A Benchmark Study on

Cassava Production, Processing and Marketing in Vietnam

Proceedings of a Workshop held in Hanoi, Vietnam
Oct 29-31, 1992.

MAFI - CIAT

A Benchmark Study on

Cassava Production, Processing and Marketing in Vietnam

Proceedings of a Workshop held in Hanoi, Vietnam. Oct 29-31, 1992, to present and discuss the results of a nation-wide survey conducted in 1991-1992.

Technical Editor : R.H. Howeler

Organized by the Centro Internacional de Agricultura Tropical (CIAT) in close collaboration with various Universities and Research Institutes in Vietnam

With financial support from the Government of Japan

Cover photo:
K. Kawano
Arrival of cassava and canna to be processed
into starch in Duong Lieu village near Hanoi

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March, 1996
Print Order: 200 Copies

Reference: *Centro Internacional de Agricultura Tropical (CIAT). 1996*
A Benchmark Study on Cassava Production, Processing and Marketing
in Vietnam. Proceedings of a Workshop held in Hanoi, Vietnam,
Oct 29-31, 1992. R.H. Howeler (Ed.). Bangkok, Thailand.

I. Cassava Vietnam - Production - Processing - Marketing - Workshop
II. Howeler, R.H.
III. Centro Internacional de Agricultura Tropical

PREFACE

The Centro Internacional de Agricultura Tropical (CIAT), located in Cali, Colombia, has within the CGIAR system the world mandate for research on cassava production and utilization, while the International Institute for Tropical Agriculture (IITA), located in Nigeria, has responsibility for cassava research in Africa. In order to facilitate communication with national cassava research programs in Asia, CIAT established a Regional Cassava Office in Bangkok, Thailand, in 1983. Through this Regional Office for Asia, a netword of cassava researchers in national research institutes and universities has been established with the objective of enhancing communication between researchers, either within or among the various cassava producing countries, in order to increase the efficiency of the research with the goal of improving the livelihood of cassava producers, processors and consumers in Asia.

Collaboration between CIAT and Vietnam was initiated during a first trip to Ho Chi Minh city in September 1988, followed by a visit to the Department of International Cooperation of the Ministry of Agriculture and Food Industry (MAFI) in Hanoi in May of 1989. A Memorandum of Understanding between CIAT and MAFI was signed during that year. Intensive collaborative research on varietal improvement and agronomic practices followed, first centered at Hung Loc Research Center of the Institute for Agricultural Sciences (IAS) of South Vietnam and at Agricultural College #3 (AC#3) in Bac Thai, North Vietnam; but this was later expanded to include other institutes and universities.

Impressed by the results of a survey on sweet potato production, organized by the International Potato Center (CIP) in close collaboration with CGPRT Center and various Vietnamese universities and research institutes, the Department of International Cooperation of MAFI requested CIAT in October 1989 to organize a similar national survey on cassava. Subsequently, the CIAT Cassava Program in Colombia agreed with this request and allocated funds, supplied by the Japanese government, to conduct the surveys, and to organize a final Workshop to present and discuss the data obtained. In February of 1990, initial steps were taken to organize the surveys, starting with the identification of appropriate collaborating institutions. Overall coordination of the surveys was assigned to the Potato Research Center (PRC) of the National Institute of Agricultural Science (INSA) in Hanoi. IAS coordinated the surveys in South Vietnam in collaboration with the University of Agriculture and Forestry (AU#4), while in North Vietnam PRC conducted the surveys in collaboration with AC#3 and the Institute for

Food Crops in Hai Hung.

After discussing the methodologies and the sampling framework to be used in the cassava production survey, the most appropriate provinces and districts to be sampled were identified. Most of the production survey in South Vietnam was conducted during June-Aug of 1990. In Oct 1990 a two-day preliminary workshop was held in Ho Chi Minh city to present the results so far obtained in South Vietnam and to organize the surveys to be conducted in North Vietnam. The latter were finalized early in 1991, after which all the data were encoded and sent for compilation and analysis to AU#4 in Ho Chi Minh city. Processing and marketing surveys were also conducted in South Vietnam in 1991 and in North Vietnam in 1992. A Workshop to present and discuss the final results of these studies was held in Hanoi in November 1992.

This Proceedings includes the papers presented and the final conclusions reached during this Workshop. An additional paper analyzing the cassava starch market in Vietnam, presented by Dang Thanh Ha at the International Cassava Starch Symposium in Colombia in January 1994, was included to complement the data previously presented at the Vietnam Cassava Workshop. Three papers presented at the Workshop by CIAT scientists are included as an Appendix. Since several errors or inconsistencies in the data were identified during the Workshop, some of the data needed to be checked and corrected. This resulted in some delay in the printing of the publication.

CIAT would like to take this opportunity to thank the organizers of the survey and the workshop, in particular Prof. Vu Tuyen Hoang, Deputy Minister of Agriculture, and Mr. Nguyen Ich Chuong, Deputy Director, Department of International Cooperation of MAFI, for taking the initiative and for their enthusiastic support during the survey. Also, we want to express our thanks to the many researchers and extension agents that were directly involved in conducting the interviews. We hope that these surveys will contribute to a better understanding of the constraints and opportunities that exist in the cassava sector in Vietnam, will help re-orient the cassava research agenda to make it more effective and more responsive to actual needs, and last but not least, will lead to a greater and more effective collaboration between the various Vietnamese institutes involved in cassava research and extension, as well as their collaboration with CIAT.

R.H. Howeler
CIAT, Bangkok
November 1995

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INAUGURAL ADDRESS

Prof. Dr. Acad. Vu Tuyen Hoang

Vice Minister, Ministry of Agriculture and Food Industry

Distinguished guests, scientists and participants,

I would like to sincerely thank you all for your presence at this Workshop, which is focused on cassava in Vietnam. Your participation implies your recognition of the importance of cassava in our agricultural production.

Ladies and gentlemen,

As you know, Vietnamese agriculture in recent years has made a lot of efforts to solve food production problems. Due to this, many positive results have been obtained in this field: in the past, Vietnam used to be a food deficit country, but nowadays Vietnam has produced not only enough food for its domestic demand but also for export.

Although the quantity of exported food is not large, it is really a great success for our country. In 1990, food production per capita was 324.4 kg, which has increased 1.18 times compared to 1976. This confirms that the Vietnamese government has made the right policies towards agriculture in general, and food production in particular. Apart from rice production, our emphasis has been put on the development of maize, sweet potato and cassava, in which cassava is considered a very important crop for the development of rain-fed agriculture in low input areas, such as the Mountainous Regions and Midlands, the Central Coast and the Southeast, which will contribute a great deal in attaining the nutritional target in our national food security strategy.

Due to the importance of root and tuber crops in agricultural production in Vietnam, the Ministry of Agriculture and Food Industry established a Root and Tuber Research Program, with the aim to assemble scientists and extension staff to work in cooperation in order to solve problems concerning varieties, soil erosion, processing and marketing of these root and tuber crops.

Over the past years, international scientific organizations such as CIAT, CIP, and IDRC have helped Vietnam a lot to carry out research in this area. Actually, a number of promising varieties of cassava from CIAT have been grown in trials in the South, the North and the Center of Vietnam; in addition to this, various planting methods of cassava have also been experimented with in our country.

Today, CIAT helps us organize "The Vietnam Cassava Workshop" with the participation of a great number of international and national scientists and economists. It is indeed the greatest workshop on cassava we have had so far here, and has the objective of identifying cassava production constraints in Vietnam. Based on recommendations made by participants of this workshop, we will define a strategy on cassava research development, as well as on processing and marketing of cassava production in Vietnam. We are certain that the workshop will be as successful as expected, and we are confident that with your assistance we will receive a lot of cooperation and help from different international and national scientific and socio-economic organizations after the workshop.

Ladies and gentlemen,

At this solemn inaugural ceremony, on behalf of the Ministry of Agriculture and Food Industry, I should like to sincerely thank CIAT, the International Center for Tropical Agriculture, and especially the organizing committee of this workshop for their help.

I wish the workshop will be successful.

Once again, thank you for your attention.

OPENING REMARKS TO THE VIETNAM CASSAVA WORKSHOP

Rupert Best

Leader CIAT Cassava Program

It is an honor and a great privilege for me to have been invited to speak at this, the inauguration of the Vietnam Cassava Research Workshop. I do so in the name of my colleagues from CIAT, Dr. Kazuo Kawano, Cassava Regional Coordinator for Asia, Dr. Reinhardt Howeler, and Dr. Guy Henry. Many of you present here will alread know my colleagues from their numerous visits to Vietnam. For me, this is my first visit, which makes it doubly pleasurable as I have the opportunity of meeting many new people and becoming better acquainted with your fascinating and dynamic country.

The International Center for Tropical Agriculture, or CIAT as we call it because of its acronym in Spanish, is part of a network of international agricultural research centers located in different parts of the world. Many of you will have come into contact with some of our 18 sister centers, such as IRRI, the International Rice Research Institute; CIMMYT, the International Center for Maize and Wheat Improvement; and of course CIP, the International Potato Center. I am very pleased that two regional scientists from CIP have been able to join us for this workshop, as together with our Vietnamese colleagues there are many areas of mutual interest that we will be discussing over the next few days that bear on roots and tubers as a whole.

CIAT with its headquarters in Colombia, South America, works on four commodities: cassava, *Phaseolus* beans, tropical forages and rice, and has recently initiated an ambitious program in natural resource management research for Latin American ecosystems.

Although it is now over 20 years since the CIAT Cassava Program was established, it is only since 1987 that we initiated contacts with cassava researchers in Vietnam. It is not my intention to go into the details of our Program nor to the extent of our cooperation here in Vietnam, as these will be the topics of special presentations on Saturday. It is sufficient to say at this point, that our goal is to work together with national programs to improve the well-being of millions of small-scale farmers, who, throughout the world, depend on cassava for their livelihood.

Cassava is among a handful of crops that is uniquely placed to play an important role in raising the incomes of the rural population that live in the more harsh environments in terms of soil and climatic conditions. In Asia, these environments are typically upland situations, which have been at the margin of the advances made through the so-called green revolution.

Through research on cassava production, processing and utilization - and research on other crops well-adapted to these difficult upland conditions - we are seeking to contribute to a second technological leap forward that will bring these sectors more fully into the mainstream of the national economy and will help to alleviate the hardship and poverty that exist in many of these regions.

Worldwide, cassava is the fourth most important source of calories in the diet of the people living in tropical countries, following rice, maize and sugarcane. The crop originated in South America, but is now grown throughout the tropical world, principally by small-scale farmers. The main attributes that have made cassava so popular among small farmers are:

- its high production of carbohydrates per unit of land and labor
- its tolerance to drought and ability to recuperate from pest and disease attack
- its indeterminate harvest period which makes it particularly suitable as a famine reserve. Where cassava is grown in Africa you never hear of starvation
- a particularly important characteristic is cassava's suitability for intercropping with cereal and legume crops, which provides the small farmer an insurance against the risk of total crop failure.

World production of cassava in 1991 was 160 million tons with an annual rate of growth in production of 2.3%. Thirty five percent of this total, or nearly 60 million tons, is produced in Asia. Over the past 20 years, growth rates in Asia have exceeded those in both Latin America and Africa. This dynamic situation is due largely to a rapid process of market diversification. Initially, cassava was introduced to Asia and grown as a food crop for direct human consumption. However, now a significant proportion of production is destined as a raw material for the production of dry cassava for animal feed and starch as well as many starch-derived products. With Asia experiencing a rapid process of urbanization, the domestic demand, both for feed concentrates and for starch-derived products in a number of manufacturing industries, especially the food industry, is likely to grow. Thailand and Indonesia over the past 15 years have also demonstrated the opportunities that exist for exporting cassava products. There is evident potential, therefore, for developing cassava and linking this development to the improvement of the welfare of the rural population. The challenge lies in providing agriculturally sustainable technologies that will maintain cassava's competitivity in terms of price and quality with respect to other carbohydrate sources.

In the achievement of this ambitious goal, CIAT, together with its national program partners, are just a part of what might be called a Global Cassava Research and Development System. This Global System must obviously include other institutions of an international or regional nature, and, of course, the donor agencies without whose support much of the work we do would not be possible. It is therefore very appropriate that at this meeting we have the good fortune to have participating a number of these institutions such as AIT (Asian Institute of Technology), SEARCA and IDRC. We are grateful for their interest and look forward to their active participation into our deliberations.

Finally, what of the purpose of this meeting? Technology generation and the transfer and adoption for any commodity must be a dynamic process, that should be subject to continuing evaluation of achievements and a reassessment of priorities. This process has to take place both at the national and international level. CIAT, for instance, could not function without the invaluable feedback it obtains from its national program partners in order to make adjustments in its research strategies. The socio-economic studies that have just been completed here in Vietnam and whose results we will be analyzing and discussing during this meeting are the key to this evaluation and to a possible reorientation of research and development activities. For CIAT's Cassava Program, it has been immensely constructive to have been involved so intimately with our Vietnamese colleagues in this survey. We greatly admire the dedication and hard work that has gone into collecting and analyzing the data. Obviously, there is still much to be done, but we have made a fine start which augers well for the outcome of this meeting. We at CIAT are committed to supporting our Vietnamese colleagues for the challenges that lie ahead. Thank you.

CASSAVA IN VIETNAM: AN OVERVIEW

Nguyen Van Thang[1]

INTRODUCTION

Vietnam is a humid tropical, long and narrow country, located between the latitudes of 8.5° and 23.5°N and longitudes 102 and 110°E. The narrowest part is only 40 km wide. Toward the east lies the sea and towards the west the Truong Son mountain range. The terrain is highly varied and tends to slope down towards the sea. This results in marked differences in soils and climatic conditions between regions. Because of this topographic and climatic heterogenuity the country has been divided into seven more or less homogeneous agro-ecological zones (**Figure 1**), ie. the North Mountainous Region (which includes the Northern Highlands and Midlands), the Red River Delta, the North Central Coast, the South Central Coast, the Central Highlands, the Southeastern Region and the Mekong Delta.

The soils of Vietnam are closely associated with its topography. The mountainous and hilly areas of the northern and central part of the country are mainly Ultisols with some Oxisols in the more tropical regions of the South (**Figure 2**). Large areas of Inceptisols are found mainly in the Mekong and Red River deltas as well as along smaller rivers and near the coast. The more recently developed Entisols are found mainly along river banks and along the coast. By overlying the cassava production map (**Figure 1**) on the soils map (**Figure 2**) it is possible to estimate the area of the various soil orders on which cassava is grown. Thus, it was estimated that in Vietnam about 66% of cassava is grown on Ultisols, 17% on Inceptisols, 7% on Oxisols, 4% on Alfisols, 3% on Entisols and 2% on Vertisols (Howeler, 1992). The soil pH generally varies from 4.5 to 6.0.

The climate also varies substantially between regions (**Table 1** and **Figures 3, 4, 5**). The northern part of the country has a subtropical climate with low winter (15°C) and high summer (29°C) temperatures. Most rain falls during the summer months of May to September (**Figure 3**), but during the winter months of Jan-March there are many rainy days with almost constant drizzle, resulting in a low number of sunshine hours (**Table 1**). In the South, however, the climate is tropical with relatively small

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[1] *Plant Production and Protection Dept., Ministry of Agric. and Food Industry (MAFI), Hanoi, Vietnam.*

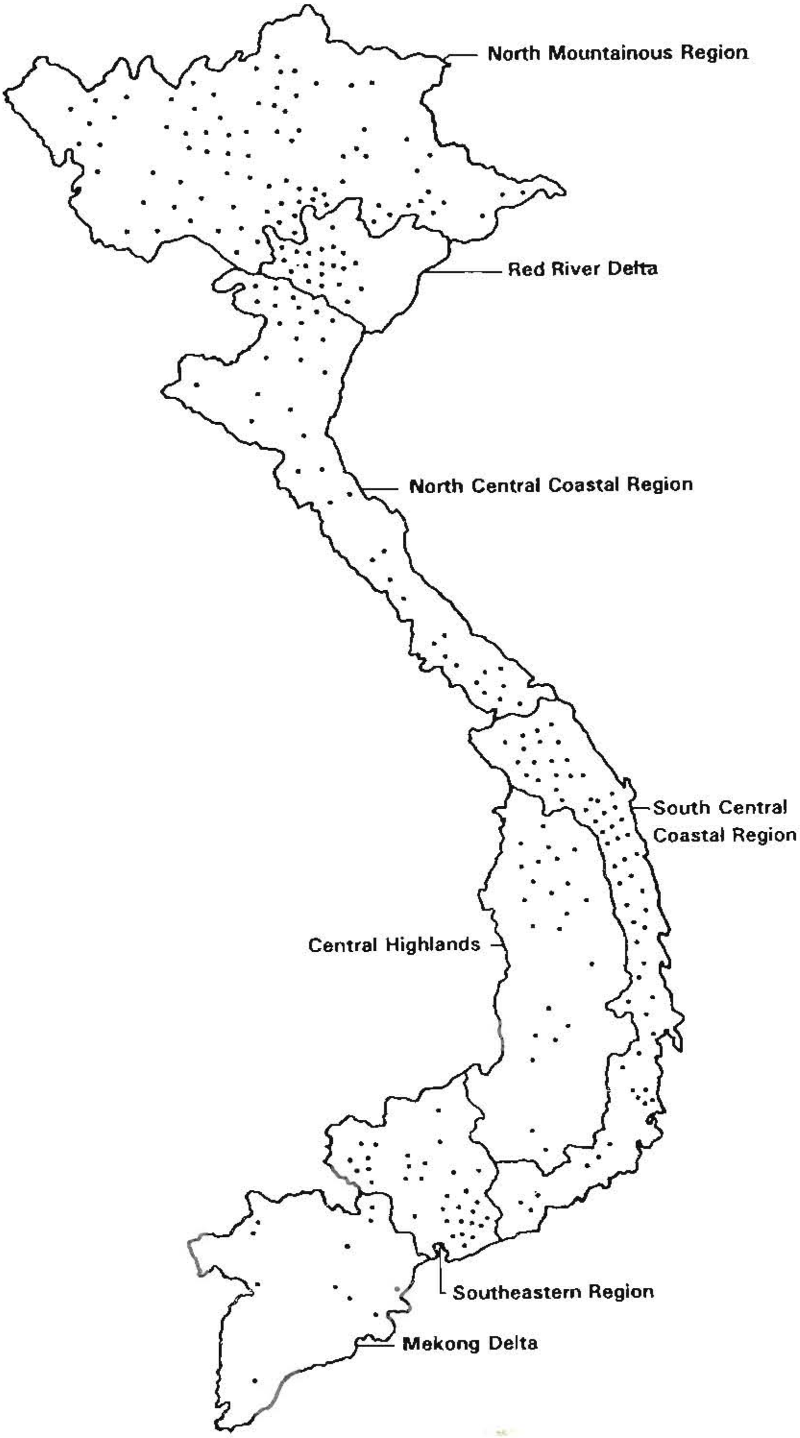

Figure 1. Cassava production areas in Vietnam in 1991. Each dot represents 1000 ha of cassava.

