal manures or green manures, soil fertility will decrease and productivity decline.

#### Specific Objectives

a) *To determine the immediate and long-term effect of various combinations of N, P and K applied annually on cassava yields and starch content, as well as on soil fertility.*

**b)** To determine the long-term effect of various green manures on cassava yields and soil fertility.

#### *Activity 13.1.1 Long-term NPK trials*

Due to the termination of the NF project in China and Vietnam, and the resulting termination of funding, only three of the four long-term NPK trials could be continued, while the one in Hainan, China was discontinued. The three remaining trials are in Thai Nguyen

University in North Vietnam, at Hung Loc Agric. Research Center in south Vietnam, and at Tamanbogo in Lampung province on Sumatra island of Indonesia. Most of these experiments have completed 12-14 consecutive years of cropping. The methodology has been described in the 2003 Annual Report.

**Results**

**Figure 13.1** shows the effect of annual application of various combinations of N, P and K on the cassava root yield and leaf life (at 3 MAP) of two varieties during the 14$^{th}$ year of planting at Thai Nguyen University. Without fertilizer application, the yields of both varieties had further decreased to only 1-2 t/ha while with high levels of NPK application yields were 21-24 t/ha. Among the three major plant nutrients, K was the most important in increasing yields, followed by N and then P. There was a significant response only to the first increment of 20 kg $P_2O_5$/ha, and to the 2$^{nd}$ increment of N corresponding to 80 kg N/ha; it is likely, however that yields and yield responses to N and P were constraint by an inadequate level of 80 kg $K_2O$/ha. To maintain high yields, an annual application of at least 160 kg N, 80 kg $P_2O_5$ and 160 kg $K_2O$/ha are required. These high rates are necessary because all plant parts were removed from the field with each harvest, which is a common practice in Vietnam. While all these plant parts are fully utilized, this practice does result in high levels of nutrient removal, which may lead to nutrient depletion and a deterioration of soil productivity. **Figure 13.1** also shows that the improved variety KM 60 produced consistently higher yields than the local variety Vinh Phu, both in the absence and presence of fertilizers. Interestingly, Vinh Phu had a longer leaf life than KM 60; in both varieties leaf life greatly increased with increasing K application, while N or P had only a slight positive effect.

Similarly, in eight FPR fertilizer trials conducted by farmers in Dong Rang village in Hoa Binh province (**Table 13.1**), highest yields and net income were consistently obtained with the highest rates of N, P and K applied, i.e. either 40 kg N, 40 $P_2O_5$ and 80 $K_2O$/ha or 60 kg N, 60 $P_2O_5$ and 120 $K_2O$/ha. In this location all three nutrients are important, but N and K were required at higher rates than P. Similar results were obtained in FPR fertilizer trials conducted by five farmers in Kieu Tung village in Phu Tho province of Vietnam. The application of 60 kg N, 40 $P_2O_5$ and 120 $K_2O$/ha combined with 10 t/ha of pig manure produced the highest average yields and net income (**Table 13.2**). These FPR fertilizer trials conducted by farmers on their own fields are an excellent way to show the importance of the right balance of nutrients for each crop; this helps to enhance adoption of improved fertilization practices, which in turn leads to higher yields and income. The combination of high-yielding varieties (such as KM 98-7 in **Table 13.1**) with adequate and well-balanced fertilization is generally the most important factors to increase cassava yields in Asia. In Vietnam, the rapid expansion of new varieties and the greater use of chemical fertilizers markedly increased cassava yields in the country, from about 8.3 t/ha in 2000 to 14.1 t/ha in 2003.

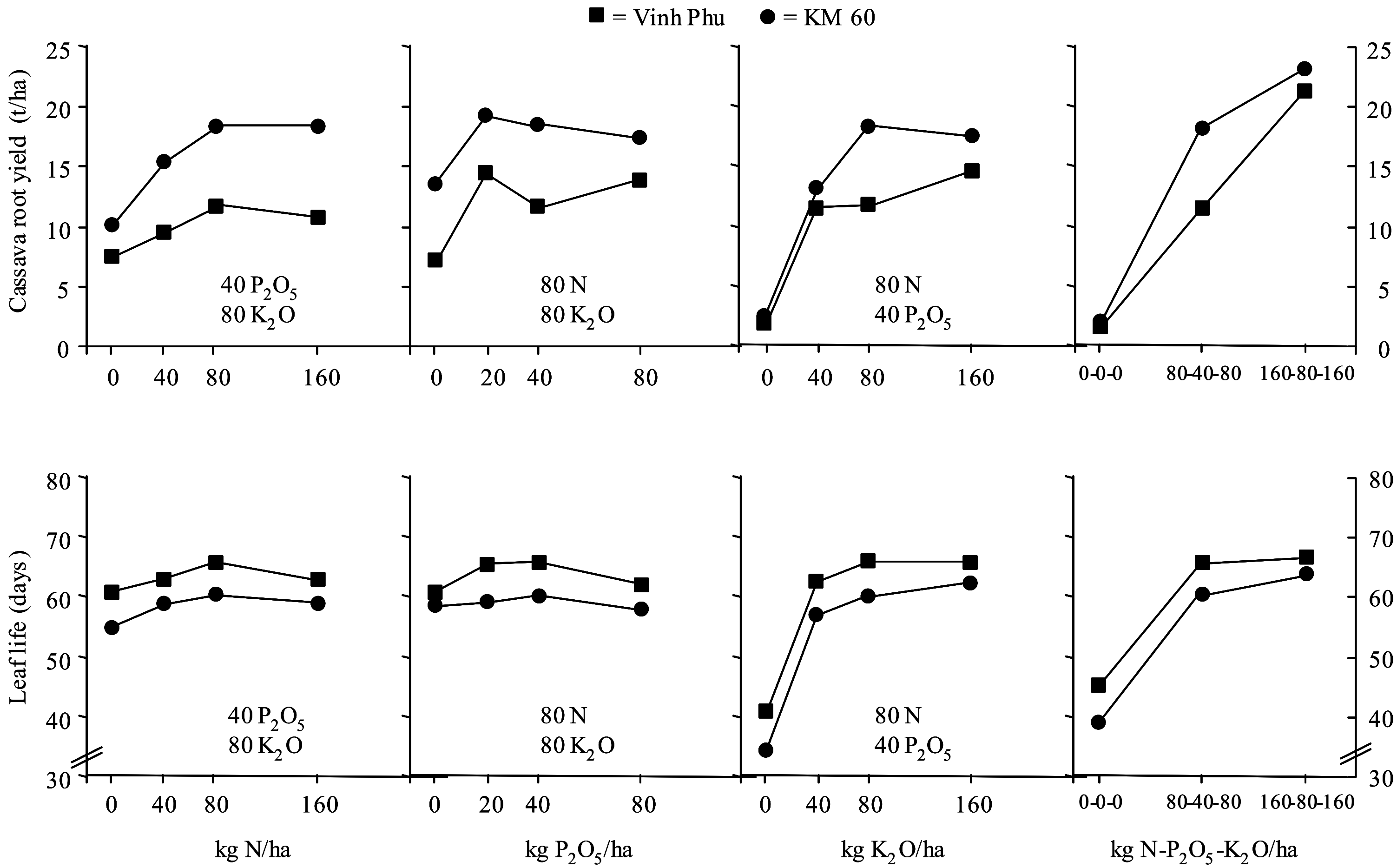


*Figure 1. Effect of the annual application of various levels of N, P and K fertilizers on the fresh root yield and on leaf life at 3 MAP of two cassava cultivars grown at Thai Nguyen University, Thai Nguyen, Vietnam, in 2003 (14th year).*

### *Activity 13.1.2 Green manure experiment in Khaw Hin Sorn, Thailand*

A similar trial was conducted for the first year in Khaw Hin Sorn Experiment Station in Chachoengsao province of Thailand. The experimental details as well as the 1st year's results of this experiment have been described in the 2003 Annual Report. Cassava variety KU 50 was planted at a planting distance of 1.0x1.0 m. Six green manure (GM) species were planted between rows at one MAP cassava. All plots received 156 kg/ha of 15-7-18 except treatment 8 which received 469 kg/ha without GM

**Results**

Table 13.3 shows the results for the second year of intercropping cassava with six green manures (GM). Unlike the first year, when highest yields were obtained with the low level of 25 kg/rai (156 kg/ha) of 15-7-18 fertilizer, during the second year this was achieved with the high rate of 75 kg/rai (469 kg/ha). Intercropping cassava with various green manure species (planted at 1 MAP cassava) and pulling and mulching the GM two months later, did not increase cassava yields except in the case of *Canavalia ensiformis;* all other GM species decreased cassava yields due to excessive competition for light, water and nutrients. The highest net income was obtained with the highest rate of chemical fertilizers, followed by the lower rate of fertilizer combined with intercropped *Canavalia ensiformis*. In both years, *Canavalia* or sword bean was the most successful of all the green manure species tested, while *Mucuna sp.* and *Crotalaria juncea* were the least successful due to their strong competitive effect on cassava.

### *Activity 13.2 Development of efficient and economical soil preparation practices.*

The rationale, specific objectives and materials and methods for these experiments have been described in the 2003 Annual Report. An experiment comparing the effect of ten different methods of soil preparation on the yield and starch content of four cassava varieties was conducted in three sites in Thailand, i.e. at Khaw Hin Sorn Experiment Station in Chachoengsao province, at TTDI Research and Development Center in Nakhon Ratchasima province, and in a farmer's field near Rayong Field Crops Research Center in Rayong province. These experiments were planted at the same sites for three consecutive years, although at TTDI and Khaw Hin Sorn some treatments were changed after the first year.

Table 13.1. Results of eight FPR fertilizer trials conducted by farmers in Dong Rang village, Dong Xuan commune, Luong Son district, Hoa Binh, Vietnam in 2003.