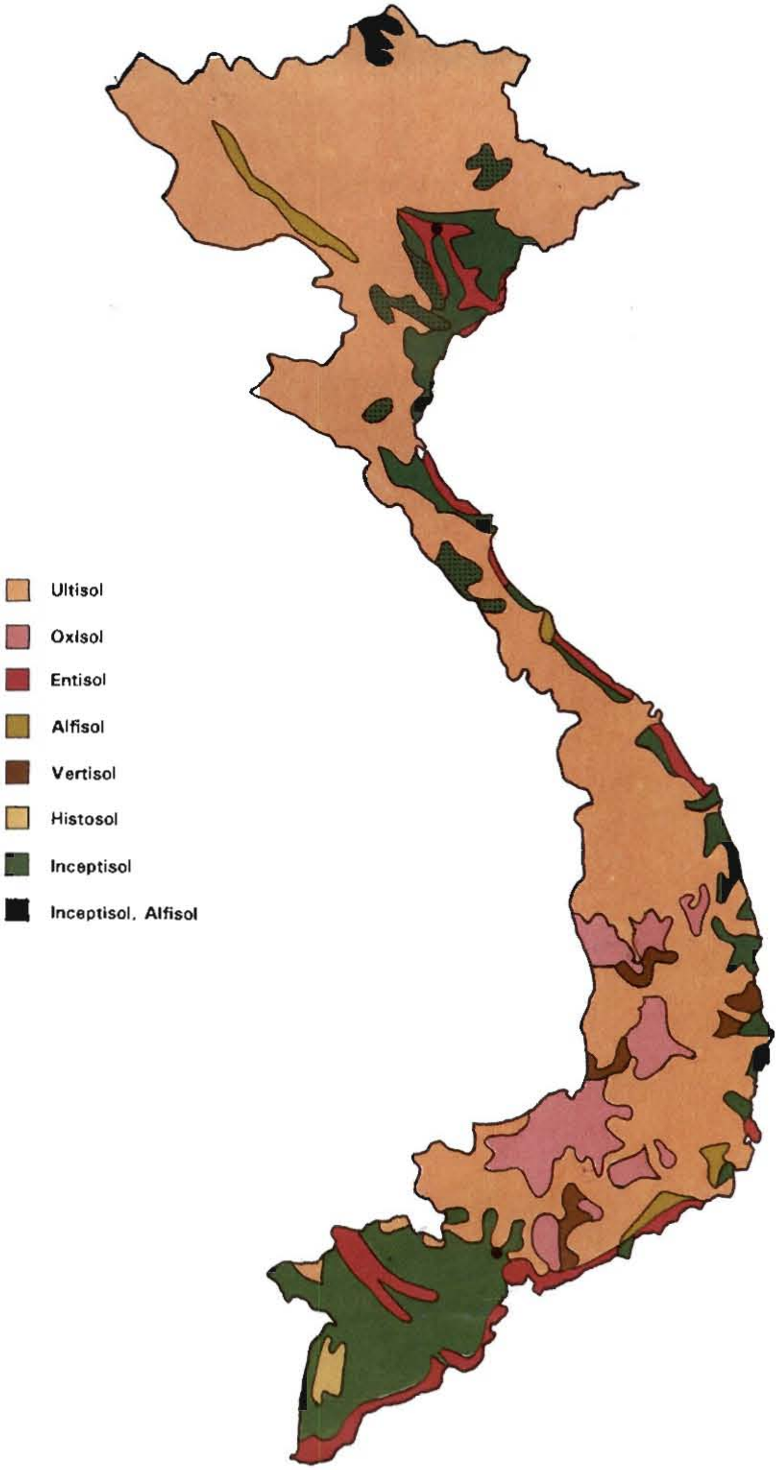

Figure 2. Soil map of Vietnam.
Source: *Adapted from FAO World Soil Map by R.H. Howeler.*

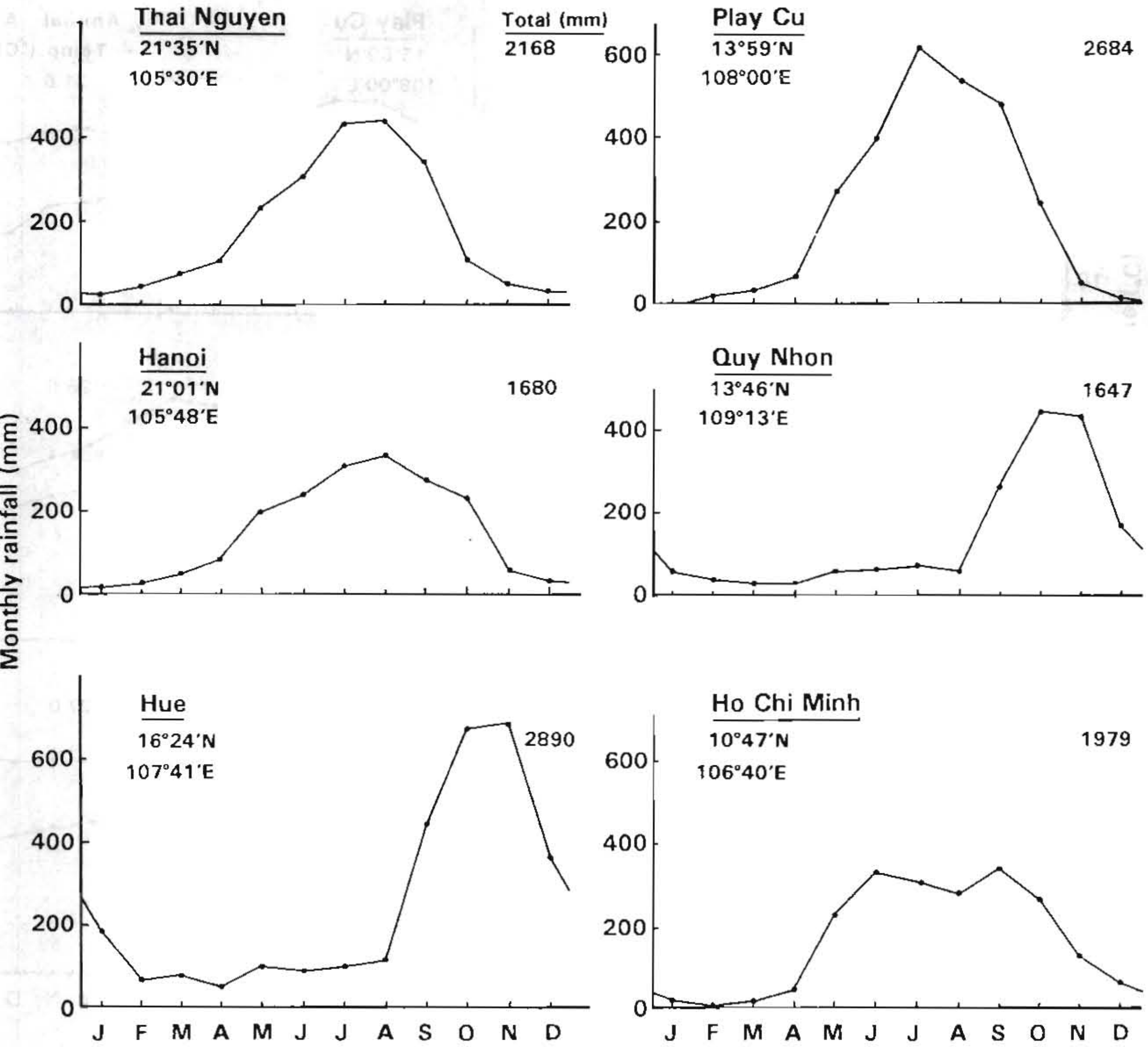

Figure 3. Rainfall distribution and total annual precipitation at six locations of Vietnam.
***Source**: Khi Hau Vietnam 1978.*

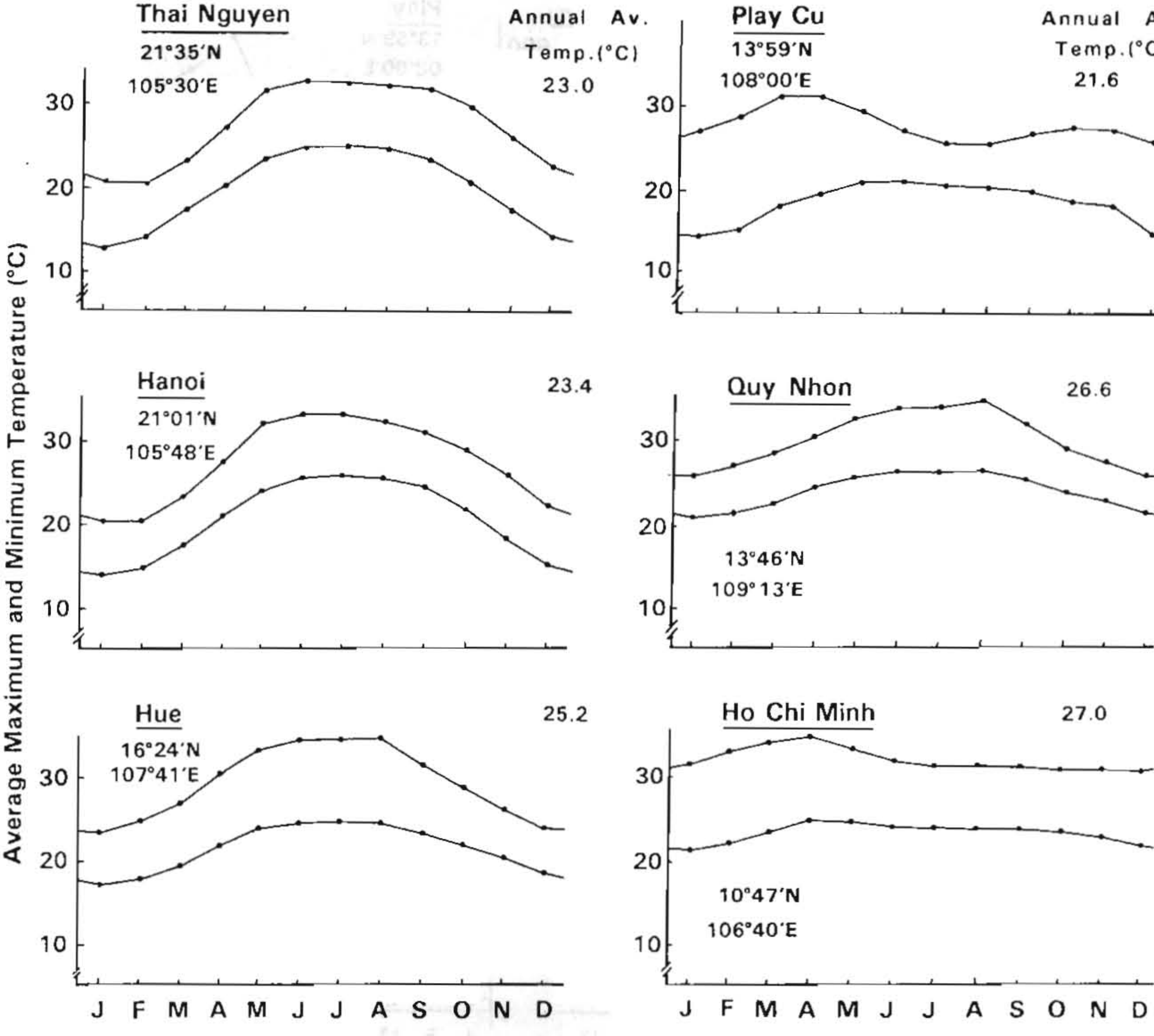

Figure 4. Average maximum (top curves) and minimum (bottom curves) temperature fluctuations at six locations in Vietnam.
Source: *Khi Hau Vietnam 1978.*

Table 1. Climatic data at eight locations in the different agro-ecological regions of Vietnam.

A. Mean temperature (°C)

Region	Month												Average
	J	F	M	A	M	J	J	A	S	O	N	D	
Northern Mountains1)	15.3	16.5	19.7	23.3	26.7	27.8	28.0	27.5	26.4	23.9	20.4	17.0	22.7
Northern Midlands2)	15.9	16.9	20.0	23.7	27.3	28.5	28.9	28.1	27.2	24.7	21.2	17.7	23.3
Red River Delta3)	16.4	17.0	20.2	23.7	27.3	28.8	28.9	28.2	27.2	24.6	21.4	18.2	23.5
North Central Coast4)	17.6	17.9	20.3	24.1	27.7	29.2	29.6	28.7	26.8	24.4	21.6	18.9	23.9
South Central Coast5)	21.7	22.6	24.4	26.7	28.4	29.0	29.0	28.8	27.3	25.7	24.2	22.4	25.8
Central highlands6)	19.0	20.7	22.7	24.0	24.0	23.0	22.4	22.2	22.3	21.7	20.7	19.3	21.8
Southeastern Region7)	25.2	26.9	28.4	29.0	28.6	27.2	26.9	26.8	26.8	26.7	26.4	25.2	27.0
Mekong River Delta8)	25.3	26.1	27.3	28.5	27.8	27.1	26.8	26.7	26.8	26.8	26.8	25.6	26.8

B. Rainfall (mm)

Region	Month												Total
	J	F	M	A	M	J	J	A	S	O	N	D	
Northern Mountains1)	32.1	49.6	73.7	131.2	225.9	306.9	236.0	399.8	288.5	167.1	59.8	26.3	1,997
Northern Midlands2)	23.5	29.8	38.9	98.3	189.7	243.4	288.8	312.4	224.0	144.6	53.9	15.7	1,663
Red River Delta3)	18.6	26.2	43.8	90.1	188.5	239.9	288.2	318.0	265.4	130.7	43.4	23.4	1,676
North Central Coast4)	52.0	44.0	46.6	61.2	136.3	116.4	122.5	188.0	490.1	427.4	191.1	68.7	1,944
South Central Coast5)	131.0	52.5	37.5	37.6	66.3	89.8	75.5	121.8	282.4	586.7	541.5	267.8	2,290
Central highlands6)	3.0	6.8	27.5	94.9	225.7	357.0	452.9	492.6	360.0	181.0	57.4	13.3	2,272
Southeastern Region7)	8.1	4.2	13.4	46.5	158.7	235.0	268.0	281.9	297.5	211.5	89.1	27.7	1,642
Mekong River Delta8)	12.4	2.2	10.4	49.7	176.6	206.4	226.6	216.8	273.1	277.1	155.3	40.9	1,647

⇓

Table 1. (Continued).

C. Number of rainy days

Region	Month J	F	M	A	M	A	J	J	S	O	N	D	Total
Northern Mountains[1]	14.2	17.3	21.7	21.6	16.1	17.2	18.5	20.0	14.7	12.1	10.6	9.4	193.4
Northern Midlands[2]	8.8	10.1	11.5	10.6	12.5	13.0	15.2	15.9	11.8	8.5	6.9	5.9	130.7
Red River Delta[3]	8.4	11.3	15.0	13.3	14.2	14.7	15.7	16.7	13.7	9.0	6.5	6.0	144.5
North Central Coast[4]	12.1	12.8	12.9	9.7	10.4	7.8	7.8	10.9	14.7	15.1	13.1	10.7	138.0
South Central Coast[5]	15.0	7.8	5.4	5.0	6.2	7.3	7.8	10.2	14.8	19.6	21.0	19.3	139.4
Central highlands[6]	1.1	0.7	3.2	7.6	16.9	22.8	26.9	26.9	24.2	14.5	6.9	2.1	153.8
Southeastern Region[7]	0.8	0.5	1.4	3.9	12.0	14.1	15.8	16.1	15.8	12.6	7.2	2.8	103.0
Mekong River Delta[8]	1.7	0.5	1.2	2.5	14.0	16.6	18.1	18.2	19.2	17.7	11.4	4.7	125.8

D. Sunshine hours

Region	Month J	F	M	A	M	J	J	A	S	O	N	D	Total
Northern Mountains[1]	57	42	45	69	154	153	176	173	172	153	120	96	1,410
Northern Midlands[2]	72	49	53	92	191	175	206	179	187	175	142	120	1,641
Red River Delta[3]	67	45	46	80	166	156	183	163	160	165	125	109	1,465
North Central Coast[4]	72	48	64	132	213	186	206	167	152	135	95	87	1,557
South Central Coast[5]	125	155	217	238	274	245	260	234	200	162	110	101	2,321
Central highlands[6]	256	260	275	233	209	142	138	118	135	179	198	233	2,376
Southeastern Region[7]	267	255	283	259	234	161	194	183	170	211	197	236	2,650
Mekong River Delta[8]	257	248	288	264	213	177	185	179	167	176	190	208	2,552

[1] Yen Bai (21° 40′ N, 104° 50′ E)
[2] Viet Tri (21° 20′ N, 105° 40′ E)
[3] Hanoi (21° 0′ N, 105° 50′ E)
[4] Vinh (18° 40′ N, 105° 45′ E)
[5] Quang Ngai (15° 10′ N, 108° 50′ E)
[6] Play Ku (14° 0′ N, 108° 0′ E)
[7] Bien Hoa (10° 55′ N, 106° 50′ E)
[8] Can Tho (10° 0′ N, 105° 45′ E)

fluctuations in monthly temperatures (25-29°C) (**Figure 4**). The rainy season is about one month delayed compared with the North, but total rainfall is similar. The dry season in the South is more intense due to an almost complete lack of rain during 5-6 months. In the Central Coastal Region total rainfall is high, but it is poorly distributed with very heavy rainfall from Sept to Nov (**Figure 3**) and a long dry season of 7-8 months (**Figures 3** and **5**).

The population of Vietnam is about 66 million, of which nearly 70% are farmers; there are 9.4 million farmer households and 21.2 million agricultural workers. However, the population is not distributed uniformly among regions, with the highest population density in the Red River and Mekong deltas.

The gross value of agricultural production in 1990 was 22,003,548 million dong (about 2.2 billion US dollars), corresponding to about 50% of gross national production. Cultivated crops account for about 76% (of which food crops 54%) and animal husbandry 24% of the gross value of agricultural products. The export value of agricultural products is about $742 million, forestry products $86.7 million and fishery products about $188 million. The above picture clearly shows the importance of agriculture in the economy of Vietnam.

In agriculture, food production plays the most important role, accounting for 98% of annual crop area (over 7.1 million ha). Flooded rice is by far the most important, having an area of 6.03 million ha and a production of about 19.22 million tons (in 1990). Other food crops are grown on 1.08 million ha, with a production of over 2.26 million tons (in rice equivalents). The main food of the Vietnamese people is rice, which accounts for 88-95% of daily food intake. But this varies among regions. Other food crops include maize, sweet potato, cassava, etc. These subsidiary food crops are very important, because they supply not only food for humans but also feed for animals, and serve as raw material for the food industry (alcohol, maltose, cakes, sweets, noodles, etc.). Cassava is a major raw material for the food industry.

Cassava Production in Vietnam

In Vietnam, cassava is often grown on sloping and hilly lands, some of which has been severely eroded, so the soil is very poor. There are many difficulties in these regions. For instance, the North Mountainous Region has a low population density and is inhabited by various ethnic groups. While the agricultural area is large, the water resources are scarce. The people's standard of living is still very low. In the Midlands, the North Central Coast, the South Central Coast and the Southeastern Region, the land is very bad, being severely eroded and there are often typhoons, floods or droughts. There are many economic difficulties, making life hard for the people (**Table 2**).

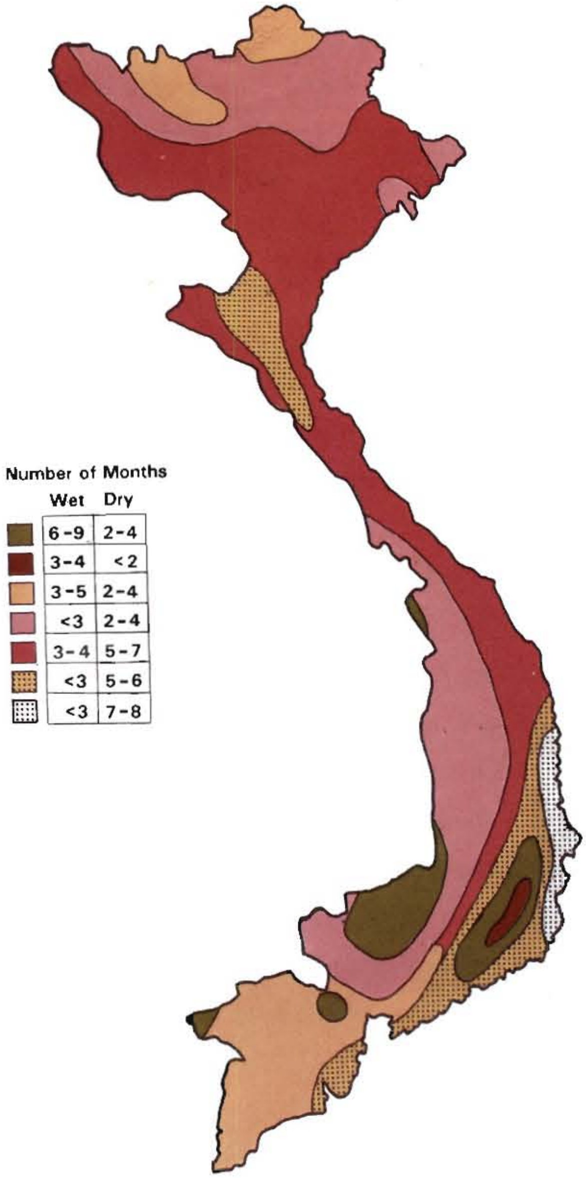

Figure 5. Agro-climatic map of Vietnam.
Adapted from Agro-climatic map of SE Asia.
***Source:** Huke, 1982.*

Table 2. Indicators of farmer's living standards in different regions.

Indicator	Northern Mountains/ Midlands	Red River Delta	North Central Coast	South Central Coast	Central Highlands	Mekong Delta
Population density (person/km^2)	82-420	784	167	148	102	352
Agric. land available ('000 m^2/worker)	2.7-4.3	2.3	3.4	3.2	6.3	4.7
Per capita food availability (kg)	216-244	294	226	274	224	568
No. persons/household	6.4	4.9	5.3	6.5	?	6.9
Per capita income/year ('000 d)	113.93	276.84	210.08	296.52	?	639.92
Per household monthly income (%) :						
<200,000 d	67.8	36.7	45.4	22.3	?	17.1
200,000-400,000 d	30.2	49.6	40.5	45.9	?	36.8
400,000-600,000 d	2.0	7.7	13.0	24.7	?	19.7
600,000-800,000 d	-	3.4	1.1	4.7	?	10.4
>800,000 d	-	2.6	-	2.4	?	16.0
Source of income (%):						
Agriculture	76.6	89.3	83.1	84.7	?	89.1
- Crops	59.7	62.6	67.4	70.5	?	79.2
- Livestock	16.9	26.6	15.7	14.2	?	9.9
Foresty	12.0	-	-	-	?	-
Handicraft	-	6.6	4.6	7.6	?	4.9

Nearly 1.2 million ha of uplands are used for production of food crops and annual industrial crops such as maize, sweet potato, cassava, canna, taro, mungbean, soybean, sugarcane, cotton, groundnut, sericulture, tobacco, vegetables, etc.

Some crops are grown only once a year, such as cassava, canna, sugarcane, sericulture (intercropped with soybean or groundnut). In some areas two to three crops are grown per year, such as jute + autumm groundnut; summer cotton + beans (followed by fallow, because of drought); spring groundnut + summer soybean + winter crops; spring tobacco + summer soybean + winter crops; spring groundnut + summer maize + winter crops. Winter crops include mainly sweet potatoes, maize and vegetables.

Cassava is grown on about 250 thousand ha and production varies between 2.2 and 2.9 million tons of fresh roots. Among the subsidiary food crops cassava accounts for about 25% of the area and 30-40% of production (in rice equivalents) (**Tables 3** and **4**). The distribution of cassava areas is not equal among regions (**Figure 1**). In 1991, the North Mountainous Region (including the Midlands) accounted for about 35% of the area and 37% of production; the South Central Coast about 22% of the area and 22% of production; the North Central Coast about 19% of the area and 12% of production; the Southeastern Region about 11% of the area and 16% of production; the Central Highlands 8% of the area and 7% of production, while the Red River and Mekong Deltas accounted for 3 and 4% of the area, and 3 and 4% of production, respectively (**Table 5**).

During the last ten years (1980-1990) cassava production in Vietnam has decreased at an average annual rate of 5.65% in terms of area and 3.91% in production, while yields increased at an average annual rate of 1.67% (**Table 6**). **Tables 7** and **8** show the change in cassava area and production during the past ten years in the various regions, while **Figure 6** shows the trend in area, production and yield since 1976 for the whole country.

The yield of cassava in Vietnam is increasing but is still rather low. There are few provinces harvesting over 10 t/ha of fresh roots (**Table 5**), even though there were many demonstration plots which produced over 30 t/ha in Ha Bac, Hoa Binh, Vinh Phu and Dong Nai provinces. Very low yields are obtained mainly in the Red River Delta, the North Central Coast and in Gia Lai/Kon Tum provinces of the Central Highlands.

Table 3. Area planted to subsidiary food crops ('000 ha).

Year	Total	Maize	Sweet potato	Cassava	Cassava as proportion of total (%)
1980	1,448.8	389.6	450.0	442.9	30.57
1981	1,332.3	384.7	441.2	379.4	28.48
1982	1,256.8	381.4	406.0	365.5	29.08
1983	1,164.2	378.3	357.5	343.0	29.46
1984	1,142.3	386.5	327.6	345.8	30.27
1985	1,129.7	397.3	320.0	335.0	29.65
1986	1,123.7	400.9	329.0	314.7	28.00
1987	1,121.4	405.6	332.2	298.9	26.65
1988	1,241.4	510.5	336.2	317.7	25.59
1989	1,193.7	509.4	327.3	284.6	23.84
1990	1,079.6	432.5	318.8	256.8	23.66
1991	-	-	348.4	273.2	-

Table 4. Production of subsidiary food crops ('000 tons).

Year	Total (1)	Maize (2)	Sweet potato (3)	Cassava (4)	Cassava as proportion of total (%) (5)
1980	2,759.0	428.8	2,417.6	3,323.0	40.15
1981	2,590.0	429.6	2,630.3	2,969.0	38.21
1982	2,438.6	438.1	2,381.0	2,860.7	39.10
1983	2,242.5	468.0	1,842.1	2,905.7	43.19
1984	2,294.4	532.2	1,641.7	3,039.0	44.15
1985	2,325.2	587.1	1,777.7	2,939.8	42.14
1986	2,376.2	569.8	1,958.7	2,882.2	40.43
1987	2,460.0	561.0	2,202.3	2,738.4	37.11
1988	2,583.1	814.8	1,901.8	2,839.3	36.64
1989	2,519.3	837.9	1,909.2	2,585.4	34.21
1990	2,376.3	684.7	1,899.6	2,275.8	31.92
1991	-	-	2,104.5	2,454.9	-

Note: (1, 5): in rice equivalents.
(2) : as dry grain.
(3, 4): as fresh roots.

Table 5. Cassava area, production and yield in each region and province of Vietnam in 1990, 1991 and 1992.

Region and province	Area ('000 ha)			Production ('000 t)			Yield (t/ha)		
	1990	1991	1992	1990	1991	1992	1990	1991	1992
North Vietnam	**140.8**	**146.7**	**159.5**	**1,180.4**	**1,268.1**	**1,373.6**	**8.39**	**8.64**	**8.61**
-North Mountainous Region	78.7	96.7	104.2	748.8	904.5	957.8	9.51	9.70	9.19
Ha Qiang	12.3	6.7	6.5	103.2	43.9	50.7	8.39	6.55	7.73
Tuyen Quang		6.4	8.1		78.1	87.5		12.20	10.91
Cao Bang	1.9	2.0	2.1	16.3	16.7	16.1	8.77	8.56	7.68
Lang Son	3.7	3.4	3.5	41.6	27.0	35.8	11.12	7.87	10.25
Lai Chau	6.3	7.6	8.8	54.3	67.4	70.9	8.65	8.83	8.09
Lao Cai	14.2	5.2	5.8	149.8	63.5	60.8	10.63	12.21	10.52
Yen Bai		10.4	10.1		127.9	117.8		12.34	11.63
Bac Thai	4.7	4.9	4.8	47.5	48.6	45.1	10.00	9.86	9.39
Son La	11.7	13.0	13.7	125.2	140.4	143.1	10.72	10.83	10.43
Hoa Binh	–[a]	12.6	14.8	–[a]	88.7	100.2	–[a]	7.04	6.76
Quang Ninh	3.3	3.4	3.3	27.2	26.9	25.7	8.17	7.99	7.82
Vinh Phu	12.2	12.9	13.2	102.6	109.9	129.1	8.37	8.50	9.76
Ha Bac	8.4	8.2	9.5	81.1	65.5	75.0	9.69	8.02	7.93
-Red River Delta	19.3	7.6	8.3	139.4	60.8	72.3	7.20	7.40	8.66
Hanoi	3.9[a]	0.4	0.7	27.7[a]	2.3	4.1	7.01	5.79	6.05
Hai Phong	0.3	0.4	0.4	2.9	3.0	2.7	9.64	7.61	7.43
Ha Tay	12.6[a]	4.3	4.3	84.3[a]	32.4	31.9	6.65[a]	7.53	7.36
Hai Hung	0.3	0.3	0.3	2.8	2.1	2.1	8.16	7.13	7.00
Thai Binh	0.1	0.2	0.0	0.4	1.8	0.5	10.00	11.00	11.00
Nam Ha	2.1	0.6	0.7	21.3	4.8	6.2	10.33	7.77	8.41
Ninh Binh		1.4	1.9		14.4	24.8		10.28	13.12

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Table 5. (Continued).

Region and province	Area ('000 ha)			Production ('000 t)			Yield (t/ha)		
	1990	1991	1992	1990	1991	1992	1990	1991	1992
-North Central Coast	42.8	42.4	47.0	292.2	302.8	343.5	6.83	7.13	7.30
Thanh Hoa	14.5	14.4	16.2	113.9	109.8	126.9	7.85	7.64	7.85
Nghe An	14.7	11.3	14.1	103.8	76.6	102.6	7.08	6.80	7.30
Ha Tinh		2.6	2.3		14.4	15.3		5.54	6.52
Quang Binh	4.0	4.2	4.4	17.3	26.1	23.4	4.29	6.21	5.27
Quang Tri	3.4	3.6	3.8	21.3	31.6	30.9	6.65	8.84	8.04
Thua Thien-Hue	6.2	6.3	6.2	35.9	44.3	44.4	5.74	7.01	7.21
South Vietnam	**116.0**	**126.5**	**124.3**	**1,095.4**	**1,186.8**	**1,194.3**	**9.44**	**9.38**	**9.60**
-South Central Coast	59.3	61.1	59.7	507.9	542.2	517.8	8.57	8.88	8.66
Quang Nam-Da Nang	17.5	17.9	17.0	166.9	172.7	163.3	9.54	9.65	9.59
Quang Ngai	11.9	12.7	11.3	88.4	95.3	79.9	7.43	7.51	7.08
Binh Dinh	10.9	11.4	12.2	71.2	78.8	85.8	6.50	6.92	7.05
Phu Yen	4.6	5.3	4.8	38.6	55.4	50.3	8.66	10.53	10.37
Khanh Hoa	7.9	7.4	7.5	89.0	83.8	87.3	11.24	11.25	11.62
Ninh Thuan	0.8	1.4	1.1	2.2	3.6	8.6	2.75	2.57	7.82
Binh Thuan	5.7	5.0	5.8	51.6	52.6	42.6	9.05	10.52	7.32
-Central Highlands	21.2	22.7	24.3	204.9	162.3	186.8	9.63	7.12	7.69
Gia Lai	13.5	9.5	9.7	125.1	86.8	32.7	9.23	9.12	3.38
Kon Tum		6.4	7.2		5.1	74.1		0.90	10.31
Dac Lac	5.6	4.5	4.8	57.7	45.8	51.4	10.27	10.09	10.57
Lam Dong	2.1	2.3	2.6	22.1	24.6	28.6	10.57	10.58	11.15

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Table 5. (Continued).

Region and province	Area ('000 ha)			Production ('000 t)			Yield (t/ha)		
	1990	1991	1992	1990	1991	1992	1990	1991	1992
-Southeastern Region	23.4	32.4	30.0	281.1	390.7	399.3	12.01	12.07	13.29
Ho Chi Minh city	0.8	0.8	0.7	7.4	7.3	7.4	9.67	9.77	9.70
Song Be	4.7	7.1	5.8	44.4	69.3	55.6	9.52	9.72	9.58
Tay Ninh	3.3	7.4	7.2	36.2	85.1	83.7	10.79	11.55	11.66
Dong Nai	14.5[b]	9.8	10.2	192.5[b]	131.8	166.6	13.25[b]	13.36	16.30
Ba Ria-Vung Tau	0.1[b]	7.3	6.1	0.5[b]	97.2	86.0	6.40[b]	13.36	14.18
-Mekong River Delta	12.1	10.3	10.3	101.5	91.6	90.4	8.38	8.86	8.80
Long An	2.5	1.9	2.0	17.3	12.0	13.8	6.70	6.48	6.87
Dong Thap	0.1	0.0	0.0	0.3	0.1	0.1	5.63	4.60	9.07
An Giang	0.9	1.9	1.6	9.1	20.8	15.0	10.54	10.72	9.96
Tien Giang	0.8	0.9	1.1	5.6	5.9	7.5	6.60	6.60	7.12
Ben Tre	0.7	0.7	0.6	5.5	5.9	6.8	8.22	8.21	8.13
Vinh Long	3.4	2.7	0.8	40.0	31.9	9.6	11.89	11.90	12.10
Tra Vinh			1.9			21.8			11.58
Can Tho	0.0	0.0	0.0	0.1	0.1	0.5	8.22	8.22	9.45
Soc Trang	0.5	0.5	0.7	4.1	4.1	5.5	8.20	8.20	8.14
Kien Giang	2.3	0.9	0.9	13.1	5.1	5.0	5.64	5.66	5.60
Minh Hai	0.9	0.8	0.7	6.4	5.7	4.8	7.09	7.02	6.86
Total Vietnam	**256.8**	**273.2**	**283.8**	**2,275.8**	**2,454.9**	**2,567.9**	**8.86**	**8.98**	**9.04**

[a] In 1991 parts of Ha Son Binh and Hanoi were combined to form Ha Tay, while the rest of Ha Son Binh was renamed Hoa Binh.

[b] In 1991 the southern part of Dong Nai province was added to Vung Tau, which was renamed Ba-Ria-Vung Tau; six other provinces were split into two.

Table 6. Cassava area, yield and production (fresh roots) in Vietnam, 1980-1992.

Year	Area ('000 ha)	Yield (t/ha)	Production ('000 t)
1980	442.9	7.50	3,323.0
1981	379.4	7.83	2,969.0
1982	365.5	7.82	2,860.7
1983	343.0	8.47	2,905.7
1984	345.8	8.78	3,039.0
1985	335.0	8.77	2,939.8
1986	314.7	9.16	2,882.3
1987	298.9	9.16	2,738.4
1988	317.7	8.94	2,939.3
1989	284.6	9.08	2,585.4
1990	256.8	8.86	2,275.8
1991	273.2	8.98	2,454.9
1992	283.8	9.04	2,567.9
Average annual growt rate (1980-1990) (%)	-5.65	+1.67	-3.91

Table 7. Distribution of cassava area (%) in agro-ecological regions.

Region	Years				Annual growth rate
	1980	1985	1989	1990	1980-1990
1. North Mountainous Region	15.13	18.74	22.94	22.72	+4.14
2. North Midlands	7.52	7.97	8.46	8.07	+0.70
3. Red River Delta	5.88	7.07	8.04	7.55	+2.53
4. North Central Coast	19.55	18.98	16.26	16.75	- 1.55
5. South Central Coast	20.77	21.40	21.25	23.06	+1.05
6. Central Highlands	8.15	6.30	7.94	8.33	+0.02
7. Southeastern Region	16.21	15.04	10.43	9.12	- 5.92
8. Mekong River Delta	6.79	4.44	4.68	4.40	- 4.43

Table 8. Distribution of cassava production in different agro-ecological regions (%).

Region	Years				Annual growth rate
	1980	1985	1989	1990	1980-1990
1. North Mountainous Region	18.99	22.41	25.89	25.64	+3.04
2. North Midlands	5.79	7.76	8.60	8.12	+3.43
3. Red River Delta	4.02	5.39	6.38	6.16	+4.36
4. North Central Coast	14.21	13.74	12.42	12.91	- 0.96
5. South Central Coast	22.12	21.81	20.12	20.13	- 0.94
6. Central Highlands	9.15	6.70	8.35	9.06	- 0.01
7. Southeastern Region	19.25	18.07	13.76	13.73	- 3.43
8. Mekong River Delta	6.47	4.12	4.48	4.25	- 4.29

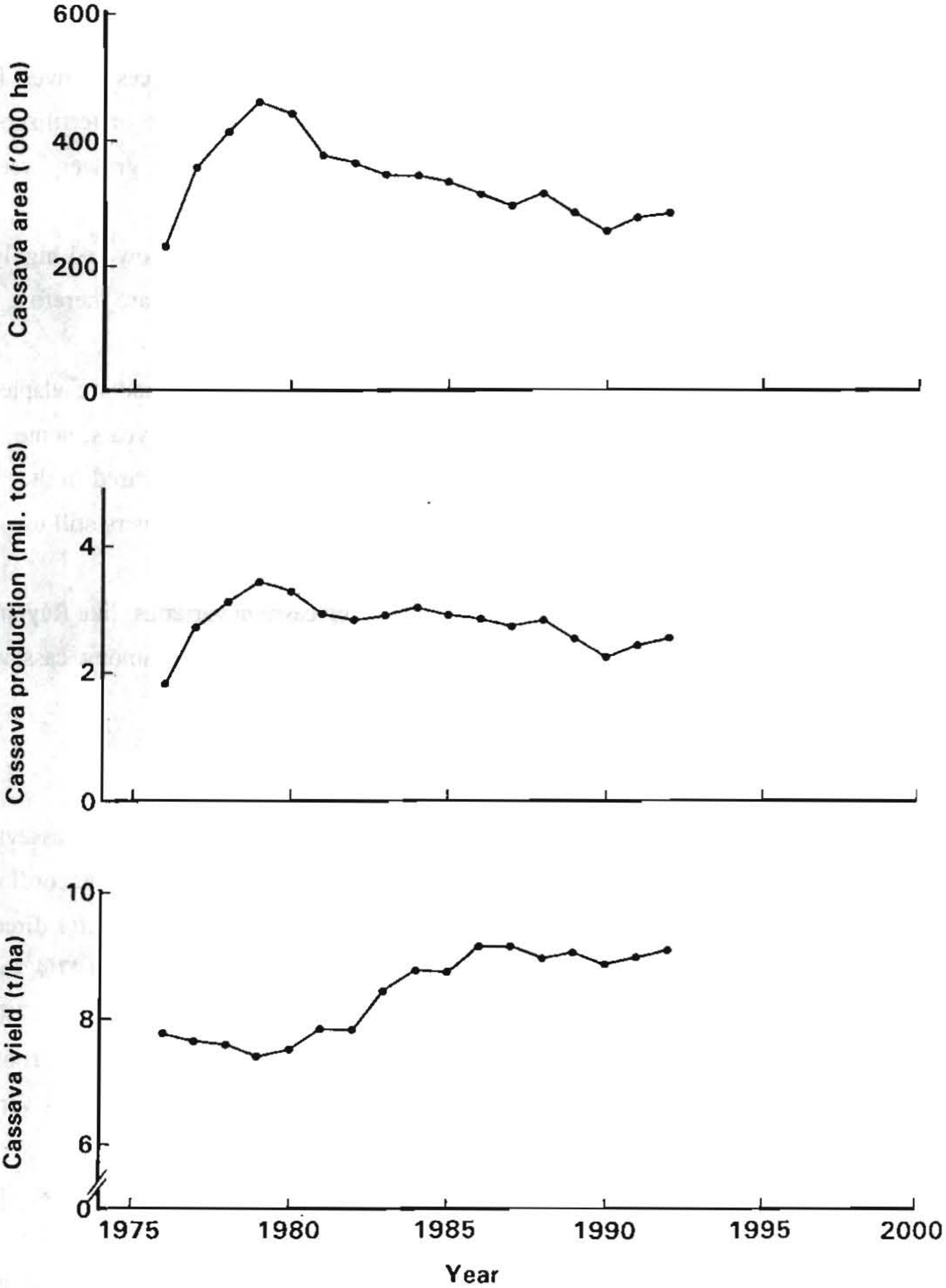

Figure 6. Cassava area, production and yield in Vietnam from 1976 to 1992.

Some of the causes for low casssava yields in Vietnam are:

1. The crop is generally grown on sloping land, which usually has infertile and highly eroded soils. The farmers' standard of living in cassava regions is generally very low, and they have not enough financial resources to invest in cassava production. The people plant cassava without manure or fertilizers, and without irrigation, so they have to wait for rain. Cassava growers weed and hill-up plants only once or twice during the crop cycle.
2. Absence of clearly defined marketing channels resulting in a low and highly variable price for cassava roots and low profits; few farmers are therefore willing to invest to increase yields.
3. There are few high yielding varieties which have good quality and are adapted to various climatic and soil conditions in Vietnam. In recent years, some good varieties, such as HL-20, HL-23, HL-24, have been released in the South, but the area under these varieties is still small and farmers still use mostly traditional varieties.

It is expected, that in the near future high-yielding cassava varieties, like Rayong 1 and Rayong 60 from Thailand, can be developed and distributed among cassava farmers.

Cassava Utilization in Vietnam

Among root and tuber crops in Vietnam (including potato, sweet potato, cassava, canna, taro, yam), cassava is most valuable in terms of utilization potential. According to the cassava survey results (**Table 9**), in Vietnam the amount of cassava used for direct human consumption is only about 12% (highest in the North Central Coast at 27% and in the North Mountainous Region at 22%), on-farm processing accounts for about 17%, cassava used for on-farm animal feeding is about 22% and that sold as fresh roots (mainly for further processing) is about 49%. The amount of cassava exported is very low.