**1. XanhVinh Phu variety**

| Treatments [1] | Cassava yield (t/ha) | | | | Gross Income [3] | Product. costs | Net income | B/C |
|---|---|---|---|---|---|---|---|---|
| | A [2] | B | C | Av. | (mil. VN dong/ha) | | | |
| 1. No NPK | 9.75 | 8.50 | 10.25 | 9.50 | 3.800 | 3.000 | 0.800 | 1.27 |
| 2. P | 11.50 | 10.75 | 12.00 | 11.42 | 4.568 | 3.347 | 1.221 | 1.36 |
| 3. K | 12.50 | 12.00 | 13.75 | 12.75 | 5.100 | 3.453 | 1.647 | 1.48 |
| 4. N | 14.50 | 12.50 | 13.75 | 13.58 | 5.432 | 3.341 | 2.091 | 1.63 |
| 5. PK | 14.25 | 14.25 | 14.50 | 14.33 | 5.732 | 3.720 | 2.012 | 1.54 |
| 6. NK | 18.00 | 17.00 | 16.50 | 17.17 | 6.868 | 3.714 | 3.154 | 1.85 |
| 7. NP | 19.50 | 18.00 | 18.00 | 18.50 | 7.400 | 3.608 | 3.792 | 2.05 |
| 8. NPK | 23.00 | 20.75 | 21.25 | 21.67 | 8.668 | 3.981 | 4.687 | 2.18 |

[1] N = 40 kg N/ha; P = 40 kg $P_2O_5$/ha; K = 80 kg $K_2O$/ha; Variety: Xanh Vinh Phu

[2] A = Mr. Mai; B = Mr. Tien; C = Mr. Quy

[3] Prices (VN dong):

Cassava: 400/kg fresh roots.
Urea: (46% N3,000/kg
Fused Mg phosphate (15% $P_2O_5$):1,000/kg
KCl (60% $K_2O$): 2,800/kg

**2. XanhVinh Phu variety**

| Treatments $N-P_2O_5-K_2O$ (kg/ha) | Cassava yield (t/ha) | | | | Gross Income [2] | Product. costs | Net income | B/C |
|---|---|---|---|---|---|---|---|---|
| | A [1] | B | C | Av. | (mil. VN dong/ha) | | | |
| 1. No NPK | 6.25 | 11.25 | 14.25 | 10.58 | 4.232 | 3.000 | 1.232 | 1.41 |
| 2. 40-40-80 | 13.75 | 16.25 | 19.00 | 16.33 | 6.531 | 3.981 | 2.551 | 1.64 |
| 3. 40-60-80 | 13.75 | 14.25 | 16.75 | 14.92 | 5.968 | 4.114 | 1.854 | 1.45 |
| 4. 60-40-80 | 15.00 | 15.00 | 18.75 | 16.25 | 6.500 | 4.111 | 2.389 | 1.58 |
| 5. 60-60-120 | 15.75 | 17.00 | 19.75 | 17.50 | 7.000 | 4.431 | 2.569 | 1.58 |

[1] A = Mrs. Nga; B = Mr. Hieu; C = Mrs. Van

[2] Prices: as above

**3. SM 17-17-12 vatiety**

| Treatments | Cassava yield (t/ha) | | | Gross Income [2] | Product. costs | Net income | B/C |
|---|---|---|---|---|---|---|---|
| | A [)] | B | Av. | (mil. VN dong/ha) | | | |
| 1. No NPK | 11.75 | 12.50 | 12.13 | 4.606 | 3.000 | 1.606 | 1.54 |
| 2. 40-40-80 | 18.00 | 18.75 | 18.38 | 6.984 | 3.981 | 3.003 | 1.75 |
| 3. 40-60-80 | 17.50 | 19.30 | 18.40 | 6.992 | 4.114 | 2.878 | 1.70 |
| 4. 60-40-80 | 19.50 | 18.00 | 18.75 | 7.125 | 4.111 | 3.014 | 1.73 |
| 5. 60-60-120 | 20.00 | 21.25 | 20.63 | 7.836 | 4.431 | 3.405 | 1.77 |

1) A = Mrs. Nga; B = Mr. Hieu
2) Prices: cassava = 380 VND/kg fresh root (SM 17-17-12 variety) others: as above.

Table 13.2. Average results of five FPR fertilizer trial conducted by farmers in Kieu Tung village, Phuong Linh commune, Thanh Ba district, Phu Tho, Vietnam in 2003.

| Fertilizer treatments | Cassava yield (t/ha) | | | | | | Gross income | Product Costs [2] | Net income | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | Av. [1] | (mil. VN dong/ha) | | | B/C |
| 1. 10t/ha FYM | | 15.5 | | 8.5 | 19.7 | 17.60 | 8.800 | 5.000 | 3.800 | 1.76 |
| 2. 10t/ha FYM+60N+60$P_2O_5$+120$K_2O$ | 18.5 | 19.6 | 14.8 | 16.5 | 25.9 | 22.75 | 11.375 | 6.556 | 4.819 | 1.74 |
| 3. 10t/ha FYM+60N+60$P_2O_5$+80$K_2O$ | 17.2 | 18.2 | 13.2 | 14.2 | 23.8 | 21.00 | 10.500 | 6.356 | 4.144 | 1.65 |

[1] Using average yield of 2 and 5

[2] Prices (VN dong):

Cassava: 500/kg fresh roots
Urea (46% N): 3,200/kg
SSP (17%$P_2O_5$): 1,300/kg
KCl (60% $K_2O$): 3,000/kg
Labour: 10,000/manday
Pig manure + application: 200/ k= 2.000 mil. dong/ha
Labour for monoculture without fert. or manure (300 md/ha) = 3.000 mil. dong/ha
Labour for fertilizer application = 0.080 mil. dong/ha

Table 13.3. Estimated costs of production of treatments in the green manure experiment conducted at Khaw Hin Sorn Research Station, Khaw Hin Sorn, Chachoengsao,Thailand in 2003/04 (2nd year).

| Treatments | Root yield (t/ha) | Starch content (%) | Gross Income[1] | Product. costs[2] | Net income |
|---|---|---|---|---|---|
| | | | ----------('000 baht/ha)---------- | | |
| 1. Check without GM; 25 kg/rai 15-7-18 | 26.28 | 23.6 | 28.17 | 13.63 | 14.54 |
| 2. *Crotalaria juncea;* 25 kg/rai 15-7-18 | 20.83 | 22.7 | 21.95 | 11.91 | 10.04 |
| 3. *Canavalia ensiformis;* 25 kg/rai 15-7-18 | 27.07 | 23.1 | 28.75 | 13.59 | 15.16 |
| 4. Pigeon pea ICPL 304; 25 kg/rai 15-7-18 | 24.18 | 23.4 | 25.82 | 12.81 | 13.01 |
| 5. Cowpea CP 4-2-3-1; 25 kg/rai 15-7-18 | 21.66 | 22.3 | 22.66 | 12.25 | 10.41 |
| 6. *Mucuna;* 25 kg/rai 15-7-18 | 21.17 | 23.8 | 22.78 | 12.00 | 10.78 |
| 7. Mungbean; 25 kg/rai 15-7-18 | 25.08 | 23.6 | 26.89 | 12.83 | 14.06 |
| 8. Check without GM; 75 kg/rai 15-7-18 | 32.16 | 23.8 | 34.60 | 17.71 | 16.89 |

[1] Prices: cassava: bath 1.20 kg fresh roots; 0.02 baht reduction per 1% starch reduction

[2] Costs: 15-7-18 fertilizers baht 360/50 kg

land preparation 300/rai
Glyphosate (500 ml/rai) 75/rai
cassava planting 150/rai
herbicide application 60/rai
fertilizer application 40/rai
planting/ harvesting GM 120/rai
harvest cassava 120/tonne
transport cassava 150/tonne

**Results**

Table 13.4 shows the results for the third year in Rayong, while Table 13.5 shows a summary of the effect on yield for all three sites over three years. During the 3rd year in Rayong the use of a subsoiler followed by a 3-disk plow resulted in the highest yield as well as the highest starch content of all four varieties. As indicated in Table 13.4 this resulted in the highest gross and net income. This treatment leaves the soil surface rather rough for planting, but results in better drainage and probably less runoff and erosion. Table 13.5 shows that this treatment also produced the highest yield during the 2nd year, while during the first year it produced the 2nd highest yield, after the traditional practice of 3-disk plow followed by 7-disk harrow and up/down ridging.

Table 13.4. Effect of various methods of land preparation on the average root yield and starch content aswell as the production costs, and gross and net income obtained with four cassava varieties planted in a farmer's field near Rayong Field Crops Research Center in Huay Pong subdistrict of Rayong, Thailand, in 2003/04 (3d year).

| Plant spacing treatments[1)] | Cassava yield (t/ha) | Starch content (%) | Gross Income [1)] | Production costs | Net income |
|---|---|---|---|---|---|
| | | | ('000 B/ha) | | |
| 1. No tillage; Glyphosate | 22.39 | 21.8 | 23.20 | 12.79 | 10.41 |
| 2. Chisel plow; Glyphosate | 22.84 | 22.1 | 23.80 | 13.67 | 10.13 |
| 3. Subsoiler; Glyphosate | 22.62 | 22.4 | 23.71 | 13.98 | 9.73 |
| 4. Subsoiler + chisel; Glyphosate | 25.04 | 23.5 | 26.79 | 15.58 | 11.21 |
| 5. Cassava harvester; Glyphosate | 23.43 | 21.6 | 24.18 | 14.32 | 9.86 |
| 6. 3-disk plow | 23.82 | 22.9 | 25.20 | 13.46 | 11.74 |
| 7. Subsoiler + 3-disk plow | 27.68 | 23.5 | 29.62 | 15.26 | 11.36 |
| 8. 3-disk plow + 7-disk harrow | 24.02 | 21.4 | 24.69 | 14.27 | 10.42 |
| 9. 3-disk + 7-disk + contour ridging | 25.35 | 23.0 | 26.87 | 15.38 | 11.49 |
| 10. 3-disk + 7-disk + up-down ridging | 23.41 | 21.2 | 23.97 | 14.72 | 9.25 |
| **Average** | **24.06** | **22.3** | **25.20** | **14.34** | **10.86** |

[1)]Price: cassava: baht 1.20/kg fresh roots at 30% starch; 0.02 baht reduction for each 1% starch reduction

At TTDI the use of the subsoiler followed by chisel plow and application of Glyphosate to kill weeds before planting produced the highest average yields over the three years. However, during the third year, the no-tillage treatment produced the highest yield. During that year cassava growth and yields were very poor due to a severe drought in the middle of the wet season. In Khaw Hin Sorn the trial was moved to a different site in the 2nd year. Yields were exceptionally high in the 2nd year, but decreased substantially in the 3rd year. The traditional practice of 3-disk plow followed by 7-disk harrow and up-down ridging produced the highest yield. Averaged over all three locations and three years, the traditional practice of 3-disk + 7-disk + ridging produced the highest yield, closely followed by subsoiler + chisel plow using Glyphosate, or subsoiler followed by 3-disk and 7-disk plow. The subsoiler in combination with chisel or 3-disk plow, or 3-disk + 7 disk harrow seems to improve drainage resulting in higher yields. However, the no-tillage treatment, using only Glyphosate to control weeds, produced an overall average yield of 91% of the maximum yield. Even though it may result in a higher net income than full land preparation, it is unlikely that this practice will be adopted by farmers, as it does make manual planting and harvesting more difficult; it may be more acceptable once both these operations are mechanized.