The main cassava products produced in farmer households are dry chips, dry starch, wet starch, maltose, alcohol and noodles (made from mixed cassava and canna starch). People process cassava to allow its conservation and to sell little by little. Besides canna and cassava, other root and tuber crops are not used for processing.

Until now, cassava production is poorly developed, the market is unstable, prices are highly variable and grower's income is often low.

During the years of abundant rice availability cassava can not be sold or is sold at a very low price. Some farmers don't even harvest cassava but keep plants in the field until next year. On the contrary, during years of a bad rice harvest, cassava will be consumed easily, consumers come to the field to harvest themselves and pay a high price.

People continue to plant cassava because in most highly infertile soils there are no other crops more suitable. Even sweet potato, which can be called a poor farmers' crops, can not grow well. Furthermore, cassava is planted as a reserve food for people and animals in case other crops fail.

Although cassava is an important crop, having strategic importance in agriculture in Vietnam, especially in the rainfed areas, cassava production is still not well developed and there are no policies to encourage the planting and utilization of cassava.

Table 9. Cassava utilization in different regions of Vietnam (%).

Region	On-farm			
	Human consumption	Animal feeding	Processing	Fresh root sale
North Vietnam	19.1	34.9	7.0	39.0
North Mountainous Region	15.4	39.4	6.5	38.7
Red River Delta	22.0	23.8	3.4	50.8
North Central Coast	27.5	28.8	11.2	32.5
South Vietnam	6.7	13.7	24.4	55.2
South Central Coast	10.9	19.4	40.0	29.7
Central Highlands	2.1	12.2	32.7	53.0
Southeastern Region	5.2	11.8	8.8	74.2
Total Vietnam	12.2	22.4	16.8	48.6

Source: Cassava Survey in Vietnam, 1991.

Cassava Research in Vietnam

Cassava and sweet potato are crops of poor farmers, because they grow easily, don't require much investments like rice or maize and are widely adapted. But research on cassava has barely started and there are fewer documents and books on cassava than on rice, maize and sweet potato.

Before 1980, there were some documents on a survey about cassava cultivars and planting techniques conducted by teachers and students of Agricultural University No.1 (at Hanoi), No.2 (at Ha Bac), No.3 (at Bac Thai), as well as trials on intensive cassava cultivation by the Nations' Youth College (at Hoa Binh). In these trials and small demonstrations, fresh root yields of 60-80 t/ha have been obtained, planting cassava with the application of green manure, farm yard manure, NPK fertilizers as well as irrigation.

Cassava processing research is also very limited. Making dry chips, starch (dry and wet), alcohol, maltose, noodles and cakes are long-standing traditional techniques used by farmers in some localities, such as Ha Bac, Vinh Phu, Yen Bai, Ha Tay, Thua Thien-Hue, Dong Nai, Kon-Tum, etc.

Not only is the number of research projects on cassava very limited, but researchers have not been collaborating effectively with each other in studying the crop.

Currently, there are several institutions conducting research on cassava, for example the Agricultural College No.3 (at Bac Thai), No.2 (at Hue), the Food Crops Institute (at Hai Hung), INSA (at Hanoi), IAS (at Ho Chi Minh city), and the Potato and Vegetable Research Centre (at Hanoi). However, these institutions have not collaborated well with each other to outline a long-term and common research program on cassava. This deficiency has been partially overcome by the establishment of a National Root and Tuber Crops Program. The first step was taken in the organization of a collaborative survey on cassava production, processing and consumption, including the evaluation of the results. In addition, the cassava germplasm collection introduced from the Thai-CIAT program and from other countries was evaluated in various locations of North and South Vietnam with support and guidance of CIAT. It is hoped that the future potential of cassava in Vietnam will be discovered and that the crop will be further developed for the benefit of farmers, processors and consumers.

Recommendation

There are few other food crops that are as well adapted as cassava to poor, sloping lands in rainfed areas in Vietnam. That is the reason we must have a strategy on cassava research, cultivation and utilization. Now the government has shown interest in root and tuber crops, especially in cassava. The National Root and Tuber Crops Program was established in Aug 1990 in order to coordinate the research in the areas of agronomy, breeding, processing and marketing, both inside and outside the field of agriculture, in order to unite the various activities into a common program. And recently, the State Committee of Sciences and MAFI have passed a scientific project called "Research on Breeding of Root and Tuber Crops with High Yield and Good Quality" during the next five years (1992-1996) under the guidance of the Potato and Vegetable Research Centre.

The following recommendations have been made to help accomplish these activities successfully:

1. From now to the year 2000 (1992-2000), local economists, extension officers and government managers have to make a development strategy on root and tuber crops in general, and on cassava in particular, in order to turn cassava into a crop which can generate an improved income for producers and processors.
2. Local scientist have to work out a complete research strategy on cassava, which includes breeding, agronomy, production, processing and utilization, and must collaborate in research, not only with other research institutions but also with extension organizations in order to help test and quickly disseminate the results of the research and stimulate technological progress in cassava production in Vietnam.

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INTRODUCTION TO THE VIETNAMESE CASSAVA BENCHMARK STUDY: OBJECTIVES AND METHODOLOGY

Guy Henry[1]

INTRODUCTION

In Vietnam, rice is the most important food staple, both in terms of absolute acreage and production; it is also the most preferred in the daily diet. Cassava, like maize and sweet potato, is a secondary or subsidiary crop. Although cassava only constitutes about a quarter of total Vietnamese secondary crops' acreage, it is important because of its many end-uses and its capacity to produce relatively good yields under poor climatic and soil conditions.

As most secondary crops in the Developing World, cassava has not enjoyed high priorities in the allocation of national research resources in Vietnam. However, a wide range of research institutes and universities have (on and off) conducted research on cassava production related topics. Most of these research activities have been focussed on the alleviation of biotic and abiotic cassava constraints. To a much lesser extent and more recently, research has been conducted on cassava utilization, processing and postharvest aspects (Nghiem, 1992). These latter activities have only been conducted for a limited number of crops, including rice and sweet potato.

The International Center for Tropical Agriculture (CIAT), which has a world mandate for cassava research, has collaborated with several agricultural research institutes in Vietnam since 1987, through its Asian Regional Cassava Program office.

Initially, this was limited to small-scale cassava germplasm introductions and evaluations in several sites. However, this soon expanded to include agronomy and soil research experiments towards testing of technologies to reduce soil erosion and maintain soil fertility in cassava based cropping systems.

Besides CIAT, the International Potato Center (CIP) has been conducting collaborative research with several Vietnamese institutes focussing on potato and sweet potato production problems. In 1988/89 CIP, with several Vietnamese collaborators and assisted by the CGPRT Center (in Bogor, Indonesia), conducted a diagnostic study on sweet potato production and marketing aspects in selected areas of Vietnam. This

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experience led the Vietnamese government to request CIAT to assist in conducting a similar study on cassava in Vietnam. Preliminary discussions on the organization of a Vietnamese Cassava Benchmark Study were initiated in 1990.

Up to 1989, potato, sweet potato and cassava research had been conducted separately, but in most cases by the same institutes. In addition, both CIP and CIAT worked on their respective mandate crops with several institutions, but without much relevant collaboration. In 1990, the Ministry of Agriculture and Food Industry (MAFI) took a significant decision to coordinate all Vietnamese research on cassava, potato and sweet potato through a newly founded Vietnamese Root Crops Research Program, with its headquarters at the former Potato Research Center in Van Dien, Thantri, Hanoi. This decision has been the first step towards a strategic (re)organization of root and tuber crops research in Vietnam.

This introductory paper aims to present the rationalization of a cassava benchmark study as part of a strategic root and tuber research planning exercise. In addition, it presents the objectives and methodology that was followed in executing the benchmark study. The paper will conclude with the organization of this workshop and the results that are expected.

STRATEGIC RESEARCH PLANNING:A METHODOLOGY

The International Service for National Agricultural Research (ISNAR) has had a long experience analyzing national agricultural research in many developing countries. This has resulted in several innovative approaches and methodologies. Strategic planning[2] is one such approach. Hence, the goal of strategic planning is to match objectives to available resources and defining ways to achieve the objectives, given these resources; and this, through an interative process (Collion, 1989).

Strategic planning can be conducted at the national level and at the institute level. Although the relevance of this paper is not with regard to one institute but to a group of collaborating institutes, the institute level approach will be followed. Given this, we have to assume that the research goals and missions of the collaborating institutes have already been defined by the national agricultural research policy and strategy. Also, at the institute level, the results of the environmental analysis at the national (system) level must

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[2] This section draws heavily upon the work at ISNAR on Strategic Planning by Collion (1989).

be assumed and as such the research planning only focuses on the part of the environment which is of relevance for the institute.

As can be seen in **Figure 1**, the strategic planning follows a sequence of activities or processes, that include the following: (1) analysis of current status; (2) environmental analysis; (3) determination of the desired future; (4) gap analysis; (5) long-term program formulation; and (6) action plan.

Analysis of Current Status.

The collaborating institutes have to asses their actual objectives, strategies and output (performance) in order to identify the <u>institutes' strengths</u> and weaknesses. As such, the relevance of the allocation of physical, human and financial resources to each program *vis-a-vis* the research impact needs to be analyzed. In addition, the efficiency and effectiveness of the <u>research organization</u> in relation to achieving its objectives needs to be assessed. The type of research organization (by crop, by discipline, by theme, etc.) includes the mix of disciplines and the relevant interaction with the "users" (farmers, processors, etc.) and extension agents.

Environmental Analysis.

As mentioned earlier, the goals and mission that are assigned to the institutes are supposed to be the results of the environmental analysis at the national level. Issues that have to be dealt with at the institute level include (Collion, 1989; pp.37):

(1) Economic policies that are relevant to the research mandate of the institutes.
(2) Specific linkage mechanisms with extension services for the diffusion of technologies.
(3) Assessment of the socio-economic and political environment of the mandate areas.
(4) Characterization of the institutes' clients (or users).
(5) Specific interests from "stakeholders" (like donors, etc).
(6) Linkages with other (national) research institutes, universities, NGO's and the private sector (industry).
(7) Linkages with international organizations (with respect to mutually beneficial research activities).

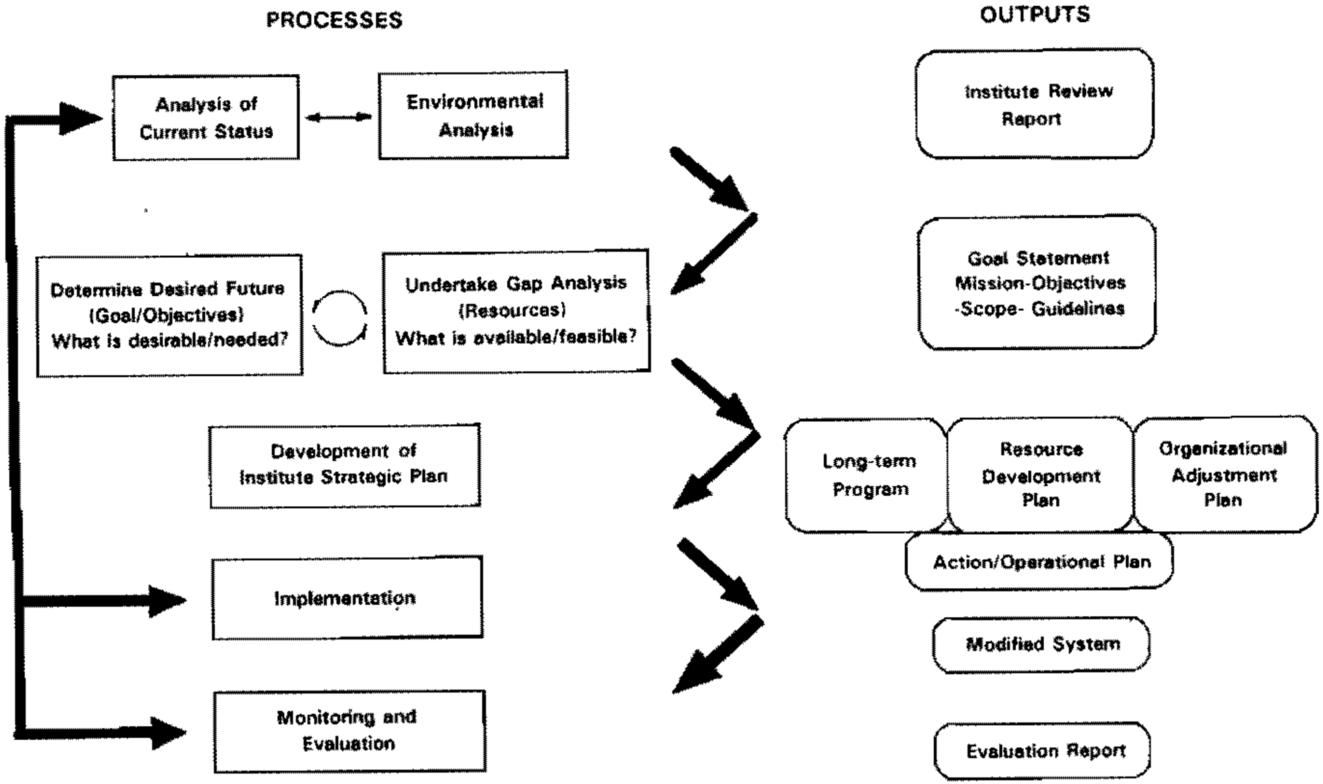

Figure 1. Strategic planning model and output at the institute level (Collion, 1989).

Determination of the Desired Future.

While in the environmental analysis the current status of research *vis-a-vis* the current goals and mission of the institutes are assessed, in this activity, the issue of "what should be our objectives given the goal and mission laid down by the national government" needs to be discussed. As such, new or revised objectives may be proposed.

Gap Analysis.

In this analysis one compares the current and desired status of the institutes taking into account the environmental conditions, emphasizing organization, distribution and level of resources by different objectives.

Given differences in objectives and assigned resources, a dialogue between the institutes and the national level will attempt to resolve this.

Long-term Program Formulation.

In order to translate the institutes (new) objectives into specific programs, the following questions need to be answered based on the collected information of the current status and environment of analysis (Collion, 1989):

(1) What are the objectives and what are the major constraints to overcome? To what extent are these technical and researcheable?

(2) If the problems are researcheable, can the constraints be removed by using present knowledge?

(3) Following the objectives, what are the problems in order of priority and what is the appropriate "research path"?

(4) For each of the researcheable problems what is the institute's comparative advantage *vis-a-vis* other collaborating (national or international) institutes? This also includes the assessment of the research strategy regarding basic, applied, and adaptive research, and on station vs. on-farm research.

(5) What will be the probability of successful adoption and impact of the research and what will be the research lag time and adoption time and ceiling?

(6) What will be the critical mass of resources needed? How much is available in -house and what needs to be looked for elsewhere?

Action Plan.

While most of the development of the strategic plan so far has been conducted by research managers, the implementation into a plan of action must be done by the scientific staff itself. The minimum unit of detail for the action plan should be a research project. A research project is mostly an interdisciplinary activity, which should be clearly outlined with specific objectives, methodology, expected results, collaboration, time table and resource requirements.

At this stage the strategic planning has visited all aspects of objectives, problems, priorities, organization, strategy and resource allocation in such a way as to optimize an efficient and effective investment of (scarce) research resources. In the next section, a diagnostic and analytical base-line study, called "benchmark study", is discussed that generates information regarding the "current status" and "environmental analysis" for cassava research planning in Vietnam.

THE VIETNAMESE CASSAVA BENCHMARK STUDY

Objectives.

As has been described in the proceeding section, strategic research planning includes an environmental analysis and an assessment of the current status. The type of data that is needed to generate information for these analyses include the following: (a) national and regional level strategic (political) information; (b) institutional level strategic and organization level data; (c) regional and farm/processor level socio-economic information; and (d) farm and processor level production and processing data.

This section proposes the framework of the Cassava Benchmark Study to generate data concerning the last two types of information. In order to identify and analyze constraints and opportunities for the Vietnamese cassava sector, (scarce) existing secondary data needed to be complimented by primary data. Hence, it was proposed to conduct a Cassava Benchmark Study, which is a diagnostic study that characterizes cassava production, processing and marketing aspects, and which forms the basis for analyzing constraints and opportunities. As such, a benchmark study is both descriptive and analytical. In addition, it can serve as a base study for the analysis of impact of technology. The Cassava Benchmark Study included the following (sub) studies.

(a) **Farm-level survey** focusing on cassava production, on-farm processing, utilization, and consumption. This included first-level marketing strategies and farmgate prices, as well as production and processing costs. In addition, major constraints were asked to be ranked.

(b) **(Semi)urban processor survey** focussing on both technical and socio-economic aspects of the processing of different cassava products.

(c) **Rural and (semi)urban cassava product marketing survey** focusing on product flows, prices, destination, pricing points, marketing agents and marketing margins.

Project Organization

Given the objectives and the type of studies that were indentified, first priority was to seek appropriate project collaborators. Since most research institutes consisted of a majority of biological scientists, the lack of socio-economists became quickly apparent. However, experienced socio-economic collaborators were identified at the University of Agriculture and Forestry #4 in Thu Duc, Ho Chi Minh city. As such, preliminary discussions in 1990 gave the project the following range of collaborators.

(1) **National Institute of Agricultural Sciences (INSA)** in Hanoi, presented an in -house knowledge on most aspects of cassava post-harvest utilization and processing (coordinator:Quach Nghiem).

(2) **The National Root and Tuber Research Center** in Hanoi, has the cassava production experience (project coordinator:Truong Van Ho).

(3) **Food Crops Research Institute (FCRI)** in Hai Hung, with experience in North Vietnamese cassava production aspects.

(4) **University of Agriculture (UA#3)** in Bac Thai, which has scientists experienced in both crop production and socio-economics.

(5) **Institute of Agriculture Sciences (IAS)** in Ho Chi Minh city, with a large experience on cassava production and some experience in cassava processing (southern coordinator:Pham Van Bien).

(6) **University of Agriculture and Forestry (UAF#4)** in Ho Chi Minh city, has the in-house experience for both agricultural production, socio-economics and data processing aspects (project data coordinator:Pham Thanh Binh).

During the discussions in Hanoi with both political and scientific leaders it was decided that the National Root and Tuber Crops Research Program would take overall project leadership; IAS would have southern Vietnam coordinating responsibility and UAF#4 would have the overall data processing and analyzing responsibility.

Research Methodology

Further discussions with the coordinating institutes focussed on the identification of available resources and took into account the relative comparative advantage of each collaborating institute regarding appropriate available man-power, transport facilities, knowledge of the research areas, etc. CIAT reviewed the resources necessities and committed itself to a major share of the project expenses and the costs of the concluding workshop. In addition, it committed itself to twice-yearly input from the Cassava Program's agronomist and economist.

Next, a general workplan was developed for the execution of the afore-mentioned studies through the following steps:

(a) Study the available secondary data to identify the major issues to be included in the survey.

(b) Organize and execute a Rapid Rural Appraisal (RRA) by a multi-disciplinary team including extension agents to visit the research area and conduct informal interviews with producers/processors/intermediaries/consumers that form the information base for developing the questionnaires.

(c) Develop the questionnaires, and test them in the field, refine them until a final questionnaire results.

(d) Collect secondary data on the "universe" in order to calculate the sample structure and size for the survey. This also includes "pre-stratification".

(e) Form survey teams and train the surveyors in the appropriate contents and methodology of surveying.

(f) Execute the survey.

(g) Collect and check the surveys; codify, computer process and analyze the data.

(h) From the various analyses of the data, distill the major cassava constraints and/or opportunities.

1. Farm Level Production/Processing Survey

Based on the available secondary cassava area data for Vietnam the survey areas were selected. The major criteria was the relative importance of cassava, and the homogeneity vs. heterogeneity of production or processing systems in the areas, in order to develop as "rich" and as representative a data set as possible. This resulted in the following selected agroecological zones:

(1) North Mountainous Region (Northern Highlands and Midlands)

(2) Red River Delta

(3) North Central Coast

(4) South Central Coast

(5) Central Highlands

(6) Southeastern Region

The calculation of the sample size and selection of the sample units were a direct consequence of the available resources. As always in surveying, the trade-off exists between statistical error and available resources. It was decided that in each zone three provinces were to be selected (in addition to one province that was of interest because of its export position); in each province, one to three districts; in each district three villages. In each village, eight cassava production and/or processing households were randomly selected. **Table 1** shows the complete listing of the sample structure and **Figure 2** shows the location of the districts and provinces included in the survey. As mentioned, the final sample unit was a "cassava household". As such a total number of 1117 households were surveyed.

2. Rural, Semi-urban and Urban Marketing and (Semi-urban and Urban) Processing Survey in South Vietnam

While in the afore-mentioned rural household survey all collaborating institutes assisted and covered total Vietnam, this marketing survey was conducted by UAF#4 and covered only several selected southern zones. The selection of the zones was based on specific processing characteristics that were identified in the previous survey and included the following zones:

(1) Ho Chi Minh City (18 interviews)

(2) Southeastern Region (17 interviews)

(3) South Central Coast (27 interviews)

(4) Central Highlands (14 interviews)

This survey was not developed based on a formal questionnaire but rather, interviews were held with key informants. These informants included farmers, (wholesale and retail) traders, middlemen, and (further) processors. A total number of 76 key informants were interviewed.

Table 1. Number of households in each district, province and ecological region included in the cassava production survey in Vietnam.

Region	Province	District	No.of households in		
			district	province	region
North Mountainous Region	4. Ha Tuyen	A. Yen Son	24	48	286
		B. Son Duong	24		
	8. Hoang Lien Son	A. Tran Yen	24	48	
		B. Van Yen	24		
	9. Bac Thai	A. Dong Hy	24	72	
		B. Phu Luong	24		
		C. Bach Thong	24		
	11. Vinh Phu	A. Yen Lap	24	72	
		B. Song Thao	24		
		C. Thanh Hao	24		
	12. Ha Bac	A. Tan Yen	24	46	
		B. Luc Nam	24		
Red River Delta	14. Ha Son Binh	A. Quoc Oai	24	72	96
		B. Chuong My	24		
		C. Luong Son	24		
	15. Hai Hung	A. Chi Linh	24	24	
North Central Coast	19. Nghe An/ Ha Tinh	A. Anh Son	24	72	120
		B. Huong Khe	24		
		C. Nghia Dan	24		
	20. Quang Binh	A. Bo Trach	24	48	
		B. Quang Ninh	24		
Total North Vietnam	**9 provinces**	**21 districts**			**502**
South Central Coast	23. Quang Nam-Da Nang	A. Hoa Vang	24	72	288
		B. Thang Binh	24		
		C. Que Son	24		
	24. Quang Ngai	A. Son Tinh	24	24	
	25. Binh Dinh	A. Phu My	24	48	
		B. Phu Cat	24		
	27. Khanh Hoa	A. Dien Khanh	24	72	
		B. Cam Ranh	24		
		C. Van Ninh	24		
	28. Binh Thuan/ Ninh Thuan	A. Ham Tan	24	72	
		B. Ham Thuan Nam	24		
		C. Phan Thiet	24		
Central Highlands	29. Gia Lai/Kon Tum	A. Play Cu	25	25	100
	30. Dac Lac	A. Buan Ma Thuat	25	25	
	31. Lam Dong	A. Duc Trong	25	50	
		B. Don Duong	25		
Southeastern Region	32. Song Be	A. Dong Phu	40	68	227
		B. Thuan An	28		
	33. Tay Ninh	A. Duong Minh Chau	30	63	
		B. Hoa Thanh	33		
	34. Dong Nai	A. Xuyen Moc	24	96	
		B. Long Thanh	24		
		C. Thung Nhat	24		
		D. Chau Thanh	24		
Total South Vietnam	**11 provinces**	**24 districts**			**615**
Total Vietnam	**20 provinces**	**45 districts**			**1,117**

1. Hanoi
2. Ho Chi Minh
3. Haiphong
→ 4. Ha Tuyen
5. Cao Bang
6. Lang Son
7. Lai Chau
→ 8. Hoang Lien Son
→ 9. Bac Thai
10. Son La
→ 11. Vinh Phu
→ 12. Ha Bac
13. Quang Ninh
→ 14. Ha Son Binh
→ 15. Hai Hung
16. Thai Binh
17. Ha Nam Ninh
18. Thanh Hoa
→ 19. Nghe Tinh
→ 20. Quang Binh
21. Quang Tri
22. Thua Thien
→ 23. Quang Nam Da Nang
→ 24. Quang Nhai
→ 25. Binh Dinh
26. Phu Yen
→ 27. Khanh Hoa
→ 28. Thuan Hai
→ 29. Gia Lai-kon Tum
→ 30. Dac Lac
→ 31. Lam Dong
→ 32. Song Be
→ 33. Tay Ninh
→ 34. Dong Nai
35. Long An
36. Dong Thap
37. An Giang
38. Tien Giang
39. Ben Tre
40. Cuu Long
41. Hau Giang
42. Kien Giang
43. Minh Hai

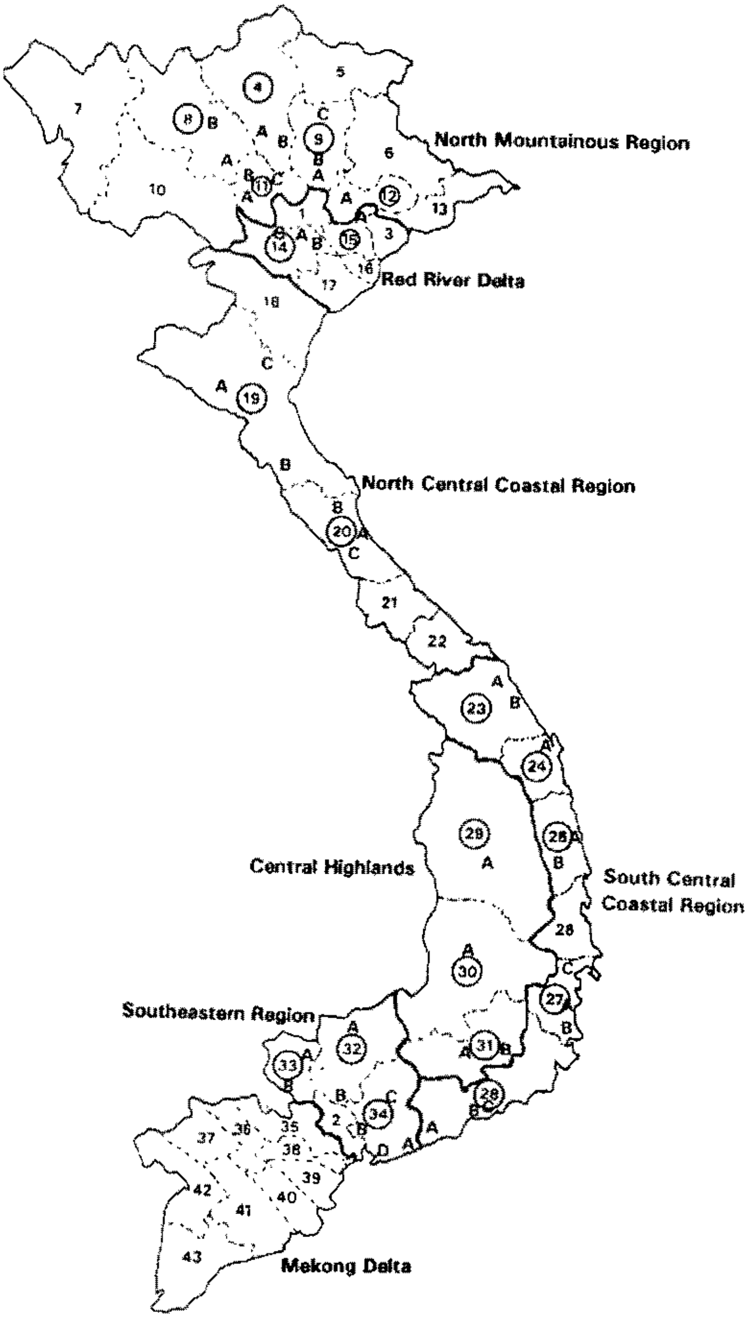

Figure 2. Location of districts, provinces and regions included in Cassava Production Survey (See Table 1).

3. Rural, Semi-urban and Urban Cassava Marketing and Porcessing Survey in North Vietnam

The organization of this survey took much more time since it was difficult to identify experienced socio-economists to coordinate the survey. Finally, the Department of Agricultural Economics at UA#3 took the coordinating role, with collaboration of INSA and the National Root and Tuber Crops Research Program. The survey started late 1991 and was conducted in the following areas:

(1) Ha Bac province (32 respondents)
(2) Bac Thai province (56 respondents)
(3) Vinh Phu province (16 respondents)
(4) Ha Tuyen province (48 respondents)
(5) Hanoi (6 respondents)

The research area was pre-stratified in order to capture highland, medium altitude, and lowland areas. This survey was based on a short formal questionnaire that was directed to farmers, traders, middlemen and processors. A total of 158 questionnaires were completed.

After each survey was completed and the data was checked and cleaned, the questionnaires were sent to UAF#4 to be coded, transcribed and computer analyzed. Preliminary tables were distributed to all project-collaborators. During the summer of 1992 one of the economists of UAF#4 went to CIAT in Colombia to be further trained in the analysis of survey data with SAS-statistical packages for micro-computers. Both production function and factor efficiency analyses were conducted at CIAT. The trainee has now the knowledge and experience to further analyze the Vietnamese cassava data (by farm size, region, etc.) and to analyze future surveys for his university.

After data analysis was completed at UAF#4, collaborators were supplied with complete data sets and tables on their specific areas of interest, in order to write the appropriate research papers for the Cassava Research Workshop. As such, they will present, as teams, the survey data (complemented with secondary data) to inform about the major characteristics of cassava production, processing, marketing and utilization in Vietnam. These papers will form the basis for analyzing cassava constraints and opportunities, which are needed to develop the future Vietnamese cassava research agenda.

THE VIETNAMESE CASSAVA RESEARCH WORKSHOP

In the previous section the organization and implementation of the Vietnamese Cassava Benchmark Study were presented. In this section the set-up of the workshop will be discussed, and related to the Strategic Research Planning methodology, presented in an earlier section.

It was attempted to structure the workshop in such a way as to deal with the relevant questions that need to be posed for a "long-term program formulation", as discussed in the strategic research planning methodology. As such, the opening speech by a representative of MAFI has the objective to present the Vietnamese governments' long-term mission and goals for agricultural development. This is of fundamental importance for (re) defining the objectives of the National Root and Tuber Crops Research Program, which have to be congruent to national objectives.

The following presentations aim to present a clear picture about (some historic and) current cassava practices in Vietnam. In addition, current cassava research issues and priorities are presented at the same time.

The field trip aims to give participants practical knowledge of some cassava production and processing aspects for specific areas (near Hanoi). This will hopefully complement the presentations of the previous day in order to achieve a better understanding of the Vietnamese cassava sector.

The morning session of the third day of the workshop includes presentations by CIAT scientists on different aspects of research activities, organization and planning. This gives the Vietnamese scientists and decision makers an example of how a fellow cassava research program is organized, how it sets its priorities, how it has developed its strategies, and what different topics are being researched and in what manner. It will be of special interest to learn how CIAT's Cassava Program integrates production, processing and marketing research activities, which has been an underlying philosophy of the program, and which has had significant impact.

The last plenary session of the workshop includes two presentations on cassava and sweet potato constraints and opportunities. These presentations each distill their analyses from the respective cassava and sweet potato benchmark studies. Although in the case of sweet potato, no in-depth processing survey has (yet) been conducted, hopefully enough information exists to discuss the most important issues that may exist regarding this area as well. These two papers will serve to discuss the identification of most important areas for future cassava (and sweet potato) research in Vietnam, and set the stage for discussion on priorities of the research topics.

An important aspect that in many countries has been (relatively) neglected, is the role, organization, integration and strategy of technology transfer. As such, this will be discussed in the afternoon session. First a short introductory presentation will be given to summarize the government's (MAFI) philosophy, strategy and organization at the national level, regarding agricultural technology transfer, in general. Secondly, a case example will be given on cassava technology transfer in South Vietnam. Together, these two introductions will serve to lead the discussion on an appropriate strategy and organization of cassava technology transfer for the future. An aspect of great importance is the integration of technology transfer with research institutes (both under MAFI and the Ministry of Education).

The workshop will be concluded with a most important (closed) discussion session on the fourth day that aims to draw the major conclusions from the workshop, and based on these, set out to define the organization of the cassava research agenda (relative to other roots and tubers), taking into account relative comparative advantages of the various institutes, resource availability, mandate areas, etc. It is hoped, that this session will develop a draft proposal on the future (priorized) research agenda and its organization, including an assessment of the "minimal critical mass" of research resources and proposed projects that need additional (outside) funding. In order to advance these discussions, it may be useful to follow the six questions that were stated for the long-term program planning.

The Workshop Proceedings will serve the National Root and Tuber Crops Research Program to argue the relative importance of certain areas of research, lack of resources for specific positions, activities or projects. In addition, these Proceedings can be used to serve as a baseline for program and/or project evaluation in the intermediate and/or long term future.

EXPECTED OUTCOME

As was presented in the second section of this paper, the basic objective of any strategic research planning exercise is to make scarce research resources both more effective and efficient and congruent with both national (government) and other "stakeholders" goals and objectives. Parts of this exercise is the responsibility of research and government decision-makers, while other analyses can be conducted by the scientists themselves. Once the exercise has come to the final stage of developing research projects and the execution of these projects it is expected that this kind of research is the most relevant and has the highest probability of successful adoption and impact.

The efficient re-allocation of research resources will ultimately serve the alleviation of constraints and take advantage of opportunities in the cassava sector, which in turn will improve the well-being of cassava farmers, processors and consumers, of whom we know that they are among the poorest of the country with few alternatives to improve their livelihood. Hence, this Vietnamese strategic research planning exercise will directly benefit our final target-audience.

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CASSAVA CULTIVARS AND BREEDING RESEARCH IN VIETNAM

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ABSTRACT

The results of a cassava cultivar survey revealed a certain regional trend in farmers' use of cultivars. However, four cultivars, i.e. Xanh Vinh Phu, HL-23, HL-20 and HL-24, are widely grown in nearly all parts of the cassava producing regions from the North to the South. One important feature for successful cultivars appears to be the storability of planting material.

The evaluation of indigenous cultivars confirmed the superior yielding ability of HL-20, HL-23, HL-24 and Xanh Vinh Phu over other local cultivars. HL-20, HL-23, HL-24 and Xanh Vinh Phu are all "sweet" cultivars.

A collaborative varietal improvement program with CIAT started in 1988 and clonal and seedling selections of the materials introduced from Thailand and Colombia are now centered at the Hung Loc Research Center of the Institute of Agricultural Science (IAS) in the South and at the Agricultural College No.3 (AC#3) in Bac Thai in the North. A network of on-farm trials was established by IAS in the South and a similar network is being established in the North jointly by AC#3, the Food Crop Research Institute (FCRI) and the Potato and Vegetable Research Center (PVRC) of INSA. Initial results are highly promising in that some advanced Thai clones are showing yielding ability and root starch content far superior to the best local cultivars, both in the experiment stations and in farmers' fields.

It is important to determine whether the Vietnamese cassava production is ready to adopt highly efficient but "bitter" cultivars, which can be selected more readily than dual purpose "sweet" cultivars.

INTRODUCTION

Cassava production in Vietnam probably began at the end of the 18th century. Cassava became an important source of human food all over the country, especially in the highland areas. The cassava production area of Vietnam is among the ten largest in the world, but the national average yield fluctuates between 7 and 10 t/ha, which is far

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below the proven potential of the crop and is among the lowest in Asia. It is believed that soil nutrient exhaustion by continuous plantings of cassava and other field crops is one of the main reasons for the low yields, but whether cassava planting is the cause or the result is not well understood.

Worldwide, cassava for human consumption, either fresh or processed, still occupies the major part of the crop's utilization. Yet, it is the cassava production for factory processing, such as for starch and animal feed, that is rapidly expanding and demanding new production technology for higher efficiency. One of the major objectives of the recent cassava survey in Vietnam is to analyze the present cultivar situation and define the varietal characteristics required in the future.

Before the 1980s, no significant research on cassava varietal improvement had been carried out in Vietnam. Collection of cultivars and their evaluation were conducted during the 1980s by the national institutions, both in the North and South. Cooperation of CIAT with the Institute of Agricultural Sciences of South Vietnam (IAS) began in 1988 and with the Agricultural College No. 3 (AC#3) in Bac Thai in 1989. Recommended cultivars from Thailand, selected clones from the Thai-CIAT breeding program and advanced breeding materials in the form of hybrid seeds have been introduced, both from CIAT/Colombia and from the Thai-CIAT program.

Selection of these materials has been conducted initially at Hung Loc Research Center of IAS in Dong Nai Province and at AC#3; the most advanced materials are now being evaluated in a network of on-farm trials in the South and a similar network is being formed in the North. The Root Crop Improvement Programs at the Food Crop Research Institute in Hai Hung and at the Potato and Vegetable Research Center in Hanoi are now joining this network of evaluation.

Cultivar Distribution

There was no official document on cassava cultivar distribution and their origin. At least 40 cultivars are believed to be planted throughout the country, of which cultivars called Canh Nong in the North and Gon in the South are considered to be the oldest.

As a part of the general cassava survey, names of the cultivars used by each cassava grower were obtained from the questionaires (1,089 farmers) (**Table 1**). As expected, there is a certain regional trend in varietal distribution such that cultivars Mi Trang and Vinh Phu (Xanh Vinh Phu) are predominantly planted in the Red River Delta and in the North Mountainous Region of North Vietnam, respectively, while cultivars H-

34, HL-23, HL-24 and HL-20 are planted mainly in the South Central Coast and the Central Highlands.

One feature of the cassava production scheme, which was revealed by the survey and is much related to the varietal requirement, is storage duration of planting stakes (**Table 2**). Only a small proportion of cassava farmers throughout the country plant cassava using the stakes within one week of storage. On average, some 27% of the farmers surveyed stored their planting stakes for 2 to 4 weeks and 50% for 5 to 12 weeks. In the northern provinces of the Red River Delta, all the farmers surveyed stored the stakes for more than 5 weeks and about 20% stored for more than 12 weeks.

Evaluation of Indigenous Cultivars

The results of the evaluation at Hung Loc Research Center in the South (**Table 3**) and at AC#3 in the North (**Table 4**) revealed that HL-20 (or Gon Long Thanh),HL-24, HL-23 and Vinh Phu (or Xanh Vinh Phu) were among the highest yielders of all the locally available cultivars, both in terms of fresh root yield and in root starch content; this may explain the result of the survey that these cultivars are most widely planted throughout the country.

Probably even more noteworthy is the fact that cultivars HL-20, HL-23, HL-24 and Xanh Vinh Phu are classified as "sweet" cultivars. It is very important to analyze whether:

1. These high-yielding sweet cultivars are planted throughout the country for direct human consumption as a carry-over from the days when most cassava was used for human consumption, or
2. These cultivars are actually functioning as dual-purpose cultivars?

Collaborative Breeding Programs with CIAT

Three years of intensive evaluation of introduced cultivars and selected clones from Thailand at Hung Loc Research Center revealed that, in general, Thai materials are well adapted to the seasonally dry climate of South Vietnam and many of them possess distinctly higher yield capacity and higher root dry matter content (**Table 5**). Selections at Hung Loc Center from hybrid seed introduced from Colombia and Thailand also gave very good results (**Table 6**).

Table 1. Distribution of the most common cassava cultivars planted in Vietnam in 1991 (% of farm households).