***Activity 13.3 Determination of the response to various methods of application of Zn in calcareous soils.***

The rationale and specific objectives of these experiments were presented in the 2003 Annual Report.

**Results**

The experiment on different levels and methods of application of Zn to cassava planted in calcareous soils at TTDI's Research and Development Center in Nakhon Ratchasima province of Thailand was repeated in 2003/04 (**Table 13.6**). The average root yields and starch contents obtained in 2003/04 were similar to those in the 2002/03 experiment (Table 13.4, CIAT Annual Report of IP-3 for 2003). In the 2nd year, the average yield of Rayong 72 and KU-50 was 15.8 t/ha without Zn application and 20.7 t/ha with the combined use of stake treatment with 2% $ZnSO_4.7H_2O$, 5 kg Zn/ha applied to the soil and three foliar applications with 1% $ZnSO_4.7H_2O$. Soil application of 10 kg Zn/ha also produced a high yield, followed by stake treatment with 2% $ZnSO_4.7H_2O$. However, the high cost of soil applications and foliar treatments generally did not justify the slight increase in yield, resulting in a negative net income. The highest net income was obtained by the check plot, without Zn application, due to the lower production costs. While many plants suffered initially from severe Zn deficiency, most plants recuperated even without any Zn treatment once their root system became well established and these roots became infected with natural soil mycorrhizae, which contribute to the more efficient uptake of Zn from the soil.

Table 13.5. Summary of results of a soil preparation experiment conducted for three consecutive years in three sites in Thailand from 2001/02 to 2003/04.

| Treatments | Rayong | | | | TTDI | | | | Khaw Hin Sorn | | | | Average 3 Loc. | Average 2d+3d year 2 Loc. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1st year | 2d year | 3d year | **Av.** | 1st year | 2d year | 3d year | **Av.** | 1st year | 2d year | 3d year | **Av.** | | |
| 1. No tillage; Glyphosate | 11.46 | 23.94 | 22.39 | **19.26** | 19.91 | 26.07 | 15.14 | **20.37** | 21.45 | 32.71 | 24.90 | **26.35** | 21.99 | 24.70 |
| 2. Chisel plow; Glyphosate | 12.03 | 24.92 | 22.84 | **19.93** | 17.78 | 25.10 | 10.93 | **17.94** | 20.56 | 34.18 | 21.80 | **25.51** | 21.13 | 23.00 |
| 3. Subsoiler; Glyphosate | 13.70 | 24.21 | 22.62 | **20.18** | 16.31 | 24.32 | 10.10 | **16.91** | 19.20 | 33.01 | 24.48 | **25.56** | 20.88 | 22.98 |
| 4. Subsoil+chisel; Glyphosate | 14.85 | 25.99 | 25.04 | **21.96** | 21.87 | 28.71 | 14.20 | **21.59** | 19.07 | 37.65 | 23.12 | **26.61** | 23.39 | 25.92 |
| 5. Cassava harvester; Glyphosate | 14.60 | 25.82 | 23.43 | **21.28** | 16.08 | 25.52 | 12.52 | **18.04** | 18.56 | 39.50 | 26.66 | **28.24** | 22.52 | 26.05 |
| 6. 3disk plow | 13.66 | 22.76 | 23.82 | **20.08** | 18.00 | - | - | **-** | 18.81 | - | - | **-** | - | - |
| 7. Subsoiler+3disk plow | 17.57 | 28.54 | 27.68 | **24.60** | 16.59 | - | - | **-** | 24.71 | - | - | **-** | - | - |
| 8. 3disk plow+7disk harrow | 11.93 | 23.00 | 24.02 | **19.65** | 18.15 | 23.31 | 8.92 | **16.79** | 21.27 | 41.99 | 27.67 | **30.31** | 22.25 | 25.47 |
| 9. 3disk+7disk+contour ridging | 17.47 | 24.60 | 5.35 | **22.47** | 18.32 | 26.57 | 8.53 | **17.81** | 24.88 | 46.35 | 25.40 | **32.21** | 24.16 | 26.71 |
| 10. 3disk+7disk+up/down ridging | 19.50 | 25.86 | 23.41 | **22.92** | 17.52 | - | - | **-** | 23.25 | - | - | **-** | - | - |
| 11. Subsoiler+7disk; Glyphosate | - | - | - | **-** | - | 25.35 | 11.91 | **-** | - | 36.24 | 26.42 | **-** | - | 24.98 |
| 12. Subsoiler+7disk harrow | - | - | - | **-** | - | 24.90 | 10.04 | **-** | - | 28.65 | 28.39 | **-** | - | 23.00 |
| 13. Subsoiler+3disk+7disk | - | - | - | **-** | - | 26.40 | 10.88 | **-** | - | 38.95 | 29.16 | **-** | - | 26.35 |
| **Average** | **16.68** | **24.96** | **24.06** | **21.23** | **18.05** | **25.63** | **11.32** | **-** | **21.18** | **36.92** | **25.80** | **-** | **-** | **26.35** |

***Activity 13.4 Evaluation of cassava varieties and determination of optimum plant spacing for cassava leaf production.***

**Rationale**

Cassava root pellets are widely used in Europe for animal feeding. In Thailand this is not yet widely practiced due to the availability of other cheap raw materials for the production of animal feed, such as broken rice and maize. The low protein content of cassava roots and the inadequate local supply of soybean limits the local use of cassava in animal feed rations. However, cassava leaves are known to contain high levels of crude protein with a good amino acid spectrum. Recent research indicate that the low-medium tannin content of cassava leaves actually improves protein digestibility. Thus, intensive research was initiated to identify the best varieties for leaf production and to determine the most economic way of producing high yields of leaves as well as roots.

**Specific Objective**

a) *To determine the best varieties and cultural practices for obtaining high leaf and root yields and maximize net farm income.*

**Results**

*Varietal evaluation:*

**Table 13.7** shows the results of a varietal trial for leaf production conducted at TTDI Research and Development Center in Nakhon Ratchasima province, one of three such trials conducted in Thailand in 2003/04. This year both leaf and root production were markedly reduced due to a prolonged drought during the wet season. The total dry leaf yield, the sum of four cuts, averaged only 5.58 t/ha at TTDI, as compared to 15.3 t/ha last year in Rayong and 11.5 t/ha in Khon Kaen. Among the 25 varieties/lines tested, the highest dry leaf yield of 9.55 t/ha was obtained with the breeding line CMR 41-61-59, while high leaf yields were also obtained with the newly released variety Huay Bong 60 and Rayong 90, as well as the line CMR 41-111-129. Root yields this year were also low, on average 10.89 t/ha. These low yields are partially due to incomplete plant stands due to the lack of good quality planting material of some lines. The highest root yield was obtained with the two recommended varieties, Rayong 90 and Rayong 5, followed by CMR 41-61-59 and Huay Bong 60. These and many new breeding lines are being further evaluated in 2004/05. For farmers, the production of cassava leaves for animal feed is only economically profitable if the selected varieties produce both high yields of dry leaves with high crude protein content, as well as high yields of roots with adequate starch contents.

Table 13.6. Effect of methods and levels of application of Zn on the root yield and starch content of two cassava varieties, as well as the gross and net income when grown at TTDI Research and Development Center at Huay Bong, Daan Khun Thot, Nakhon Ratchasima, Thailand in 2003/04.

| | Treatment | Root yield (t/ha) | | | Starch content (%) | | | Gross income[2)] | Product costs[3)] | Net income |
|---|---|---|---|---|---|---|---|---|---|---|
| | | R 72 | KU50 | **Av.** | R 72 | KU50 | **Av.** | --------('000 B/ha)-------- | | |
| 1. | Check, no Zn | 16.66 | 14.94 | 15.80 | 20.0 | 23.3 | 21.6 | 16.31 | 11.55 | 4.76 |
| 2. | Stake dip, 2% $ZnSO_4$ | 22.71 | 15.09 | 18.90 | 19.6 | 22.6 | 21.1 | 19.32 | 14.74 | 4.58 |
| 3. | Stake dip, 4% $ZnSO_4$ | 19.02 | 14.04 | 16.53 | 19.8 | 23.3 | 21.6 | 17.06 | 14.91 | 2.15 |
| 4. | Stake dip, 6% $ZnSO_4$ | 16.34 | 13.15 | 14.74 | 19.9 | 23.5 | 21.7 | 15.24 | 15.22 | 0.02 |
| 5. | Stake dip, 8% $ZnSO_4$ | 19.15 | 13.74 | 16.44 | 19.8 | 22.9 | 21.4 | 16.90 | 16.48 | 0.42 |
| 6. | Soil application, 5kg Zn/ha | 19.68 | 17.67 | 18.68 | 19.6 | 23.7 | 21.6 | 19.28 | 18.22 | 1.06 |
| 7. | Soil application, 10kg Zn/ha | 22.22 | 16.81 | 19.52 | 20.3 | 24.3 | 22.3 | 20.42 | 22.79 | -2.37 |
| 8. | Soil application, 20kg Zn/ha | 21.79 | 16.03 | 18.91 | 20.0 | 24.1 | 22.0 | 19.67 | 31.31 | -11.64 |
| 9. | Soil application, 30kg Zn/ha | 21.56 | 16.11 | 18.84 | 19.2 | 22.4 | 20.8 | 19.14 | 39.97 | -20.83 |
| 10. | Foliar application 1% $ZnSO_4$ | 14.40[1)] | 13.66 | 14.03 | 17.9[1)] | 22.5 | 20.2 | 14.09 | 16.96 | -2.87 |
| 11. | Foliar application 2% $ZnSO_4$ | 18.81 | 12.23 | 15.52 | 19.4 | 23.3 | 21.4 | 15.95 | 18.56 | -2.61 |
| 12. | Foliar application 3% $ZnSO_4$ | 18.20 | 12.73[1)] | 15.46 | 18.7 | 21.1[1)] | 19.9 | 15.43 | 19.74 | -4.31 |
| 13. | Foliar application % $ZnSO_4$ | 19.98 | 17.30 | 18.64 | 19.7 | 23.5 | 21.6 | 19.24 | 21.80 | -2.56 |
| 14. | Stake 2%+5kg Zn +1% foliar | 23.27 | 18.04 | 20.66 | 19.5 | 23.6 | 21.6 | 21.32 | 27.01 | -5.69 |
| 15. | Stake 2%+5kg Zn +2% foliar | 21.75 | 13.77 | 17.76 | 20.6 | 23.3 | 22.0 | 18.47 | 27.42 | -8.95 |
| 16. | Stake 2%+5kg Zn +4% foliar | 19.76 | 18.88 | 19.32 | 20.8 | 23.7 | 22.2 | 20.17 | 30.25 | -10.08 |
| | Average | 19.71 | 15.26 | 17.48 | 19.7 | 23.2 | 21.4 | 17.97 | 21.68 | -3.71 |

1) Low yield and starch content due to competition from nearby tree in Rep III
2) Price: cassava: baht 1.20/kg fresh roots at 30% starch, 0.02 baht reduction for every 1% starch reduction
3) Production costs: see Table 13.4c.

*Variety x plant spacing:*

Results of a plant spacing trial for leaf production using three varieties/lines at TTDI Center are shown in Tables 8 and 9. Cassava stakes were planted at a spacing of 60x60, 50x50, 40x40 and 30x30 cm. Table 13.8 shows that four cuts of plant tops during the 10-month growth cycle produced a total average dry leaf yield of only 5.5 t/ha. Leaf yields tended to increase with increasing plant density. However, the opposite is true for root production, which generally decreased with increasing plant density. Similarly, gross income tended to increase with increasing density, while production costs and the resulting net income markedly decreased with increasing plant density. At high plant density the higher cost of planting material and planting (at 30x30 cm the number of plants per area is 4 times higher as compared to planting at 60x60 cm) is only partially offset by a lower cost for weeding, while the higher cost of harvesting leaves (due to higher leaf yields) is partially offset by the lower costs of harvesting and transport of roots. Total production costs were consistently highest at higher plant densities, resulting in a negative net income at the closest spacing of 30x30 cm. **Table 13.9** indicates that, on average, for the three varieties/lines, highest leaf yields were obtained at 30x30 cm, highest root yields at 40x40 cm, and highest net income at 60x60 cm plant spacing. This confirms results of last year's experiments, which also indicated that a high net income is generally obtained at a wider spacing (60x60 cm) because of higher root yields and lower production costs. Other planting arrangements such as 60x30 cm or strips of closely-spaced plants alternated with walk ways of 90 cm to facilitate the frequent harvests, are presently being investigated. Ultimately, the optimum balance of leaf and root yields will depend on the price of leaves and roots, which can vary from year to year.

Table 13.7. Dry leaf yield from four cuts and final root yield of 25 cassava varieties and lines evaluated for leaf production at TTDI Research and Development Center in Huay Bong, Nakhon Ratchasima, Thailand in 2003/04.

| Variety[1)] | Dry leaf yield (t/ha) | | | | | Root yield |
|---|---|---|---|---|---|---|
| | 1st cut | 2nd cut | 3rd cut | 4th out | **Total** | (t/ha) |
| 1. Rayong 1 | 2.35 | 1.38 | 0.72 | 2.18 | **6.63** | 4.86 |
| 2. Rayong 5 | 2.28 | 1.76 | 1.07 | 1.89 | **7.00** | 17.24 |
| 3. Rayong 60 | 1.92 | 1.05 | 0.53 | 1.18 | **4.68** | 10.88 |
| 4. Rayong 90 | 2.17 | 1.78 | 1.36 | 2.31 | **7.62** | 21.76 |
| 5. Rayong 72 | 2.35 | 1.04 | 0.70 | 1.40 | **5.49** | 15.22 |
| 6. KU50 | 2.84 | 1.56 | 0.85 | 1.78 | **7.03** | 14.52 |
| 7. Huay Bong 60 | 3.11 | 2.21 | 1.43 | 2.04 | **8.79** | 16.67 |
| 8. CMR 41-42-3 | 1.73 | 1.47 | 1.10 | 1.65 | **5.95** | 12.67 |
| 9. CMR 41-60-24 | 2.53 | 1.90 | 1.18 | 2.52 | **8.13** | 10.42 |
| 10. CMR 41-61-59 | 3.37 | 2.19 | 1.00 | 2.99 | **9.55** | 16.90 |
| 11. CMR 41-111-129 | 2.55 | 1.74 | 1.16 | 2.50 | **7.95** | 12.15 |
| 12. CMR 41-114-125 | 2.36 | 1.84 | 0.88 | 1.93 | **7.01** | 11.46 |
| 13. CMR 42-54-53 | 1.08 | 1.39 | 1.16 | 1.65 | **5.28** | 7.24 |
| 14. CMR 42-90-338 | 1.05 | 0.85 | 0.57 | 1.34 | **3.81** | 10.07 |
| 15. CMR 42-87-318 | 1.68 | 1.26 | 0.67 | 1.13 | **4.74** | 8.22 |
| 16. CMR 42-01-2 | 1.35 | 1.54 | 0.68 | 1.78 | **5.35** | 7.52 |
| 17. CMR 42-07-9 | 1.30 | 1.69 | 1.04 | 1.51 | **5.54** | 8.10 |
| 18. CMR 42-21-59 | 0.08 | 0.08 | 0.07 | 0.06 | **0.29** | - |
| 19. CMR 42-61-108 | 1.36 | 1.37 | 1.01 | 1.81 | **5.55** | 6.54 |
| 20. CMR 42-59-173 | 1.32 | 1.34 | 0.53 | 1.07 | **4.26** | 3.01 |
| 21. OMR 41-33-34 | 0.58 | 0.43 | 0.36 | 0.53 | **1.90** | - |
| 22. CMR 41-96-2 | - | - | - | - | **-** | - |
| 23. CMR 41-20-58 | 1.83 | 1.38 | 0.71 | 1.77 | **5.69** | 8.10 |
| 24. CMR 35-22-196 | 0.38 | 0.69 | 0.35 | 0.67 | **2.09** | - |
| 25. Hanatee | 1.52 | 0.89 | 0.36 | 0.92 | **3.69** | 5.10 |
| **Average** | **1.79** | **1.37** | **0.81** | **1.61** | **5.58** | **10.89** |

Table 13.8. Dry cassava leaf yields from four cuts, root yield, starch content, as well as production costs and the gross net income obtained when three varieties were grown at four plant spacings at TTDI Research and Development Center in Huay Bong, Nakhon Ratchasima, Thailand in 2003/04.

| Treatments[1)] | Dry leaf yield (t/ha) | | | | | Root yield | Starch content | Gross income[2)] | Product. costs | Net income |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1st cut | 2nd | 3rd | 4th cut | Total | (t/ha) | (%) | ('000 B/ha) | | |
| A-1 | 1.76 | 1.30 | 0.88 | 1.58 | 5.52 | 23.40 | 20.3 | 51.14 | 42.67 | 8.47 |
| -2 | 2.14 | 1.25 | 0.79 | 1.58 | 5.76 | 17.22 | 20.8 | 46.30 | 42.53 | 3.77 |
| -3 | 2.46 | 1.09 | 0.69 | 1.43 | 5.67 | 20.04 | 19.3 | 48.11 | 46.93 | 1.18 |
| -4 | 2.49 | 2.17 | 1.19 | 1.70 | 7.55 | 15.87 | 19.4 | 53.43 | 56.31 | -2.88 |
| B-1 | 1.54 | 1.02 | 0.69 | 1.48 | 4.73 | 18.10 | 23.6 | 43.05 | 39.74 | 3.31 |
| -2 | 1.58 | 0.79 | 0.67 | 1.58 | 4.62 | 18.61 | 22.3 | 42.57 | 41.65 | 0.92 |
| -3 | 2.50 | 1.22 | 0.66 | 1.84 | 6.22 | 21.29 | 23.8 | 54.01 | 47.88 | 6.13 |
| -4 | 2.47 | 1.83 | 1.36 | 1.72 | 7.38 | 12.28 | 23.8 | 50.11 | 55.15 | -5.04 |
| C-1 | 0.91 | 0.82 | 0.63 | 1.22 | 3.58 | 14.28 | 19.4 | 32.01 | 37.45 | -5.44 |
| -2 | 1.16 | 0.85 | 0.59 | 1.12 | 3.72 | 14.78 | 19.9 | 33.35 | 39.62 | -6.27 |
| -3 | 1.27 | 1.02 | 0.77 | 1.54 | 4.60 | 18.55 | 19.8 | 41.48 | 45.35 | -3.87 |
| -4 | 1.99 | 1.90 | 1.47 | 1.46 | 6.82 | 14.57 | 19.3 | 48.47 | 55.15 | -6.68 |
| **Average** | **1.86** | **1.27** | **0.87** | **1.52** | **5.51** | **17.42** | **21.0** | **45.34** | **45.87** | **-0.53** |