Code	Province/Region	Vinh Phu[1]	Mi Trang	Chuoi	Man	Du	Ha Bac	Gon (Mi Do)	H-34	HL-20[2]	HL-23[3]	HL-24[4]	Others
A	**NORTH VIETNAM**	**33.2**	**33.6**	**7.6**	**1.9**	**1.2**	**1.2**	**9.7**	**7.0**	**0.0**	**0.0**	**0.0**	**4.6**
I	**North Mountainous Region**	**51.2**	**16.0**	**12.9**	**0.0**	**1.4**	**1.1**	**7.7**	**0.0**	**0.0**	**0.0**	**0.0**	**9.8**
04	Ha Tuyen	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0
08	Hoang Lien Son	61.2	0.0	12.2	0.0	8.2	2.0	8.2	0.0	0.0	0.0	0.0	8.2
09	Bac Thai	61.1	0.0	34.7	0.0	0.0	2.8	1.4	0.0	0.0	0.0	0.0	0.0
11	Vinh Phu	68.1	0.0	8.3	0.0	0.0	0.0	17.0	0.0	0.0	0.0	0.0	0.0
12	Ha Bac	0.0	99.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
II	**Red River Delta**	**4.2**	**92.7**	**0.0**	**2.1**	**0.0**	**0.0**	**1.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
14	Ha Son Binh	5.6	90.3	0.0	2.8	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.0
15	Hai Hung	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
III	**North Central Coast**	**9.8**	**27.5**	**0.0**	**6.9**	**2.0**	**2.5**	**11.8**	**9.6**	**0.0**	**0.0**	**0.0**	**30.0**
19	Nghe An/Ha Tinh	16.4	29.5	0.0	11.5	3.3	4.9	11.5	8.2	0.0	0.0	0.0	14.7
20	Quang Binh	0.0	24.4	0.0	0.0	0.0	0.0	12.2	12.2	0.0	0.0	0.0	51.2
B	**SOUTH VIETNAM**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**7.9**	**28.5**	**12.5**	**19.7**	**15.3**	**16.1**
IV	**South Central Coast**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**6.6**	**28.2**	**0.0**	**36.3**	**0.7**	**28.2**
23	Quang Nam - Da Nang	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	0.0	69.6	0.0	27.5
24-25	Quang Ngai/Binh Dinh	0.0	0.0	0.0	0.0	0.0	0.0	12.9	15.7	0.0	68.6	0.0	2.9
27	Khanh Hoa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	96.8	0.0	3.2	0.0	0.0
28	Binh Thuan/Ninh Thuan	0.0	0.0	0.0	0.0	0.0	0.0	12.7	4.2	0.0	1.4	2.8	78.0
V	**Central Highlands**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**2.0**	**77.0**	**0.0**	**0.0**	**21.0**	**0.0**
29	Gia Lai/Kon Tum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	50.0	0.0
30	Dac Lac	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0	0.0	0.0	84.0	0.0
31	Lam Dong	0.0	0.0	0.0	0.0	0.0	0.0	4.0	96.0	0.0	0.0	0.0	0.0

Table 1. (Continued).

Code	Province/Region	Vinh Phu[1]	Mi Trang	Chuoi	Man	Du	Ha Bac	Gon (Mi Do)	H-34	HL-20[2]	HL-23[3]	HL-24[4]	Others
VI	**Southeastern Region**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**12.4**	**6.8**	**33.6**	**8.2**	**30.9**	**8.1**
32	Song Be	0.0	0.0	0.0	0.0	0.0	0.0	14.5	1.6	3.2	0.0	55.6	25.1
33	Tay Ninh	0.0	0.0	0.0	0.0	0.0	0.0	11.1	0.0	41.3	6.3	41.0	0.0
34	Dong Nai	0.0	0.0	0.0	0.0	0.0	0.0	11.7	14.9	48.9	14.9	7.4	2.2
	TOTAL VIETNAM	**14.9**	**15.0**	**3.5**	**0.8**	**0.6**	**0.6**	**8.7**	**18.9**	**6.8**	**10.9**	**8.4**	**10.9**

[1] also known as Xanh Vinh Phu

[2] also known as Gon Long Thanh

[3] also known as Trang Thai Lan (Mi Hong)

[4] also known as Tran Thai Lan

Table 2. Storage time of planting stakes in different regions of Vietnam (% in each region).

Region	Storage time in weeks			
	0-1	2-4	5-12	>12
North Mountainous Region	27.2	12.5	51.6	8.7
Red River Delta	0.0	0.0	79.2	20.8
North Central Coast	37.3	45.1	17.7	0.0
South Central Coast	22.3	37.7	39.6	0.4
Central Highlands	2.0	18.0	78.0	2.0
Southeastern Region	8.6	40.5	48.2	2.7
TOTAL VIETNAM	**18.4**	**27.1**	**49.5**	**5.0**

Table 3. Yield potential of local cultivars in South Vietnam[1].

Cultivar (local name)	Collection code	Starch yield (t/ha)	Fresh yield (t/ha)	Starch content (%)
SWEET				
Gon Long Thanh (Mi Trang)	HL-20	8.9	29.8	29.2
Trang Quang Ngai	HL-24	8.5	32.1	26.5
Trang Thai Lan (Mi Hong)	HL-23	7.5	29.8	25.0
Bun Cam Ranh	HL-22	7.2	28.3	25.4
San Nep	HL-12	7.1	24.5	29.1
Ba Thang Bien Hoa	HL-19	6.9	26.3	26.4
Gon Hung Loc	HL-18	6.7	23.5	28.7
Gon Phan Nhann Cu Chi	HL-11	6.2	24.3	25.5
Ba Thang Hoc Mon	HL-16	6.1	24.0	25.3
Ba Thanh Bin Chanh	HL-1	5.9	25.6	23.0
Gon Ha Noi	HL-2	5.6	22.8	24.4
Bun Ham Tan	HL-13	5.2	18.5	28.3
Gon Chia Thuy	HL-15	3.9	15.3	25.6
Gon Binh Duong	HL-17	3.8	13.7	27.7
Mi Gon Cu Chi	HL-10	3.5	17.7	19.5
BITTER				
Mi San Ham Tan	HL-21	7.5	25.0	30.0
Tau Mo	HL-5	6.8	25.6	26.7
An Do Dong Nai	HL-3	5.6	22.9	24.6
An Do Phu Khanh	HL-7	5.2	18.5	27.9
An Do Cam Ranh	HL-8	4.6	18.4	25.0
An Do Binh Doung	HL-14	4.5	16.7	27.0
An Do Ham Tan	HL-9	3.3	15.3	21.5

[1] Data taken from yield trials conducted at Hung Loc Research Center in 1983-1986.

Table 4. Yield potential of local cultivars in North Vietnam[1].

Group	Cultivar (local name)	Collection code	Starch yield (t/ha)	Fresh yield (t/ha)	Starch content (%)
SWEET	Xanh Vinh Phu (Mi Xanh)	VC-2	8.7	29.8	29.2
	Bun Trang	VC-6	7.7	32.1	26.5
	Chuoi Trang	VC-5	7.7	29.8	25.0
	Xanh Ha Bac	VC-3	6.7	28.3	25.4
	Can Nong	VC-1	6.6	24.5	29.1
	Choui Do (Mi Do)	VC-4	6.3	26.3	26.4
	Ha Nam	VC-8	6.1	23.5	28.7
	Trang	VC-9	5.5	24.3	25.5
	Gon	VC-10	5.4	24.0	25.3
	Nghe	VC-7	5.4	25.6	23.0
BITTER	Du	VC-11	8.8	28.8	30.7
	Than Den	VC-15	6.7	24.7	27.3
	SC 202	VC-12	6.1	28.9	26.6
	SC 205 (La Tre)	VC-13	5.9	25.2	23.5
	H-34	VC-14	3.8	15.1	25.5

[1] Data taken from yield trials conducted at AC#3 in 1983-1985.

Table 5. Evaluation of clones introduced from the Thai-CIAT program and evaluated at Hung Loc Research Center[1].

Clone	Origin		Dry root yield (t/ha)	Fresh root yield (t/ha)	RDMC[2] (%)	Total plant weight (t/ha)	HI
	Hybridization	Initial selection					
Kasetsart 50	Thai-CIAT	Thailand	11.5	30.0	38.3	48.4	0.62
Rayong 60	Thailand	Thai-CIAT	10.4	27.4	38.0	44.2	0.60
CM6125-125	CIAT HQ	Thai-CIAT	10.0	27.5	36.3	43.7	0.63
MKUC28-71-66	Thai-CIAT	Thai-CIAT	9.8	25.4	38.6	40.3	0.63
CM4758-29	CIAT HQ	Thai-CIAT	9.3	24.9	37.3	38.9	0.64
CM4231-32	CIAT HQ	Thai-CIAT	9.3	24.4	38.1	36.4	0.67
CM6125-129	CIAT HQ	Thai-CIAT	9.0	24.4	36.9	42.8	0.57
CM6125-117	CIAT HQ	Thai-CIAT	8.3	22.1	37.5	37.5	0.59
Rayong 3	CIAT HQ	Thailand	8.1	20.8	38.9	28.9	0.72
CM5262-27	CIAT HQ	Thai-CIAT	8.0	21.6	37.1	36.6	0.59
CM5257-33	CIAT HQ	Thai-CIAT	7.9	20.9	37.8	30.7	0.68
Rayong 1	Thai Traditional		7.8	20.9	37.4	47.5	0.44
CM5604-21	CIAT HQ	Thai-CIAT	7.2	19.6	36.8	33.2	0.59
HL-24	(Local control)		6.9	19.2	35.9	41.7	0.46
HL-23	(Local control)		5.8	15.9	36.4	28.9	0.55

[1] Mean of three Yield Trials conducted at Hung Loc Research Center, Dong Nai, Vietnam in 1989-1992.

[2] Root dry matter content.

Table 6. Evaluation at Hung Loc Research Center[1], of clones selected from hybrid seed introductions from CIAT/Colombia and the Thai-CIAT program.

Clone	Origin		Dry root yield (t/ha)	Fresh root yield (t/ha)	RDMC[2] (%)
	Hybridization	Selection			
SM981-2	Colombia	Vietnam	12.4	35.5	35.0
SM1095-7	Colombia	Vietnam	11.8	35.5	33.3
OMR32-02-3	Thailand	Vietnam	11.1	31.7	35.1
SM981-3	Colombia	Vietnam	10.9	29.8	35.8
SM1096-10	Colombia	Vietnam	10.4	26.9	38.6
OMR32-06-3	Thailand	Vietnam	9.8	25.1	38.9
OMR32-13-9	Thailand	Vietnam	9.8	26.3	39.2
SM905-2	Colombia	Vietnam	9.3	25.1	37.2
SM1129-2	Colombia	Vietnam	9.3	24.5	38.1
SM1141-5	Colombia	Vietnam	9.1	24.5	37.1
SM1157-1	Colombia	Vietnam	9.1	24.4	37.3
OMR32-31-9	Thailand	Vietnam	8.7	23.0	37.7
SM1157-3	Colombia	Vietnam	7.9	21.3	37.2
SM1135-8	Colombia	Vietnam	7.1	19.2	41.4
HL-24 (Local control)			6.1	17.2	35.5

[1] Data from a Preliminary Yield Trial conducted at Hung Loc Research Center in 1991/92. Only selected clones (14 clones selected from a total of 58 clones) are presented.

[2] Root dry matter content.

Encouraged by these results, some of the most advanced clones were evaluated in a network of on-farm trials and the initial results were very promising (**Table 7**). Equally noteworthy is the fact that the best indigenous selections, i.e. HL-23 and HL-24 showed a higher on-farm yield level than the traditionally most commonly grown cultivar, Gon, while the best CIAT selections, Rayong 60 and CM 6125-125 showed still a higher yield level than HL-23 and HL-24. The results suggest that a step-by-step yield improvement is imminent by using these new cultivars.

Similar progress has been made at AC#3 in the North as well, and initial results indicate that Rayong 60 was significantly better in fresh yield and root dry matter content than the best local cultivar, Vinh Phu (**Table 8**). Rayong 60 and Kasetsart 50 are being evaluated in several on-farm trials jointly managed by AC#3, FCRI and PVRC.

Convincingly promising though these Thai materials are, the majority of them are classified as "bitter", because the Thai cassava industry does not require "sweet" cultivars and no conscious efforts have been made in selecting good "sweet" cultivars in Thailand.

Hence, it is vitally important to determine whether the Vietnamese cassava consumers and processors primarily need dual-purpose cultivars, or whether they are ready to adopt "bitter" cultivars, which may be selected more readily for higher yield, higher starch content and tolerance to adverse conditions.

Table 7. Results of on-farm trials conducted by Hung Loc Research Center in South Vietnam, 1991/92.

Clone	Fresh root yield (t/ha) on the farm of								
	A	B	C	D	E	F	G	H	Mean
Rayong 3	12.3	12.5	13.8	14.2		13.2			13.2
Rayong 60		16.8			17.4		17.2	18.6	17.5
CM5257-33		10.5	12.1	12.1					11.6
CM6125-117	14.7	13.7	16.7	16.4	16.7	15.7			15.7
CM6125-125	17.1	16.2	19.6	18.6	20.0	17.8			18.2
CM6125-129	15.6	13.4	18.4	15.8	15.4	14.6			15.5
MKUC28-71-66	16.4	14.6				16.4			15.8
HL-23			12.6	13.7	12.3		18.0	15.3	14.4
HL-24	10.6		11.8	14.8	14.5	10.4	13.8	12.2	12.6
Gon		11.0				8.4	8.9		9.4

Farmer A; Mr. Nguyen Van Lai
B; Mr. Tran Dan
C; Mr. Tran Van Tai
D; Mr. Nguyen Van Thang
E; Mr. Nguyen Dinh Van
F; Mr. Truong Van Nguon
G; Ms. Nguyen Thi Sam
H; Mr. To Van Minh

Table 8. Evaluation at Agricultural College #3, Bac Thai, North Vietnam, of clones introduced from the Thai-CIAT program[1].

Clone	Parents	Dry root yield (t/ha)	Fresh root yield (t/ha)	RDMC[2] (%)	Total plant weight (t/ha)	HI
Rayong 60	MCol1684xR1	14.6	35.0	41.7	66.0	0.53
Rayong 1		13.1	37.4	34.9	66.4	0.56
Kasetsart 50 (MKUC28-77-3)	R1xR90	12.6	31.1	40.6	68.5	0.45
CM5267-27		11.8	28.7	41.2	67.4	0.42
Vinh Phu (Local control)		11.3	30.9	36.5	48.6	0.63
Rayong 3	MMex55 x MVen307	10.1	27.7	36.3	50.7	0.54
Hanatee		9.1	27.0	36.7	66.7	0.40

[1] Result of a Replicated Yield Trial conducted at AC#3 in 1991.

[2] Root dry matter content.

CASSAVA CULTURAL PRACTICES IN VIETNAM

Pham Van Bien[1], *Hoang Kim*[2] *and R.H. Howeler*[3]

INTRODUCTION

Cassava is the third most important food crop in Vietnam, after rice and maize. The cassava growing area occupies about 300,000 ha, with a mean yield of about 9 t/ha. Cassava is planted in almost every province of Vietnam.

Lying between 8 and 23° latitude N and 102-110° longitude E, Vietnam has been divided into seven ecological regions. Among these, the major cassava producing regions are: The Northern Hilly and Mountainous region, the North and South Central Coastal regions and the South- eastern region, located north of the Mekong Delta.

The average temperature in the cassava producing areas ranges from 22 to 27°C. The temperature is lower in the North where the climate is rather subtropical with cold winters. The average temperature there in the winter fluctuates between 15 and 20°C.

The annual rainfall in the different ecological regions varies from 1500-2500 mm and the dry season extends from 2-4 to 7-8 months. Cassava is a drought tolerant crop, so it can yield 8-10 t/ha even under drought conditions. Almost no farmers irrigate cassava.

Cassava in Vietnam is used principally for domestic consumption, mainly as an animal feed (especially for pigs and chickens). The utilization of cassava for export is only considered in recent years.

Although cassava was introduced to Vietnam about one and a half century ago (in the early part of the 19th century), the traditional cassava cultural practices were developed by farmers during a long period of cultivation.

SURVEY METHODS

The survey on cassava cultural practices was conducted in the six ecological regions, where cassava production is of major importance:

- North Mountainous Region
- Red River Delta

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- North Central Coast
- South Central Coast
- Central Highlands
- Southeastern Region

The survey was conducted in 20 provinces in these six ecological regions. In each province, one to three districts, and in each district three villages were selected, corresponding to the major cassava producing areas. In each village eight cassava households were interviewed.

A group of cassava researchers, which had been trained in the survey methodology, conducted the interviews. The data collected on survey sheets were analyzed by computer. A group of economists from UAF was in charge of data collection and processing for the whole country.

RESULTS

1. Cassava Soil Characteristics

Cassava is a crop for poor people grown on poor soils. **Table 1** shows that in North Vietnam about 68% of the cassava growing area has a rocky soil, while 18 and 12% have clayey and sandy soils, respectively. Rocky soils are particularly prevalent in Ha Son Binh and Ha Bac provinces. In South Vietnam most cassava soils are sandy in the Central Coastal area and in the Southeastern Regions, while rocky soils predominate in Gia Lai-Kon Tum and are also common in Dac Lac province.

In North Vietnam, cassava is grown mainly in areas with ondulating and hilly topography **(Table 2)**. About 89% of cassava in North Vietnam is grown in these kinds of soils. The cassava growing areas in the provinces of the Central Highlands have a similar topography.

In the Southeastern region and the Central Coastal area, cassava is grown mainly on white-grey soils or coastal sandy soils. These regions are flat, poor in nutrients and not suitable for rice cultivation. The cassava growing area in this type of soils occupies more than 70% of total cassava of the South **(Tables 2 and 3)**. This survey does not include the Mekong Delta region where the area devoted to cassava is not very important. However, cassava grows well on acid sulfate soils of the Mekong Delta under conditions of high nitrogen, potassium and organic matter application. Cassava is not affected by aluminium toxicity when grown in these soils.

Table 1. Type of cassava-growing soils (ha).

Code	Province/Region	Total area	Sandy		Silty (loam)		Clayey		Rocky	
			Area	%	Area	%	Area	%	Area	%
A	**NORTH VIETNAM**	**106.06**	**12.26**	**11.6**	**2.46**	**2.3**	**19.06**	**18.0**	**72.28**	**68.1**
I	**North Mountainous Region**	**57.87**	**5.42**	**9.4**	**0.66**	**1.4**	**14.16**	**24.5**	**37.63**	**65.0**
04	Ha Tuyen	9.56	0.00	0.0	0.00	0.0	3.96	41.4	5.60	58.6
08	Hoang Lien Son	11.48	2.48	21.6	0.50	4.4	5.23	45.6	3.27	28.5
09	Bac Thai	20.94	0.82	3.9	0.00	0.0	3.04	14.5	17.08	81.6
11	Vinh Phu	7.65	1.72	22.5	0.00	0.0	1.83	23.9	4.10	53.6
12	Ha Bac	8.24	0.40	4.8	0.16	1.9	0.10	1.2	7.58	92.0
II	**Red River Delta**	**23.00**	**0.75**	**3.3**	**0.00**	**0.0**	**0.00**	**0.0**	**22.25**	**96.7**
14	Ha Son Binh	20.81	0.00	0.0	0.00	0.0	0.00	0.0	20.81	100.0
15	Hai Hung	2.19	0.75	34.2	0.00	0.0	0.00	0.0	1.44	65.7
III	**North Central Coast**	**25.19**	**6.09**	**24.2**	**1.80**	**7.1**	**4.90**	**19.4**	**12.40**	**49.2**
19	Nghe An/Ha Tinh	17.37	2.05	11.8	0.65	3.7	3.00	17.3	11.67	67.2
20	Quang Binh	7.82	4.04	51.7	1.15	14.7	1.90	24.3	0.73	9.3
B	**SOUTH VIETNAM**	**293.70**	**223.58**	**76.1**	**13.27**	**4.5**	**27.86**	**9.5**	**28.99**	**9.9**
IV	**South Central Coast**	**67.30**	**55.01**	**81.7**	**6.24**	**9.3**	**2.15**	**3.2**	**3.90**	**5.8**
23	Quang Nam - Da Nang	8.17	4.68	57.3	0.42	5.1	0.00	0.0	3.07	37.6
24-25	Quang Ngai/Binh Dinh	11.31	10.13	89.6	0.50	4.4	0.05	0.4	0.63	5.6
27	Khanh Hoa	34.96	29.64	84.8	5.32	15.2	0.00	0.0	0.00	0.0
28	Binh Thuan/Ninh Thuan	12.86	10.56	82.1	0.00	0.0	2.10	16.3	0.20	1.6

⇓

Table 1. (Continued).

Code	Province/Region	Total area	Sandy		Silty (loam)		Clayey		Rocky	
			Area	%	Area	%	Area	%	Area	%
V	**Central Highlands**	**38.51**	**0.00**	**0.0**	**0.00**	**0.0**	**20.91**	**54.3**	**17.60**	**45.7**
29	Gia Lai/Kon Tum	14.90	0.00	0.0	0.00	0.0	1.80	12.1	13.10	87.9
30	Dac Lac	8.30	0.00	0.0	0.00	0.0	4.40	53.0	3.90	47.0
31	Lam Dong	15.31	0.00	0.0	0.00	0.0	14.71	96.1	0.60	3.9
VI	**Southeastern Region**	**187.89**	**168.57**	**89.7**	**7.03**	**3.7**	**4.80**	**2.5**	**7.49**	**4.0**
32	Song Be	31.50	31.50	100.0	0.00	0.0	0.00	0.0	0.00	0.0
33	Tay Ninh	95.80	95.80	100.0	0.00	0.0	0.00	0.0	0.00	0.0
34	Dong Nai	60.59	41.27	68.1	7.03	11.6	4.80	7.9	7.49	12.4
	TOTAL VIETNAM	**399.76**	**235.84**	**59.0**	**15.73**	**3.9**	**46.92**	**11.7**	**101.27**	**25.3**

Table 2. Slope of cassava fields (ha).