1) Varieties
A = Rayong 72
B = CMR 41-60-24
C = Rayong 5

Density
1 = 60 x 60 cm = 27,778 plants/ha
2 = 50 x 50 cm = 40,000 plants/ha
3 = 40 x 40 cm = 62,500 plants/ha
4 = 30 x 30 cm = 111,111 plants/ha

2) Prices:
cassava dry leaves: baht 5.0 /kg
cassava fresh roots: 1.2 /kg at 30% starch; 0.02 baht reduction per1% reduction in starch content

Table 13.9. Effect of plant spacing on the total dry leaf yield, fresh root yield and net in come obtained with three cassava varieties planted at TTDI Research and Development Center at Huay Bong,*Nakhon Ratchasima, Thailand in 2003/04.*

| Spacing | Total dry leaf yield (t/ha) | | | | Fresh root yield (t/ha) | | | | Net income ('000 B/ha) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rayong | CMR | Rayong | | Rayong | CMR | Rayong | | Rayong | CMR | Rayong | |
| (cm) | 72 | 41-60-24 | 5 | Av. | 72 | 14-60-24 | 5 | Av. | 72 | 41-60-24 | 5 | Av. |
| 60x60 | 5.52 | 4.73 | 3.58 | 4.61 | 23.40 | 18.10 | 14.28 | 18.59 | 8.47 | 3.31 | -5.44 | 2.11 |
| 50x50 | 5.76 | 4.62 | 3.72 | 4.70 | 17.22 | 18.61 | 14.78 | 16.87 | 3.77 | 0.92 | -6.27 | -0.53 |
| 40x40 | 5.67 | 6.22 | 4.60 | 5.50 | 20.04 | 21.29 | 18.55 | 19.96 | 1.18 | 6.13 | -3.87 | 1.15 |
| 30x30 | 7.55 | 7.38 | 6.82 | 7.25 | 15.87 | 12.28 | 14.57 | 14.24 | -2.88 | -5.04 | -6.68 | -4.87 |
| Average | 6.12 | 5.74 | 4.68 | 5.51 | 19.13 | 17.57 | 15.54 | 17.41 | 2.64 | 1.33 | -5.56 | -0.53 |

***Activity 13.5 Conducting FPR trials on varieties, fertilization, weed control, green manures, intercropping, erosion control and pig feeding in Thailand, Vietnam and China.***

The rationale, specific objectives and materials and methods were outlined in the 2003 Annual Report. Table 13.10 shows that in 2003/04, the last year of the Nippon Foundation-funded cassava project in Thailand, Vietnam and China, a total of 244 FPR trials were conducted in those three countries. During the 5-year period of the second phase of this project, a total of 1,154 FPR trials were conducted by farmers on their own fields in a total of 99 project sites (villages). Farmers were most interested in testing varieties, followed by chemical fertilizers, erosion control practices, intercropping (mainly in Vietnam) and green manures (mainly in Thailand). In Vietnam and China farmers also tested various feed rations with ensiled cassava roots and leaves in FPR pig feeding trials.

Table 13.10. 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** |

## Results

*FPR erosion control trials:*

In 2003/04 a total of 34 FPR erosion control trials were conducted on farmers' fields. Table 13.11 shows one example of a trial conducted by seven farmers with adjacent plots on a 40% slope in Kieu Tung village in north Vietnam. The same trial with only slight modification of treatments had been planted on the same plots for nine consecutive years. The planting of contour hedgerows of vetiver grass was consistently the best practice, reducing erosion from 87 to 37 t/ha and increasing cassava yields from 25 to 30 t/ha, resulting in the highest net income and benefit-cost ratio. However, in other trials, contour hedgerows of *Tephrosia candida* and *Paspalum atratum* were also very effective in reducing erosion and increasing cassava yields. These beneficial effects tended to increase over time, as these contour hedgerows contributed to the natural formation of terraces, mostly as a result of land preparation. Figures 2 and 3 clearly show how the planting of contour hedgerows became increasingly more effective over time in decreasing soil losses by erosion while also increasing cassava yields as compared to the check plot without hedgerows. Vetiver grass was usually more effective than *Tephrosia candida* in reducing erosion, while *Leucaena* was more effective in increasing yields, probably through the supply of N to cassava in the *Leucaena* prunings.

When the results of all erosion control experiments, demonstration plots and FPR trials were converted to relative cassava yields and relative soil losses (with the check plot without hedgerows taken as 100%) it was possible to compare the "average" effect of each soil conservation practice on erosion and yield. In Vietnam (Table 13.12), contour hedgerows of vetiver grass were on average most effective in reducing erosion, by 52 and 49%, as well as in increasing cassava yields by 13 and 15%, for cassava monoculture and intercropped with peanuts, respectively. Hedgerows of *Tephrosia candida* and *Paspalum atratum* also decreased erosion by about 50% while increasing cassava yields between 5 and 12%. Lack of fertilizer application not only decreased yields but also increased erosion by 37 to 102%. Closer spacing was the most effective practice to increase yields, but was not effective in reducing erosion. Similarly, in Thailand (Table 13.13), hedgerows of vetiver grass and *Paspalum atratum* were most effective in decreasing erosion by 42 and 47%, respectively, but both species also reduced cassava yields by about 10% through crop competition and by occupying some area of the production field. Contour ridging, closer plant spacing and lemon grass hedgerows were intermediately effective in reducing erosion, but were most effective in increasing yields. Lack of fertilizer application slightly decreased yields, but increased erosion by 140%, while up-and-down ridging increased erosion by 24%.

From all these experiments and FPR trials it can be concluded that fertilizer application and contour hedgerows of vetiver grass, *Tephrosia candida, Paspalum atratum* and lemon grass are the most effective erosion control practices, while closer plant spacing and contour ridging are intermediately effective in erosion control, but may be more effective in increasing cassava yields.

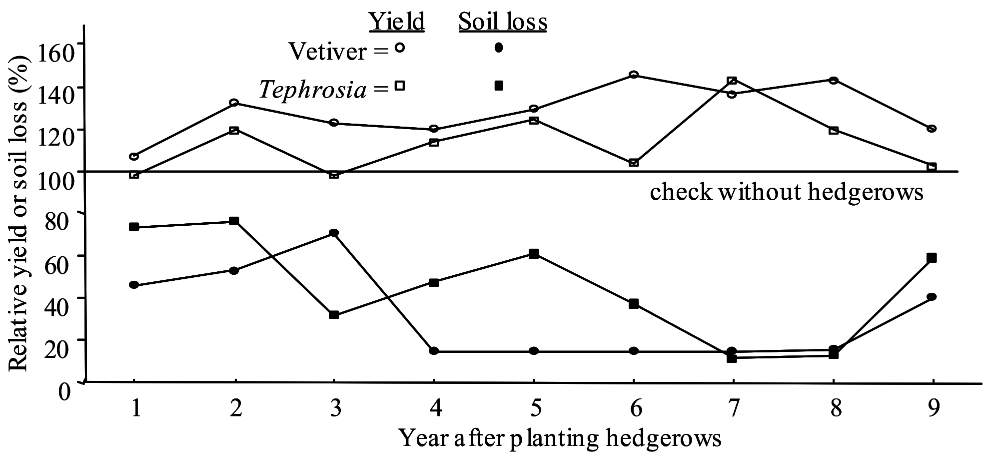


*Figure 2. Trend in relative yield and relative soil loss by erosion when cassava was planted with contour hedgerows of vetiver grass or Tephrosia candida during nine consecutive years of cassava cropping. Data are average values for one FPR erosion control trial in Kieu Tung and two trials in Dong Rang in North Vietnam from 1995 to 2003.*

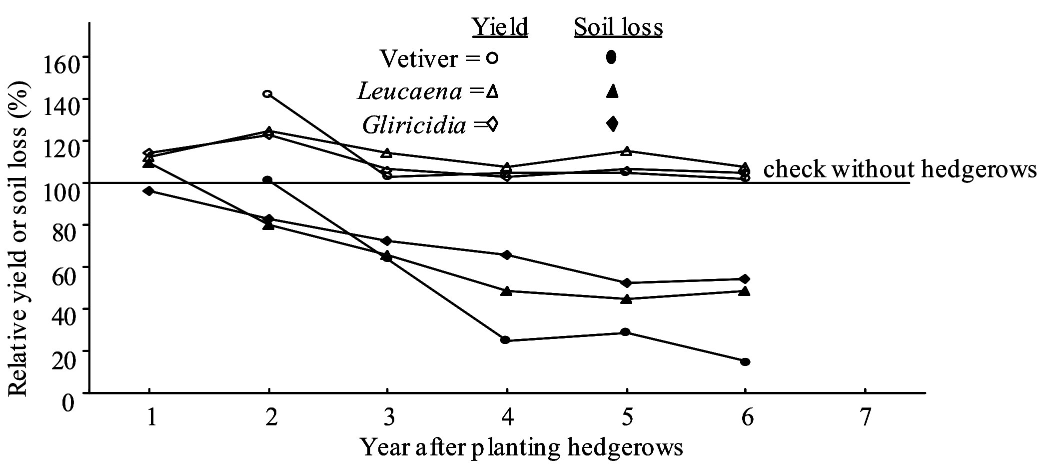


*Figure 3. Trend in relative yield and relative soil loss by erosion when cassava was planted with contour hedgerows of vetiver grass, Leucaena leucocephala or Gliricidia sepium in comparison with the check without hedgerows during six consecutive years in Hung Loc Agric. Research Center in South Vietnam from 1997 to 2003.*

*Intercropping:*

In 2003/04 FPR intercropping trials were conducted by 26 farmers, all in Vietnam. Table 13.14 shows an example of one such trial conducted by four farmers in Tran Phu commune of Ha Tay province in North Vietnam. All intercrops slightly reduced cassava yields but generally increased total gross income. Intercropping with two rows of peanut increased net income by 140% as compared to monoculture. This has become a common practice, especially in north Vietnam.

*Varietal evaluation:*

In 2003/04 varieties were evaluated by 80 farmers in China, Thailand and Vietnam. Table 13.15 shows the average results of three FPR variety trials conducted in Hong Tien commune in Tuyen Quang province. With adequate and well- balanced fertilization, the local variety La Tre (= SC 205) had a respectable yield of 21.4 t/ha, but was still outyielded by all other varieties or lines tested. The most popular improved variety, KM 94 (= KU 50) produced the highest yield of 32.8 t/ha.

Table 13.11. Results of an FPR erosion control trial conducted by seven farmers on about 40% slope in Kieu Tung village, Phuong Linh commune, Thanh Ba district, Phu Tho, Vietnam in 2003.

| Treatments | Dry soil loss (t/ha) | Yield: (t/ha) cassava | peanut | Gross income[2] (mil.VN dong/ha) | Product. costs[2] | Net income | B/C |
|---|---|---|---|---|---|---|---|
| 1. C; with fertilizers; no hedgerows (TP) | 87.5 | 25.2 | | 12.600 | 6.403 | 6.197 | 1.97 |
| 2. C+P; no fertilizers; no hedgerows | 66.5 | 21.5 | 0.48 | 13.630 | 7.290 | 6.340 | 1.87 |
| 3. C+P; with fertilizers; no hedgerows | 74.4 | 28.5 | 0.40 | 16.650 | 8.693 | 7.957 | 1.92 |
| 4. C; with fertilizers; *Tephrosia* hedgerows | 44.6 | 22.4 | | 11.200 | 6.453 | 4.747 | 1.74 |
| 5. C+P; with fertilizers; pineapple hedgerows | 41.1 | 19.5 | 0.38 | 12.030 | 8.743 | 3.287 | 1.38 |
| 6. C; with fertilizers; vetiver hedgerows | 36.8 | 30.2 | | 15.100 | 6.453 | 8.647 | 2.34 |
| 7. C; with fertilizers; *Tephrosia* hedgerows | 46.4 | 27.2 | | 13.600 | 6.453 | 7.147 | 2.11 |

[1] Fertilizers = 60 kg N+40 $P_2O_5$+120 $K_2O$/ha; all plots received 10 t/ha of pig manure

[2]Prices (VN dong):

Cassava: 500/kg fresh roots
Peanut: 6,000/kg dry pods
Urea (46% N): 3,200/kg
SSP (17%$P_2O_5$): 1,300/kg
KCl (60% $K_2O$): 3,000/kg
Cost of fertilizers: 1.323 mil. dong/ha
Peanut seed (84 kg/ha): 10,000/kg - 0.840 mil. dong /ha
Pig manure + application 200/kg: 2.000 mil. dong/ha
Labour: 10,000/manday
Labour for monoculture without fert. or manure (300 md/ha): 3.000mil. dong/ha
Labour for C+P without fert. or manure (445 md/ha): 4.450 mil. dong/ha
Labour for fertilizer application: 0.080 mil. dong/ha
Labour for hedgerow planting and maintenance: 0.050 mil. dong /ha

Table 13.12. 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.

| Soil conservation-practices[2)] | Rel. cassava yield (%) | | Rel. dry soil loss (%) | |
|---|---|---|---|---|
| | 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 (15) | 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

Table 13.13. 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

Table 13.14. Average results of four FPR intercropping trials conducted by farmers in Tran Phu Commune, Chuong My district, Ha Tay, Vietnam in 2003.

| Treatments | Cassava yield (t/ha) | Intercrop yield (t/ha) | Gross income[1)] | Seed costs[2)] | Product. costs[2)] | Net income |
|---|---|---|---|---|---|---|
| | | | ('000 d/ha) | | | |
| 1. Cassava monoculture | 24.54 | - | 9,816 | 0 | 5,460 | 4,356 |
| 2. C+1 row peanut | 21.93 | 1.187 | 14,707 | 480 | 8,115 | 6,592 |
| 3. C+2 rows peanut | 22.52 | 2.000 | 19,008 | 960 | 8,595 | 10,413 |
| 4. C+2 rows mungbean | 21.42 | 0 | 8,568 | 2000 | 9,635 | -1,067 |
| 5. C+2 rows soybean | 21.28 | 0.162 | 9,322 | 800 | 8,435 | 887 |

[1)]Prices:
cassava: dong 400/kg fresh roots
peanut: 5,000/kg dry pods
soybean 5,000/kg dry seed

[2)]Costs:
labor: dong 15,000/manday
NPK fertilizers: 0.86 mil. dong/ha
peanut seed (80 kg/ha): 12,000 /kg - 0.96 mil dong/ha for 2 rows
mungbean seed (80 kg/ha): 25,000 /kg - 2.00 mil dong/ha for 2 rows
soybean seed (80 kg/ha): 10,000 /kg - 0.80 mil dong/ha for 2 rows
labor for cassava monoculture without fertilizers - 4.5 mil. dong/ha (300 md/ha)
labor for cassava intercropping without fertilizers - 6.675 mil.dong/ha (445 md/ha)
labor for cassava fertilizer application - 0.10 mil. dong/ha

Table 13.15. Average results of three FPR variety trials conducted by farmers in Hong Tien commune, Son Duong district, Tuyen Quang, Vietnam in 2003.

| Treatments[1)] | Cassava yield (t/ha) | Gross income[2)] | Product. costs[2)] | Net income | Farmers' preference (%)[3)] |
|---|---|---|---|---|---|
| | | ('000 d/ha) | | | |
| 1. La Tre (local = SC 205) | 21.35 | 10,675 | 4,330 | 6,345 | 7 |
| 2. KM 94 | 32.80 | 16,400 | 4,330 | 12,070 | 100 |
| 3. KM 98-7 | 23.13 | 11,565 | 4,330 | 7,235 | 7 |
| 4. SM 26-6-3 | 26.93 | 13,465 | 4,330 | 9,135 | 27 |
| 5. SM 28-80-3 | 25.46 | 12,730 | 4,330 | 8,400 | 13 |
| 6. OMR 35-2-6 | 30.23 | 15115 | 4,330 | 10,785 | 44 |
| 7. CM 92-56-1 | 25.93 | 12,965 | 4,330 | 8,635 | 9 |
| 8. KM 21-10 | 31.86 | 15,930 | 4,330 | 11,600 | 93 |
| 9. KM 21-2 | 26.23 | 13,115 | 4,330 | 8,785 | 13 |

[1)]Fertilized with 1,100 kg/ha of 7:4:7 = 77 N: 44 $P_2O_5$ : 77 $K_2O$

[2)]Prices and costs: as above

[3)]Out of 45 farmers

***Activity 13.6 Enhancing adoption of new varieties and improved management practices through farmer participatory research (FPR) and extension (FPE) activities.***

The rationale, specific objectives and the FPE methodologies used have been described in detail in the 2003 Annual Report.

**Results**

Tables 16 and 17 show to what extent various types of technologies, such as new varieties, improved fertilization, intercropping and erosion control practices were adopted in seven communes in Son Duong district of Tuyen Quang province and in six communes of Pho Yen district in Thai Nguyen province in 2003/04. New varieties, i.e. KM 94 in Son Duong district and KM 98-7 and KM 95-3 in Pho Yen district, had been most widely adopted, followed by intercropping in Pho Yen (practically none in Son Duong), better fertilization and erosion control practices. Erosion control was not widely adopted in Pho Yen because most of the cassava fields there are either terraced or have only gentle slopes; in contrast, in Son Duong district erosion control is widely practiced on quite steep slopes of 20-40%. In 2003 cassava yields in these communes ranged from 28 to 34 t/ha, as compared to 6-8 t/ha before the project started in 1995 in Pho Yen and in 2000 in Son Duong.

Table 13.18 shows how the number of households adopting different types of new technologies increased during the last four years of the project in Vietnam as a result of the rapid expansion of the project to more and more sites. It is clear that most farmers chose to adopt mainly new varieties, followed by intercropping, balanced fertilization and erosion control practices. The adoption of soil conservation practices increased dramatically from 2002 to 2003 mainly because of the widespread adoption of contour hedgerows of *Tephrosia candida* and *Paspalum atratum* in Van Yen district of Yen Bai province of north Vietnam. In that district alone farmers planted in one year a total of 500 km of double-row contour hedgerows of *Tephrosia candida* and *Paspalum atratum* to control erosion. In contrast, farmers in Thailand planted in that year only about 20 km of contour hedgerows of vetiver grass to reach a total of 150 km of hedgerows in 2003/04. It is clear that hedgerow species that can be multiplied by seed, such as *Tephrosia candida* and *Paspalum atratum* can be adopted more easily and more cheaply than species like vetiver grass which requires vegetative propagation.