Code	Province/Region	Total area	Flat		Non-flat	
			Area	%	Area	%
A	**NORTH VIETNAM**	**106.06**	**11.50**	**10.8**	**94.56**	**89.2**
I	**North Mountainous Region**	**57.87**	**3.34**	**5.8**	**54.53**	**94.2**
04	Ha Tuyen	9.56	0.18	1.9	9.38	98.1
08	Hoang Lien Son	11.48	0.10	0.9	11.38	99.1
09	Bac Thai	20.94	0.82	3.9	20.12	96.1
11	Vinh Phu	7.65	2.24	29.3	5.41	70.7
12	Ha Bac	8.24	0.00	0.0	8.24	100.0
II	**Red River Delta**	**23.00**	**1.50**	**6.5**	**21.50**	**93.5**
14	Ha Son Binh	20.81	1.21	5.8	19.60	94.2
15	Hai Hung	2.19	0.29	13.2	1.90	86.8
III	**North Central Coast**	**25.19**	**6.66**	**26.4**	**18.53**	**73.6**
19	Nghe An/Ha Tinh	17.37	3.45	19.9	13.92	80.1
20	Quang Binh	7.82	3.21	41.0	4.61	58.9
B	**SOUTH VIETNAM**	**293.70**	**209.00**	**71.2**	**84.70**	**28.8**
IV	**South Central Coast**	**67.30**	**41.31**	**61.4**	**25.99**	**38.6**
23	Quang Nam - Da Nang	8.18	1.80	22.0	6.37	78.0
24-25	Quang Ngai/Binh Dinh	11.31	10.08	89.1	1.23	10.9
27	Khanh Hoa	34.96	23.32	66.7	11.64	33.3
28	Binh Thuan/Ninh Thuan	12.86	6.11	47.5	6.75	52.5
V	**Central Highlands**	**38.51**	**7.92**	**20.6**	**30.59**	**79.4**
29	Gia Lai/Kon Tum	14.90	0.00	0.0	14.90	100.0
30	Dac Lac	8.30	5.40	65.1	2.90	34.9
31	Lam Dong	15.31	2.52	16.5	12.79	83.5
VI	**Southeastern Region**	**187.89**	**159.77**	**85.0**	**28.12**	**15.0**
32	Song Be	31.50	31.10	98.7	0.40	1.3
33	Tay Ninh	95.80	85.60	89.4	10.20	10.6
34	Dong Nai	60.59	43.07	71.1	17.52	28.9
	TOTAL VIETNAM	**399.76**	**220.50**	**55.2**	**179.26**	**44.8**

Table 3. Color of cassava growing soils (ha).

Code	Province/Region	Total area	White light-grey		Yellow reddish		Dark-brown		Dark-brown black	
			Area	%	Area	%	Area	%	Area	%
A	**NORTH VIETNAM**	**106.06**	**12.99**	**12.2**	**55.83**	**52.6**	**24.68**	**23.3**	**12.38**	**11.7**
I	**North Mountainous Region**	**57.87**	**6.38**	**11.0**	**30.78**	**53.2**	**13.74**	**23.7**	**6.79**	**11.7**
04	Ha Tuyen	9.56	0.10	1.0	8.50	88.9	0.78	8.2	0.00	1.9
08	Hoang Lien Son	11.48	0.10	0.9	8.46	73.7	2.70	23.5	0.22	1.9
09	Bac Thai	20.94	4.31	20.6	9.35	44.6	3.70	17.7	3.58	17.1
11	Vinh Phu	7.65	1.87	24.4	4.31	56.3	1.36	17.8	0.11	1.4
12	Ha Bac	8.24	0.00	0.0	0.16	1.9	5.20	63.1	2.88	34.9
II	**Red River Delta**	**23.00**	**0.92**	**4.0**	**8.67**	**37.7**	**10.54**	**45.8**	**2.87**	**12.5**
14	Ha Son Binh	20.81	0.70	3.4	7.20	34.6	10.26	49.3	2.65	12.7
15	Hai Hung	2.19	0.22	10.0	1.47	67.1	0.28	12.8	0.22	10.0
III	**North Central Coast**	**25.19**	**5.69**	**22.6**	**16.38**	**65.0**	**0.40**	**1.6**	**2.72**	**10.8**
19	Nghe An/Ha Tinh	17.37	0.85	4.9	14.00	80.6	0.30	1.7	2.22	12.8
20	Quang Binh	7.82	4.84	61.9	2.38	30.4	0.10	1.3	0.50	6.4
B	**SOUTH VIETNAM**	**293.70**	**218.86**	**74.5**	**26.88**	**9.1**	**38.42**	**13.1**	**9.54**	**3.2**
IV	**South Central Coast**	**67.30**	**57.46**	**85.4**	**6.51**	**9.7**	**2.93**	**4.3**	**0.40**	**0.6**
23	Quang Nam - Da Nang	8.17	5.87	71.8	2.20	26.9	0.00	0.0	0.10	1.2
24-25	Quang Ngai/Binh Dinh	11.31	10.54	93.2	0.74	6.5	0.03	0.3	0.00	0.0
27	Khanh Hoa	34.96	30.29	86.6	3.57	10.2	1.00	2.9	0.10	0.3
28	Binh Thuan/Ninh Thuan	12.86	10.76	83.7	0.00	0.0	1.90	14.8	0.20	1.6

Table 3. (Continued).

Code	Province/Region	Total area	White light-grey		Yellow reddish		Dark-brown		Dark-brown black	
			Area	%	Area	%	Area	%	Area	%
A	**NORTH VIETNAM**	**106.06**	**12.99**	**12.2**	**55.83**	**52.6**	**24.68**	**23.3**	**12.38**	**11.7**
V	Central Highlands	38.51	0.00	0.0	1.80	4.7	29.71	77.1	7.00	18.2
29	Gia Lai/Kon Tum	14.90	0.00	0.0	0.80	5.4	7.10	47.6	7.00	47.0
30	Dac Lac	8.30	0.00	0.0	0.00	0.0	8.30	100.0	0.00	0.0
31	Lam Dong	15.31	0.00	0.0	1.00	6.5	14.31	93.5	0.00	0.0
VI	**Southeastern Region**	**187.89**	**161.40**	**85.9**	**18.57**	**9.9**	**5.78**	**3.1**	**2.14**	**1.1**
32	Song Be	31.50	31.50	100.0	0.00	0.0	0.00	0.0	0.00	0.0
33	Tay Ninh	95.80	95.80	100.0	0.00	0.0	0.00	0.0	0.00	0.0
34	Dong Nai	60.59	34.10	56.3	18.57	30.6	5.78	9.5	2.14	3.5
	TOTAL VIETNAM	**399.76**	**231.85**	**58.0**	**82.71**	**20.7**	**63.10**	**15.8**	**21.92**	**5.5**

Due to these marked differences in cassava soil characteristics, research in the North should concentrate on erosion problems and soil fertility enhancement, whereas in the South the study on cassava soil improvement and conservation by using intercropping systems is of highest priority.

2. Land Preparation

Table 4 shows that cassava land preparation methods vary among agro-ecological regions. On the sloping soils of the mountainous regions of both North and South Vietnam, most cassava fields are plowed once, while in the Red River Delta and the North and South Coastal regions they are plowed twice. Especially in some cassava areas under intensive cultivation, such as in Ha Son Binh and Quang Binh provinces, many farmers plow their cassava fields up to three times.

After plowing, most of the farmers harrow their land once in the South, once or twice in the North, but 3-4 times in Ha Son Binh and Quang Bỉnh provinces **(Table 5)**. However, more than half of all farmers in both North and South Vietnam do not harrow their fields at all, but plant directly after plowing or manual land preparation.

Nearly all tillage for cassava is done by hand or with animals. Only in some provinces of South Vietnam (Lam Dong, Tay Ninh, Song Be and Dong Nai) cassava land cultivation is done with tractors **(Tables 4 and 5)**.

According to cultural traditions of each region, farmers plant cassava on ridges or on the flat **(Table 6)**. In both North and South Vietnam about 50% of the cassava area is planted on ridges and 50% on the flat. However, large differences exist among provinces, with farmers in some provinces, like Hai Hung, Ha Son Binh and Quang Nam-Da Nang, planting predominantly on ridges, while those in Gia Lai-Kon Tum, Dac Lac, Ha Tuyen and Bac Thai planting predominantly on the flat. However, in production and experimental plots the two different cassava planting methods did not show any significant difference in yield. The ridge planting seems to be more suitable in heavy soils or on light grey and sandy soils, poor in nutrients. On relatively good soils, flat planting may produce higher yields due to better land use.

3. Planting Time

The planting time is variable, depending on local climatic conditions and cropping patterns **(Figure 1 and Table 7)**. Generally, farmers plant cassava either at the beginning (first or second semester) or at the end (4th semester) of the rainy season.

In the provinces of the North Mountainous Region and the Red River Delta, the planting is done from February to April, when soil moisture increases due to spring rains. However, the low temperature in February is a limiting factor, so in many areas cassava planted in March produces better growth and higher yields.

In the north part of the Central Coastal region, planting usually starts at the end of the year (November-December), while in the South Central Coast and the Central Highlands cassava planting is generally done in the first semester and the harvest takes place from August to October before the height of the rainy season, which may cause flooding.

In the Southeastern Region, cassava is generally planted in the second semester, at the beginning of the rainy season (April-May), but in Tay Ninh province most cassava is planted at the end of the rainy season (October).

Table 4. Number of times of plowing and power source used (% of farmers).

Code	Province/Region	Number of times					Power source			
		0	1	2	3	4	Manual	Animal	Tractor	Combination
A	**NORTH VIETNAM**	**0.2**	**53.1**	**37.2**	**9.1**	**0.4**	**41.2**	**58.0**	**0.6**	**0.2**
I	**North Mountainous Region**	**0.3**	**74.5**	**23.4**	**1.7**	**0.0**	**56.6**	**43.4**	**0.0**	**0.0**
04	Ha Tuyen	0.0	85.4	14.6	0.0	0.0	63.0	37.0	0.0	0.0
08	Hoang Lien Son	0.0	93.8	6.2	0.0	0.0	95.3	4.6	0.0	0.0
09	Bac Thai	0.0	90.2	9.8	0.0	0.0	75.4	24.6	0.0	0.0
11	Vinh Phu	0.0	52.1	42.2	5.6	0.0	31.0	69.0	0.0	0.0
12	Ha Bac	2.1	52.2	43.5	2.2	0.0	19.6	78.3	0.0	0.0
II	**Red River Delta**	**0.0**	**24.0**	**51.0**	**25.0**	**0.0**	**12.5**	**87.5**	**0.0**	**0.0**
14	Ha Son Binh	0.0	13.9	52.8	33.3	0.0	16.6	83.3	0.0	0.0
15	Hai Hung	0.0	54.2	45.8	0.0	0.0	0.0	100.0	0.0	0.0
III	**North Central Coast**	**0.0**	**20.6**	**62.7**	**14.7**	**2.0**	**27.5**	**69.2**	**2.5**	**0.8**
19	Nghe An/Ha Tinh	0.0	21.3	75.4	3.3	0.0	26.4	69.5	4.1	0.0
20	Quang Binh	0.0	19.5	43.9	31.7	4.9	29.3	68.3	0.0	2.4
B	**SOUTH VIETNAM**	**2.0**	**46.0**	**52.0**	**0.0**	**0.0**	**28.5**	**62.8**	**7.9**	**0.7**
IV	**South Central Coast**	**0.0**	**26.0**	**74.0**	**0.0**	**0.0**	**19.1**	**78.8**	**2.1**	**0.0**
23	Quang Nam - Da Nang	0.0	4.3	95.6	0.0	0.0	11.6	88.4	0.0	0.0
24-25	Quang Ngai/Binh Dinh	0.0	27.1	72.9	0.0	0.0	15.7	84.3	0.0	0.0
27	Khanh Hoa	0.0	31.8	68.2	0.0	0.0	0.0	97.7	2.3	0.0
28	Binh Thuan/Ninh Thuan	0.0	40.8	59.1	0.0	0.0	49.3	45.1	5.6	0.0

Table 4. (Continued).

Code	Province/Region	Number of times					Power source			
		0	1	2	3	4	Manual	Animal	Tractor	Combination
V	**Central Highlands**	**0.0**	**64.0**	**36.0**	**0.0**	**0.0**	**28.0**	**56.0**	**16.0**	**0.0**
29	Gia Lai/Kon Tum	0.0	16.0	84.0	0.0	0.0	4.0	96.0	0.0	0.0
30	Dac Lac	0.0	100.0	0.0	0.0	0.0	31.6	68.4	0.0	0.0
31	Lam Dong	0.0	70.4	29.5	0.0	0.0	38.6	29.5	31.8	0.0
VI	Southeastern Region	5.4	75.3	19.1	0.0	0.0	40.6	46.1	11.4	1.8
32	Song Be	0.0	85.5	14.5	0.0	0.0	14.9	66.0	12.8	6.4
33	Tay Ninh	0.0	66.7	33.3	0.0	0.0	0.0	84.1	15.9	0.0
34	Dong Nai	12.8	74.4	12.8	0.0	0.0	85.1	7.4	7.4	0.0
	TOTAL VIETNAM	**1.2**	**49.2**	**45.4**	**4.1**	**0.1**	**34.2**	**60.7**	**4.6**	**0.5**

Table 5. Number of times of harrowing and power source used (% of farmers).

Code	Province/Region	Number of times					Power source[1]		
		0	1	2	3	4	Manual	Animal	Tractor
A	**NORTH VIETNAM**	**52.2**	**22.5**	**20.1**	**3.8**	**1.4**	**7.4**	**39.8**	**0.6**
I	**North Mountainous Region**	**64.7**	**31.1**	**4.2**	**0.0**	**0.0**	**7.3**	**28.0**	**0.0**
04	Ha Tuyen	56.0	39.5	4.5	0.0	0.0	6.5	37.5	0.0
08	Hoang Lien Son	97.7	0.0	2.3	0.0	0.0	0.0	2.3	0.0
09	Bac Thai	78.5	21.5	0.0	0.0	0.0	0.0	21.5	0.0
11	Vinh Phu	37.5	58.3	4.2	0.0	0.0	5.6	56.9	0.0
12	Ha Bac	58.7	28.3	13.0	0.0	0.0	30.4	10.9	0.0
II	**Red River Delta**	**56.2**	**11.5**	**20.8**	**6.2**	**5.2**	**0.0**	**43.8**	**0.0**
14	Ha Son Binh	45.6	11.1	27.9	8.8	7.3	0.0	54.4	0.0
15	Hai Hung	87.5	12.5	0.0	0.0	0.0	0.0	12.5	0.0
III	**North Central Coast**	**19.2**	**10.8**	**57.5**	**10.8**	**1.7**	**13.3**	**65.0**	**2.5**
19	Nghe An/Ha Tinh	13.8	12.5	68.0	4.2	1.4	15.4	66.6	4.2
20	Quang Binh	26.8	7.3	41.5	21.9	2.4	9.8	63.4	0.0
B	**SOUTH VIETNAM**	**55.2**	**35.0**	**7.0**	**0.0**	**0.0**	**4.6**	**37.2**	**4.6**
IV	**South Central Coast**	**56.2**	**27.1**	**7.3**	**0.0**	**0.0**	**9.4**	**34.4**	**0.0**
23	Quang Nam - Da Nang	40.6	27.5	0.0	0.0	0.0	31.9	27.5	0.0
24-25	Quang Ngai/Binh Dinh	11.4	57.1	26.4	0.0	0.0	5.7	82.9	0.0
27	Khanh Hoa	97.7	0.0	2.3	0.0	0.0	0.0	2.3	0.0
28	Binh Thuan/Ninh Thuan	76.4	23.6	0.0	0.0	0.0	0.0	23.6	0.0

Table 5. (Continued).

Code	Province/Region	Number of times					Power source[1]		
		0	1	2	3	4	Manual	Animal	Tractor
V	**Central Highlands**	**41.0**	**53.0**	**6.0**	**0.0**	**0.0**	**1.0**	**42.0**	**16.0**
29	Gia Lai/Kon Tum	0.0	96.0	4.0	0.0	0.0	0.0	100.0	0.0
30	Dac Lac	84.2	15.8	0.0	0.0	0.0	0.0	15.8	0.0
31	Lam Dong	40.9	50.0	10.0	0.0	0.0	2.3	26.0	31.8
VI	**Southeastern Region**	**55.9**	**37.0**	**7.0**	**0.0**	**0.0**	**0.0**	**38.8**	**5.3**
32	Song Be	53.2	38.3	8.5	0.0	0.0	0.0	44.7	2.1
33	Tay Ninh	0.0	66.7	33.3	0.0	0.0	0.0	84.1	0.0
34	Dong Nai	94.9	5.1	0.0	0.0	0.0	0.0	5.1	0.0
	TOTAL VIETNAM	**53.0**	**29.4**	**12.9**	**1.7**	**0.6**	**5.8**	**38.4**	**2.8**

[1] Numbers do not add up to 100% since many farmers do not harrow their fields (see first column).

Table 6. Method of planting.

		On ridges		On the flat		Other	
Code	Province/Region	No.of farmers	%	No.of farmers	%	No.of farmers	%
A	**NORTH VIETNAM**	**218**	**45.7**	**243**	**50.9**	**16**	**3.4**
I	**North Mountainous Region**	**59**	**20.9**	**207**	**73.4**	**16**	**5.7**
04	Ha Tuyen	2	4.3	44	95.6	0	0.0
08	Hoang Lien Son	2	4.2	30	62.5	16	33.3
09	Bac Thai	8	11.3	63	88.7	0	0.0
11	Vinh Phu	21	29.6	50	70.4	0	0.0
12	Ha Bac	26	56.5	20	43.5	0	0.0
II	**Red River Delta**	**87**	**91.6**	**8**	**8.4**	**0**	**0.0**
14	Ha Son Binh	64	88.9	8	11.1	0	0.0
15	Hai Hung	23	100.0	0	0.0	0	0.0
III	**North Central Coast**	**72**	**72.0**	**28**	**28.0**	**0**	**0.0**
19	Nghe An/Ha Tinh	33	55.9	26	44.1	0	0.0
20	Quang Binh	39	95.1	2	4.9	0	0.0
B	**SOUTH VIETNAM**	**282**	**47.5**	**310**	**52.3**	**1**	**0.2**
IV	**South Central Coast**	**170**	**62.3**	**102**	**37.4**	**1**	**0.4**
23	Quang Nam - Da Nang	68	98.5	1	1.4	0	0.0
24-25	Quang Ngai/Binh Dinh	18	25.7	52	74.3	0	0.0
27	Khanh Hoa	21	33.3	41	65.1	1	1.6
28	Binh Thuan/Ninh Thuan	63	88.7	8	11.3	0	0.0
V	**Central Highlands**	**24**	**24.0**	**76**	**76.0**	**0**	**0.0**
29	Gia Lai/Kon Tum	0	0.0	25	100.0	0	0.0
30	Dac Lac	1	4.0	24	96.0	0	0.0
31	Lam Dong	23	46.0	27	54.0	0	0.0
VI	**Southeastern Region**	**88**	**40.0**	**132**	**60.0**	**0**	**0.0**
32	Song Be	8	12.7	55	87.3	0	0.0
33	Tay Ninh	58	92.1	5	7.9	0	0.0
34	Dong Nai	22	23.4	72	76.6	0	0.0
	TOTAL VIETNAM	**500**	**46.7**	**553**	**51.7**	**17**	**0.6**

Table 7. Time of planting.