Table 13.16. Dissemination of erosion control practices and new cassava variety in seven communities in Son Duong district, Tuyen Quang, Vietnam in 2003.

| | Am Thang | Hong Tien | Cap Tien | Son Duong town | Tu Thinh | Phuc Ung | Tuan Lo | **Total** |
|---|---|---|---|---|---|---|---|---|
| **1. Erosion control** | | | | | | | | |
| - No. of households | 22 | 24 | 11 | - | - | - | - | **57** |
| - Area (ha) | 8.4 | 17.0 | 4.6 | - | - | - | - | **30.0** |
| - Cassava yield (t/ha) | 28.4 | 32.0 | 31.0 | - | - | - | - | **30.8** |
| **2. Variety KM 94** | | | | | | | | |
| - No. of households | 30 | 70 | 80 | 26 | 48 | 75 | 9 | **338** |
| - Area (ha) | 12.1 | 19.8 | 7.6 | 2.8 | 5.0 | 4.2 | 5.0 | **56.5** |
| - Cassava yield (t/ha) | 31.3 | 31.8 | 36.1 | 34.3 | 35.0 | 49.2 | 35.2 | **34.3** |

Table 13.17. Dissemination of various new cassava technologies in six communes in Pho Yen district, Thai Nguyen, Vietnam in 2003.

| | Tien Phong | Dac Son | Minh Duc | Van Phai | Hong Tien | Nam Tien | **Total** |
|---|---|---|---|---|---|---|---|
| **1. Erosion control** | | | | | | | |
| - No. of households | 5 | 3 | - | - | 4 | - | **12** |
| - Area (ha) | 0.6 | 0.4 | - | - | 0.7 | - | **1.7** |
| - Cassava yield (t/ha) | 27.0 | 26.0 | - | - | 29.0 | - | **27.6** |
| **2. Varieties** | | | | | | | |
| ***- KM 95-3*** - No. of hh. | 75 | 28 | 36 | 38 | 57 | 16 | **250** |
| - Area (ha) | 5.0 | 3.2 | 1.5 | 1.8 | 3.5 | 1.5 | **16.5** |
| - Yield (t/ha) | 34.0 | 30.4 | 32.5 | 29.0 | 29.8 | 31.0 | **31.4** |
| ***- KM 98-7*** - No. of hh. | 150 | 24 | 45 | 30 | 60 | 22 | **331** |
| - Area (ha) | 12.0 | 5.8 | 3.0 | 4.0 | 8.0 | 2.0 | **34.8** |
| - Yield (t/ha) | 38.0 | 32.0 | 35.0 | 31.0 | 32.5 | 33.2 | **34.4** |
| **3. Fertilization** | | | | | | | |
| - No of households | 54 | 17 | 10 | - | - | - | **81** |
| - Area (ha) | 3.4 | 2.0 | 1.5 | - | - | - | **6.9** |
| - Cassava yield (t/ha) | 33.6 | 32.0 | 31.5 | - | - | - | **32.7** |
| **4. Intercropping** | | | | | | | |
| - No. of households | 120 | 12 | 30 | - | - | - | **162** |
| - Area (ha) | 11.0 | 1.2 | 4.0 | - | - | - | **16.2** |
| - Cassava yield (t/ha) | 36.0 | 30.8 | 29.0 | - | - | - | **33.9** |

Table 13.18. Trend of adoption of new cassava technologies in the Nippon Foundation project sites in Vietnam from 2000 to 2003.

| Technology component | Number of households adopting | | | |
|---|---|---|---|---|
| | 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, 2003.

### *Activity 13.7 Assessing the impact of the project on adoption of new technologies in Thailand and Vietnam*

The Nippon Foundation Project has tested and disseminated new cassava technologies in Thailand, Vietnam and China for ten years using farmer participatory approaches; at the end of the second phase it was decided to assess the impact of the project, and especially the FPR and FPE methodologies used, on the adoption of new technologies and on the institutionalization of the participatory approach.

**Materials and Methods**

The impact assessment was done by an outside consultant in consultation with CIAT and PRGA staff and in collaboration with national scientists in Thailand and Vietnam. For this assessment, both "participating" and "non-participating" farmers in four "project" and four "non-project" sites in each country were asked to fill in census forms for themselves and for 2-3 neighbors; this was followed by focus group discussions. The eight project sites were selected as being representative of all project sites, while the non-project sites were nearby villages (within 10 km of project sites) where the project had not been active. "Participating farmers" were defined as those that had either conducted FPR trials and/or had participated in FPR training courses, while "non-participating farmers" had not conducted trials or participated in training courses, but might have participated in field days organized by the project.

**Results**

Table 13.19 shows the extent of adoption (% of households) of various types of new technologies by both "participating" and "non-participating" farmers in Thailand and Vietnam. New varieties were widely adopted by both participating and non-participating farmers; this reached close to 100% of farmers in Thailand and 46% in Vietnam. This confirms results of recent surveys which indicate that about 99% of the cassava area in Thailand and about 40-50% in Vietnam are now planted with new high-yielding varieties. There was not a significant difference in the adoption of new varieties between participating and non-participating farmers. This may lead to the conclusion that new varieties were disseminated and were adopted independently of the NF project; or that the FPE approach was so effective that also non-participating farmers heard about new varieties and obtained planting material for adoption. The truth probably lies in between as new varieties certainly spread also to areas where the project was not operating, through conventional extension channels; but also, many non-participating farmers had heard about and obtained planting material through participation in field days or from other farmers or district extension staff who had heard of or had participated in the project's various FPR activities.

Table 13.19 shows that improved fertilization was also widely adopted by both participating and non-participating farmers, reaching about 88% in Thailand and 80% in Vietnam. The use of farm-yard manure (FYM) was rather widespread in Vietnam (59%), while planting green manures or applying FYM was less widespread in Thailand (34%). In Thailand there was significantly more adoption of these practices among participating farmers, while in Vietnam project participation was not a significant factor as farmers traditionally apply FYM and/or some chemical fertilizers to cassava. It is likely, however, that participating farmers were applying both more fertilizers and better balanced fertilizers than the non-participating farmers as they had seen the importance of applying high rates of K and N to obtain high yields; however, this could not be ascertained from the information obtained from the census forms.

Intercropping, especially with peanut, was rather widely adopted in Vietnam (35%), but not in Thailand; there was a significant difference between participating and non participating farmers only with respect to intercropping with peanut and intercropping in general, indicating that adoption of intercropping was at least partially due to project activities.

Soil conservation practices, such as contour ridging and contour hedgerows were significantly more adopted by participating than by non-participating farmers, indicating that the conducting of FPR erosion control trials and participation in FPR training courses made farmers aware of the need for erosion control and significantly enhanced the adoption of soil conservation practices. Adoption of either contour ridging or hedgerows was about 43% in Thailand and 52% in Vietnam; in Thailand this was mainly the planting of vetiver grass hedgerows (61% among participating and only 10% among non-participating farmers), while in Vietnam this was mainly contour ridging or hedgerows of *Tephrosia candida*. It may be concluded that adoption of soil conservation practices was not as widespread as that of new varieties or improved fertilization, but that the FPR approach used in the project was highly effective in enhancing adoption among project participants.

Table 13.19 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.

| Technologies adopted | Participants | | | Non-Participants | | Total | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 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
Percentages may total more than 100 percent as households can adopt more than one type of technology simultaneously

Figure 13.4 shows the average effect of the project on cassava yields of participating and non-participating farmers in Thailand and Vietnam as well as the average yield for the whole country over the 5-year period (1999-2003) corresponding to the 2nd phase of the project. In both Thailand and Vietnam, cassava yields of participating farmers increased significantly more than of non-participating farmers, while the yield of non-participants increased at a similar rate as that for the country as a whole, even though the latter yields were considerably lower than those indicated by farmers participating in the focus group discussions. These large differences may be due to inaccuracies in the determination of cassava yields on a national scale (published by both the national governments and FAO), or due to a tendency of farmers to overestimate or overstate their own yields. In any case, there is no doubt that in both countries cassava yields increased substantially over the course of the project, both as a direct result of the project and through the interventions of other projects and institutions.

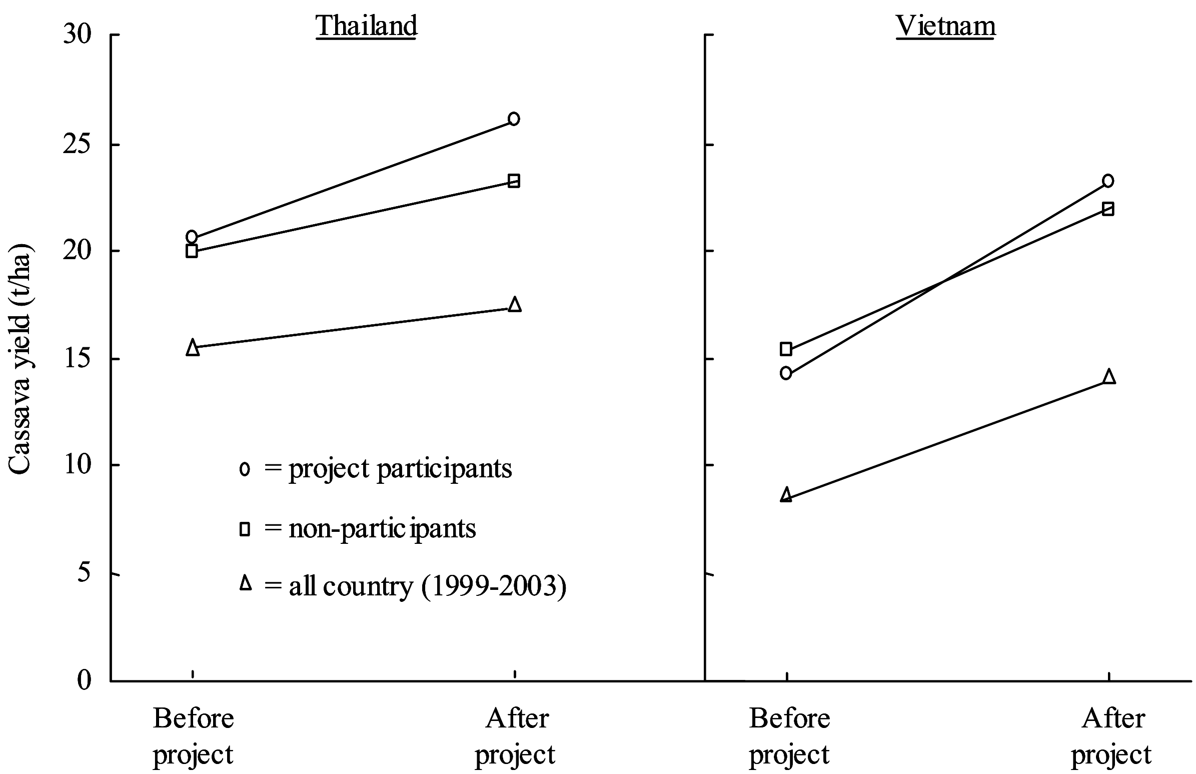


*Figure 4. Average cassava yields of farmers participating in the Nippon Foundation cassava project or of nearby but non-participating farmers, before the project started and at the end of the project. Data are from PRRA census forms collected from 439 households in Thailand and 393 household in Vietnam For comparison the national average cassava yields in 1999 (before) and 2003 (after) are also shown*

In Table 13.20 the annual increase in gross income due to these higher cassava yields are estimated using cassava area and yield data for 1994 and 2003 as published by FAO for China, Thailand and Vietnam. In China yields increased only 1.04 t/ha over this 10-year period resulting in an annual increase in gross income of 6.7 million US dollars; in Thailand yields increased 3.74 t/ha over an area of slightly more than 1 million hectares, resulting in an increase in gross income of 86.4 million dollars, and in Vietnam yields increased a remarkable 5.63 t/ha resulting in about 52.3 million dollars per year extra income for cassava farmers. Finally, for the whole of Asia, yields increased 3.17 t/ha resulting in an annual additional income of nearly 272 million US dollars for cassava farmers in Asia. This was achieved through the active and effective collaboration between CIAT and scientists and extension workers in many national programs in Asia.

Table 13.20. Estimated increase in gross income of cassava farmers in China, Thailand, Vietnam and in a total of 12 countries 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 | 240,108 | 15.21 | 16.25 | 1.04 | 27 | 6.7 |
| Thailand | 1,050,000 | 13.81 | 17.55 | 3.74 | 22 | 86.4 [2] |
| Vietnam | 371,700 | 8.44 | 14.07 | 5.63 | 25 | 52.3 |
| Asia total | 3,430,688 | 12.95 | 16.12 | 3.17 | 25 | 271.9 |

[1] Data from FAOSTAT for 2003
[2] In addition, farmers also benefited from higher prices due to higher starch content

***Activity 13.8 Exploring institutional arrangements for collaboration in the new Nippon Foundation-funded cassava project in Laos and Cambodia, and the ACIAR-funded cassava project in Indonesia and East Timor.***

**Rationale**

The CIAT Cassava Office in Asia, located in Bangkok, Thailand, works in close collaboration with researchers and extensionists in national institutions where the various projects are being implemented. Thus, with the start of two new projects in 2004 to be implemented in four countries, it was necessary to explore the most suitable institutional arrangements for this collaboration.

**Specific Objectives**
*To discuss with administrators of various national research and development institutions the objectives and proposed activities of the new cassava projects and to request their collaboration in the execution of the projects.*

**Results**
For the new Nippon Foundation-funded cassava project, collaborative arrangements were explored with national institutions in Lao PDR and Cambodia. In Lao PDR meetings were arranged with Dr. Ty Phommasack, Vice Minister of Agric. and Foresty, and with Dr. Bounthong Bouahom, Acting Director General of NAFRI, to explain the project and to request permission and collaboration for implementing the project. The project will be implemented mainly through NAFRI at the national level, and with assistance from the Provincial and District Agric. and Forestry Offices (PAFO and DAFO) of those Provinces and Districts where the project will be actively involved.

In Cambodia meetings were arranged with Dr. Men Sarom, Director of the Cambodia Agric. Research and Development Institute (CARDI) and his staff; with Dr. Kieu Borin, Director of the Center for Livestock and Agric. Development (CelAgrid), and with Mr. Eun Jun Choi, Managing Director of CJ Cambodia Co., Ltd., a Korean company with a 2000 ha cassava plantation with starch factory in Kampong Speu. It was agreed that most agronomic research and on-farm testing would be done in collaboration with the Agronomy and Farming Systems Department of CARDI, while some animal feeding trials and training might be conducted through CelAgrid. Some agronomic trials may also be conducted by the CJ Cambodia Co. at their own plantation and at their own expense; they in turn can provide the project with planting material of a few promising varieties.

For the new ACIAR-funded project, collaborative arrangements were explored with Brawijaya University (UNIBRAW), with the Research Institute for Legumes and Tuber Crops (RILET) and with the Assessment Institute for Agricultural Technologies (BPTP), all in Malang, East Java; as well as with the Central Research Institute for Food Crops and the Soil Research Institute, both in Bogor, West Java. It was agreed that Dr. Bambang Guritno, Rector of Brawijaya University, would be the project leader in Indonesia, while Dr. Wani Hadi Utomo, soil scientist at UNIBRAW, would be the project coordinator, to coordinate all activities among the various participating institutions in Indonesia.

In East Timor a meeting was arranged with Mr. Francisco Benevides, Vice Minister of Agriculture, Forestry and Fisheries (MAFF), and Mr. Lourenco Fontes, Director of the

Research and Extension Center of MAFF, to explain the project and request their permission and collaboration. It was agreed that the project would be implemented in ET under the leadership of Mr. Lourenco Fontes and with collaboration of personnel from the Research and Extension Center. In addition, Mr. Acacio da Costa Guterres, Head of the Dept. of Agronomy of the National Univ. of East Timor, will coordinate some specific cassava projects to be done with students.

***Activity 13.9 Implementing the new Nippon Foundation-funded Cassava Project in Lao PDR and Cambodia***

**Rationale**

In both Lao PDR and Cambodia cassava is mainly used for human consumption in times of food scarcity, usually during the months before the rice harvest, i.e. in Sept-Dec. Very little is presently used for on-farm animal feeding. In Cambodia, some cassava is also used for starch production, mainly by very small starch processors in Kampong Cham province and by 2-3 bigger factories in Kampong Cham and Kampong Speu provinces. In Lao PDR the few local cassava varieties tend to be eating varieties, very tall but with low root yields. In Cambodia there are 2-3 eating varieties, which are often harvested before six months for sale in the local market, as well as one high-yield and high-starch variety, called KM 94, introduced recently from Vietnam and suitable for starch extraction. Both countries could benefit from the introduction, multiplication and widespread adoption of higher yielding varieties, which could be used for on-farm animal feeding as well as for sale to starch factories, the latter mainly in Cambodia

**Specific Objectives**

1. *To introduce and evaluate promising Thai and Vietnamese varieties into Lao PDR and Cambodia*
2. *To determine the fertilizer requirements of new high-yielding cassava varieties in different soil types in Lao PDR and Cambodia*

**Materials and Methods**

Planting material of eight promising cassava varieties, both for eating and processing, were introduced from Thailand into Lao PDR and Cambodia, while a small amount of stakes of three eating varieties from Vietnam were introduced into Lao PDR. These varieties were evaluated and multiplied both in replicated experiments in experiment stations and in on-farm trials in 18 villages in various districts in Luang Prabang, Oudomxay and Xieng Khouang provinces (Table 13.21). In the latter two provinces the trials were planted by

CIAT's PRDU project in collaboration with personnel from the local PAFO and DAFO; the trials were managed by a group of farmers from each village. The varieties were planted in main plots with three fertilizer treatments, i.e. without fertilizers or manure, with only manure, and with manure and P. In Luang Prabang province the trials were planted by personnel from NAFRI as well as with local DAFO extension workers in each district.

Table 13.21. On-farm cassava trials on Laos in 2004/05.

| Village | District | Prov. 2) | Coordinates N | Coordinates E | Elevation (masl) | Ethnic group1) | Date planted | No. Var. |
|---|---|---|---|---|---|---|---|---|
| 1. Kone Lang | Pak Baeng | O | 20°04'19" | 101°10'33" | 770 | Khamu | 06-06-04 | 8 |
| 2. Mok Loi | Pak Baeng | O | 20°05'07" | 101°11'13" | 788 | Khamu | 08-06-04 | 8 |
| 3. Phou Lath | Houn | O | 20°17'10" | 101°20'36" | 640 | Khamu | 08-06-04 | 8 |
| 4. Kone Thoey | Houn | O | 20°16'27" | 101°21'00" | 1046 | Khamu | 09-06-04 | 8 |
| | | | | | | | | |
| 5. Song Hak | Phou Kout | XK | 19°37'32" | 103°05'50" | 1057 | Phouan | 16-06-04 | 8 |
| 6. Khoeng | Phou Kout | XK | | | | Phouan | 17-06-04 | 6 |
| 7. Sombone | Phou Kout | XK | | | | Phouan | 17-06-04 | 8 |
| 8. Pong | Phou Kout | XK | 19°40'08" | 103°08'43" | 1127 | Phouan | 15-06-04 | 8 |
| 9. Man | Phou Kout | XK | 19°30'32" | 103°08'08" | 1119 | Phouan | 15-06-04 | 8 |
| 10. Vieng | Phou Kout | XK | | | | Phouan | 16-06-04 | 8 |
| 11. Xieng Nuea | Phaxay | XK | 19°17'44" | 103°04'35" | 1134 | Phouan | 21-06-04 | 6 |
| 12. Xoua | Phaxay | XK | | | | Phouan | 21-06-04 | 5 |
| 13. Namka | Phaxay | XK | | | | Hmong | | |
| | | | | | | | | |
| 14. Pak Wed | X. Nguen | LP | 19°46'49" | 102°10'39" | 331 | Lao Loum | 24-05-04 | 8 |
| | | | | | | | 07-06-04 | 3 |
| 15. Pik Noi | L. Prabang | LP | | | | Lao Loum | | 2-3 |
| 16. Haat Xua | Pak Ou | LP | | | | Leu | | 2 |
| 17. Haat Pang | Pak Ou | LP | | | | Leu | | 4 |
| 18. Som Sanuk | Pak Ou | LP | 20°04'54" | 102°15'06" | 318 | Leu | | 3-4 |

1) Khamu are classified within the Lao Thoung (mid-altitude Lao)
Phouan and Leu are ethnic groups within the Lao Loum (lowland Lao)

3) O= Oudomxay; XK= Xieng Khouang; LP= Luang Prabang

**Results**

In Oct 2004, when plants were about 3-4 month old, plant growth was quite vigorous in Luang Prabang and Oudomxay provinces, but was slow in Xieng Khouang province, probably because of the lower temperature at higher elevation (1000-1100 masl) and the extremely acid and low-P soils. In most trials in Xieng Khouang, cassava plants showed a clear visual response to application of manure and especially to manure + P. In general, the local varieties were tall but with symptoms of N deficiency; of the introduced varieties, Kasetsart 50 and Rayong 72 were the most vigorous.

**Collaborators:**

Within CIAT:

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