Code	Province/Region	Total No.of farmers	1st semester		2nd semester		3rd semester		4th semester	
			No.of farmers	%	No.of farmers	%	No.of farmers	%	No.of farmers	%
A	**NORTH VIETNAM**	**484**	**340**	**70.2**	**2**	**0.4**	**6**	**1.2**	**136**	**28.1**
I	**North Mountainous Region**	**286**	**240**	**83.9**	**1**	**0.3**	**0**	**0.0**	**45**	**15.7**
04	Ha Tuyen	48	47	97.9	0	0.0	0	0.0	1	2.1
08	Hoang Lien Son	49	15	30.6	1	2.0	0	0.0	33	67.3
09	Bac Thai	72	65	90.3	0	0.0	0	0.0	7	9.7
11	Vinh Phu	71	71	100.0	0	0.0	0	0.0	0	0.0
12	Ha Bac	46	42	91.3	0	0.0	0	0.0	4	8.7
II	**Red River Delta**	**96**	**74**	**77.1**	**0**	**0.0**	**0**	**0.0**	**22**	**22.9**
14	Ha Son Binh	72	50	69.4	0	0.0	0	0.0	22	30.6
15	Hai Hung	24	24	100.0	0	0.0	0	0.0	0	0.0
III	**North Central Coast**	**102**	**26**	**25.5**	**1**	**1.0**	**6**	**5.9**	**69**	**67.6**
19	Nghe An/Ha Tinh	61	25	41.0	1	1.6	5	8.2	30	49.2
20	Quang Binh	41	1	2.4	0	0.0	1	2.4	39	95.1
B	**SOUTH VIETNAM**	**592**	**254**	**42.9**	**235**	**39.7**	**30**	**5.1**	**73**	**12.3**
IV	**South Central Coast**	**273**	**132**	**48.3**	**97**	**35.5**	**15**	**5.5**	**29**	**10.6**
23	Quang Nam-Da Nang	69	55	79.7	10	14.5	3	4.3	1	1.4
24-25	Quang Ngai/Binh Dinh	70	42	60.0	0	0.0	0	0.0	28	40.0
27	Khanh Hoa	63	35	55.6	28	44.4	0	0.0	0	0.0

Table 7. (Continued).

Code	Province/Region	Total No.of farmers	1st semester		2nd semester		3rd semester		4th semester	
			No.of farmers	%	No.of farmers	%	No.of farmers	%	No.of farmers	%
28	Binh Thuan/Ninh Thuan	71	0	0.0	59	83.1	12	16.9	0	0.0
V	**Central Highlands**	**100**	**62**	**62.0**	**38**	**38.0**	**0**	**0.0**	**0**	**0.0**
29	Gia Lai/Kon Tum	25	0	0.0	25	100.0	0	0.0	0	0.0
30	Dac Lac	25	16	64.0	9	36.0	0	0.0	0	0.0
31	Lam Dong	50	46	92.0	4	8.0	0	0.0	0	0.0
VI	**Southeastern Region**	**219**	**60**	**27.4**	**100**	**45.7**	**15**	**6.8**	**44**	**20.1**
32	Song Be	62	18	29.0	37	59.7	6	9.7	1	1.6
33	Tay Ninh	63	2	3.2	15	23.8	9	14.3	37	58.7
34	Dong Nai	94	40	42.5	48	51.1	0	0.0	6	6.4
	TOTAL VIETNAM	**1,076**	**594**	**55.2**	**237**	**22.0**	**36**	**3.3**	**209**	**19.4**

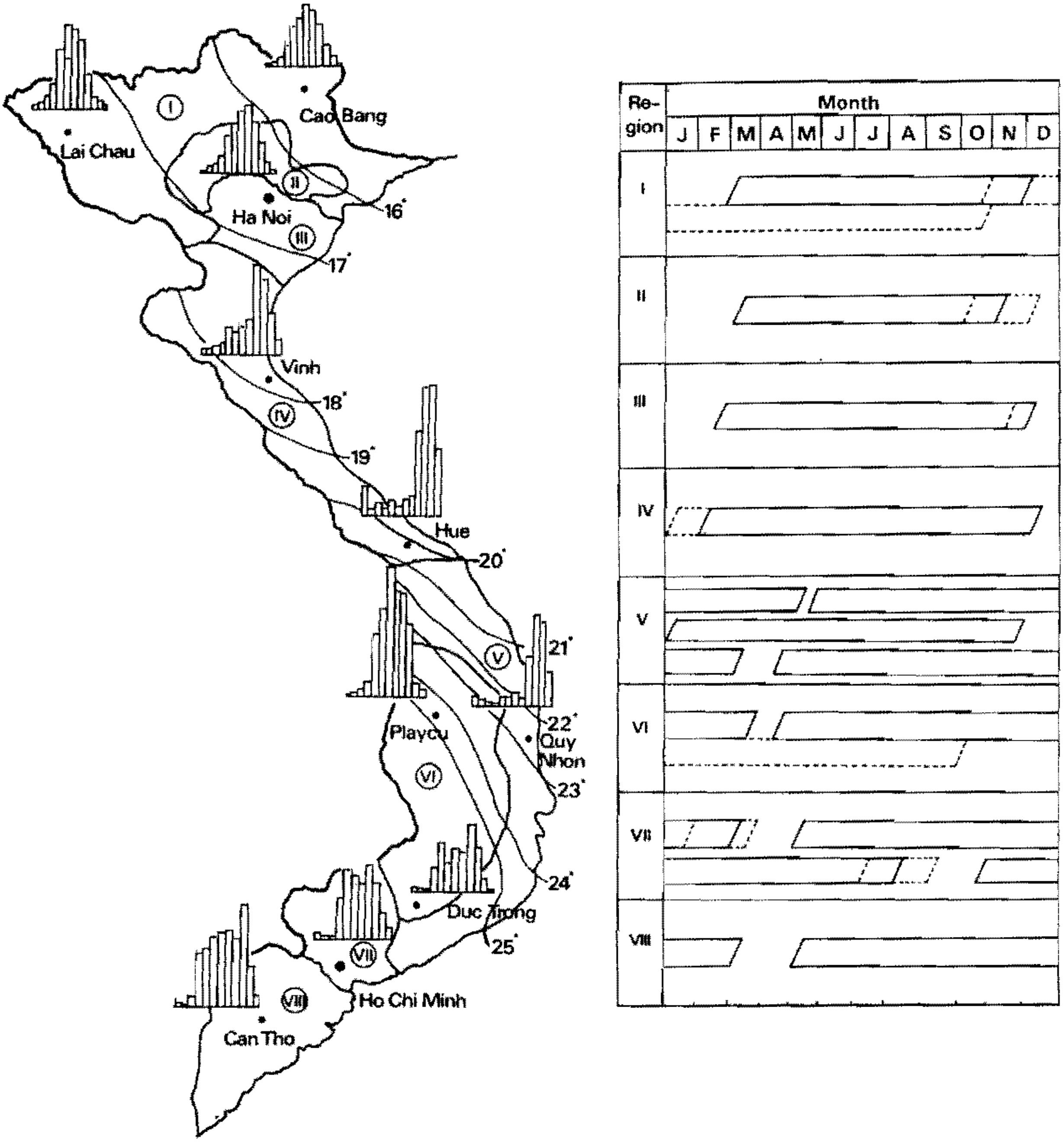

Figure 1. Cassava cropping times in eight agro-ecological regions of Vietnam. Dotted lines in diagram indicate the earliest or latest harvesting dates of cassava (from Cassava Production Survey, 1990/91). Map indicates isotherms for the temperature during January, as well as the rainfall distribution in various locations (adapted from Khi Hau Vietnam, 1987).

4. Stake Preparation and Storage

Almost in every region farmers use their own cassava stems for planting. Only a few buy their stakes, mainly the medium- and large-scale farmers of Tay Ninh and Khanh Hoa provinces **(Table 8)**. Stake quality also influences cassava growth and yield.

At the cassava harvest, long stems of 10 to 12 month old plants, free of diseases and insects are selected to cut stakes. The duration of stake storage varies from <1 to >12 weeks, depending on the harvesting time and the time of planting the next cassava crop **(Table 9)**.

In the provinces of the North Mountainous Region and the Central Coastal Regions, many farmers plant stakes taken from cassava stems harvested during the previous month. But in parts of the North Mountainous Region, in the Red River Delta, in the Central Highlands and the Southeastern Region cassava stakes are normally stored 5-12 weeks before planting **(Table 9)**.

If it is necessary to store stakes for a long time, most farmers place stems, tied in bundles, in a vertical position in a shaded area under trees or cover the stems with leaves to keep them fresh and viable.

Under conditions of reduced sunlight and low temperature of the North, some farmers store stems horizontally in an open field and still maintain good quality **(Table 10)**. However, the majority of farmers in both North and South Vietnam store stems in a vertical position in the shade.

5. Planting Method

Table 11 shows that most of the farmers in Vietnam plant stakes horizontally (76% in the North, 68% in the South). This planting method is suitable mainly on poor soils with a thin surface soil. This method maintains adequate moisture in the stakes for sprouting and for root development at the early stage.

Vertical planting is used by farmers of a few provinces such as Quang Binh, Quang Nam-Da Nang and Lam Dong, where the planting is done at the end of the wet season with heavy rain and high moisture content in the soil.

In many regions, mainly in the Central Coastal Region and the Central Highlands, farmers plant stakes in a slanted position to combine the advantages of the two previous planting methods. In a slanted planting position cassava has a relatively good root development, it can take full advantage of the soil depth and generally produces high yields, especially in areas where the surface soil is deep. Slanted planting is done mainly

Table 8. Source of cassava stakes according to farm size.

		Small scale (<0.6 ha)				Medium scale (0.6-1.05 ha)				Large scale (>1.05 ha)			
Code	Province/Region	Total No.of farmers	Prod.at farm (%)	Bought (%)	Other (%)	Total No.of farmers	Prod.at farm (%)	Bought (%)	Other (%)	Total No.of farmers	Prod.at farm (%)	Bought (%)	Other (%)
A	**North Vietnam**	**440**	**97.7**	**0.5**	**1.8**	**41**	**100.0**	**0.0**	**0.0**	**4**	**100.0**	**0.0**	**0.0**
I	**North Mountainous Region**	**269**	**100.0**	**0.0**	**0.0**	**16**	**100.0**	**0.0**	**0.0**	**2**	**100.0**	**0.0**	**0.0**
04	Ha Tuyen	45	100.0	0.0	0.0	3	100.0	0.0	0.0	0	0.0	0.0	0.0
08	Hoang Lien Son	44	100.0	0.0	0.0	5	100.0	0.0	0.0	0	0.0	0.0	0.0
09	Bac Thai	62	100.0	0.0	0.0	8	100.0	0.0	0.0	2	100.0	0.0	0.0
11	Vinh Phu	72	100.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
12	Ha Bac	46	100.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
II	**Red River Delta**	**82**	**98.8**	**1.2**	**0.0**	**13**	**100.0**	**0.0**	**0.0**	**1**	**100.0**	**0.0**	**0.0**
14	Ha Son Binh	58	98.3	1.7	0.0	13	100.0	0.0	0.0	1	100.0	0.0	0.0
15	Hai Hung	24	100.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
III	**North Central Coast**	**89**	**89.9**	**1.1**	**9.0**	**12**	**100.0**	**0.0**	**0.0**	**1**	**100.0**	**0.0**	**0.0**
19	Nghe An/Ha Tinh	49	100.0	0.0	0.0	11	100.0	0.0	0.0	1	100.0	0.0	0.0
20	Quang Binh	40	77.5	2.5	20.0	1	100.0	0.0	0.0	0	0.0	0.0	0.0
B	**South Vietnam**	**386**	**94.6**	**0.8**	**4.7**	**151**	**85.4**	**11.9**	**2.6**	**56**	**89.3**	**10.7**	**0.0**
IV	**South Central Coast**	**234**	**93.6**	**0.4**	**6.0**	**31**	**96.8**	**3.2**	**0.0**	**8**	**87.5**	**12.5**	**0.0**
23	Quang Nam-Da Nang	69	100.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0

⇓

Table 8. (Continued).

		Small scale (<0.6 ha)				Medium scale (0.6-1.05 ha)				Large scale (>1.05 ha)			
Code	Province/Region	Total No.of farmers	Prod.at farm (%)	Bought (%)	Other (%)	Total No.of farmers	Prod.at farm (%)	Bought (%)	Other (%)	Total No.of farmers	Prod.at farm (%)	Bought (%)	Other (%)
24-25	Quang Ngai/Binh Dinh	70	80.0	0.0	20.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
27	Khanh Hoa	27	96.3	3.7	0.0	28	96.4	3.6	0.0	8	87.5	12.5	0.0
28	Binh Thuan/Ninh Thuan	68	100.0	0.0	0.0	3	100.0	0.0	0.0	0	0.0	0.0	0.0
V	**Central Highlands**	**73**	**98.6**	**1.4**	**0.0**	**24**	**95.8**	**4.2**	**0.0**	**3**	**100.0**	**0.0**	**0.0**
29	Gia Lai/Kon Tum	13	92.3	7.7	0.0	10	90.0	10.0	0.0	2	100.0	0.0	0.0
30	Dac Lac	19	100.0	0.0	0.0	6	100.0	0.0	0.0	0	0.0	0.0	0.0
31	Lam Dong	41	100.0	0.0	0.0	8	100.0	0.0	0.0	1	100.0	0.0	0.0
VI	**Southeastern Region**	**79**	**93.7**	**1.3**	**5.1**	**96**	**79.2**	**16.7**	**4.2**	**45**	**88.9**	**11.1**	**0.0**
32	Song Be	39	89.7	0.0	10.3	19	73.7	10.0	15.8	5	100.0	0.0	0.0
33	Tay Ninh	1	100.0	0.0	0.0	37	70.3	29.7	0.0	25	80.0	20.0	0.0
34	Dong Nai	29	97.4	2.6	0.0	40	90.0	7.5	2.5	15	100.0	0.0	0.0
	TOTAL VIETNAM	**826**	**96.2**	**0.6**	**3.1**	**192**	**88.5**	**9.4**	**2.1**	**60**	**90.0**	**10.0**	**0.0**

Table 9. Storage time of cassava stakes.

		0-1 Week		2-4 Weeks		5-12 Weeks		>12 Weeks	
Code	Province/Region	No.of farms	(%)	No.of farms	(%)	No.of farms	(%)	No.of farms	(%)
A	**NORTH VIETNAM**	**116**	**23.9**	**82**	**16.9**	**242**	**49.5**	**45**	**9.3**
I	**North Mountainous Region**	**78**	**27.2**	**36**	**12.5**	**148**	**51.6**	**25**	**8.7**
04	Ha Tuyen	12	25.0	11	22.9	24	50.0	1	2.1
08	Hoang Lien Son	39	79.6	9	18.4	1	2.0	0	0.0
09	Bac Thai	26	36.1	0	0.0	46	63.9	0	0.0
11	Vinh Phu	0	0.0	16	22.2	32	44.4	24	33.3
12	Ha Bac	1	2.2	0	0.0	45	97.8	0	0.0
II	**Red River Delta**	**0**	**0.0**	**0**	**0.0**	**76**	**79.2**	**20**	**20.8**
14	Ha Son Binh	0	0.0	0	0.0	58	80.6	14	19.4
15	Hai Hung	0	0.0	0	0.0	18	75.0	6	25.0
III	**North Central Coast**	**38**	**37.2**	**46**	**45.1**	**18**	**17.6**	**0**	**0.0**
19	Nghe An/Ha Tinh	21	34.4	24	39.3	16	26.2	0	0.0
20	Quang Binh	17	41.5	22	53.7	2	4.9	0	0.0
B	**SOUTH VIETNAM**	**82**	**13.8**	**210**	**35.4**	**292**	**49.2**	**9**	**1.5**
IV	**South Central Coast**	**61**	**22.3**	**103**	**37.7**	**108**	**39.6**	**1**	**0.4**
23	Quang Nam - Da Nang	26	37.7	42	60.9	1	1.4	0	0.0
24-25	Quang Ngai/Binh Dinh	17	24.3	38	54.3	14	20.0	1	1.4
27	Khanh Hoa	1	1.6	17	27.0	45	71.4	0	0.0
28	Binh Thuan/Ninh Thuan	17	23.9	6	8.4	48	67.6	0	0.0
V	**Central Highlands**	**2**	**2.0**	**18**	**18.0**	**78**	**78.0**	**2**	**2.0**
29	Gia Lai/Kon Tum	0	0.0	0	0.0	25	100.0	0	0.0
30	Dac Lac	0	0.0	6	24.0	19	76.0	0	0.0
31	Lam Dong	2	4.0	12	24.0	34	68.0	2	4.0
VI	**Southeastern Region**	**19**	**8.6**	**89**	**40.4**	**106**	**48.2**	**6**	**2.7**
32	Song Be	12	19.0	23	36.5	27	42.9	1	1.6
33	Tay Ninh	3	4.8	52	82.5	8	12.7	0	5.3
34	Dong Nai	4	4.3	14	14.9	71	75.5	5	5.3
	TOTAL VIETNAM	**198**	**18.4**	**292**	**27.1**	**534**	**49.5**	**54**	**5.0**

Table 10. Method of cassava stake storage.

Code	Province/Region	In open field				In shade				In storage			
		Vertical		Horizontal		Vertical		Horizontal		Vertical		Horizontal	
		No.of farms	(%)	No.of farms	(%)	No.of farms	(%)	No.of farms	(%)	No.of farms	(%)	No.of farms	(%)
A	**NORTH VIETNAM**	**71**	**49.0**	**74**	**51.0**	**215**	**74.4**	**74**	**25.6**	**2**	**66.7**	**1**	**33.3**
I	**North Mountainous Region**	**42**	**37.5**	**70**	**62.5**	**90**	**59.6**	**61**	**40.4**	**0**	**0.0**	**0**	**0.0**
04	Ha Tuyen	3	37.5	5	62.5	7	18.4	31	81.6	0	0.0	0	0.0
08	Hoang Lien Son	10	36.2	27	62.8	5	83.3	1	16.7	0	0.0	0	0.0
09	Bac Thai	1	2.6	38	97.4	11	84.6	2	15.4	0	0.0	0	0.0
11	Vinh Phu	0	0.0	0	0.0	65	92.9	5	7.1	0	0.0	0	0.0
12	Ha Bac	22	100.0	0	0.0	2	8.3	22	91.7	0	0.0	0	0.0
II	**Red River Delta**	**11**	**73.3**	**4**	**26.7**	**72**	**90.0**	**8**	**10.0**	**0**	**0.0**	**0**	**0.0**
14	Ha Son Binh	8	66.7	4	33.3	52	86.7	8	13.3	0	0.0	0	0.0
15	Hai Hung	3	100.0	0	0.0	20	100.0	0	0.0	0	0.0	0	0.0
III	**North Central Coast**	**18**	**100.0**	**0**	**0.0**	**53**	**91.4**	**5**	**8.3**	**2**	**66.7**	**1**	**33.3**
19	Nghe An/Ha Tinh	18	100.0	0	0.0	35	89.7	4	10.3	1	100.0	0	0.0
20	Quang Binh	0	0.0	0	0.0	18	4.7	1	5.3	1	50.0	1	50.0
B	**SOUTH VIETNAM**	**78**	**94.0**	**5**	**6.0**	**401**	**82.5**	**85**	**17.5**	**1**	**100.0**	**0**	**0.0**
IV	**South Central Coast**	**3**	**100.0**	**0**	**0.0**	**171**	**68.4**	**79**	**31.6**	**0**	**0.0**	**0**	**0.0**
23	Quang Nam - Da Nang	0	0.0	0	0.0	65	94.2	4	5.8	0	0.0	0	0.0
24-25	Quang Ngai/Binh Dinh	0	0.0	0	0.0	29	55.8	23	44.2	0	0.0	0	0.0
27	Khanh Hoa	0	0.0	0	0.0	12	19.0	51	80.9	0	0.0	0	0.0
28	Binh Thuan/Ninh Thuan	3	100.0	0	0.0	65	98.5	1	1.5	0	0.0	0	0.0

Table 10. (Continued).

Code	Province/Region	In open field				In shade				In storage			
		Vertical		Horizontal		Vertical		Horizontal		Vertical		Horizontal	
		No.of farms	(%)	No.of farms	(%)	No.of farms	(%)	No.of farms	(%)	No.of farms	(%)	No.of farms	(%)
V	Central Highlands	27	84.4	5	15.6	61	91.0	6	9.0	1	100.0	0	0.0
29	Gia Lai/Kon Tum	0	0.0	0	0.0	25	100.0	0	0.0	0	0.0	0	0.0
30	Dac Lac	0	0.0	0	0.0	24	100.0	0	0.0	1	100.0	0	0.0
31	Lam Dong	27	84.4	5	15.6	12	66.7	6	33.3	0	0.0	0	0.0
VI	**Southeastern Region**	**48**	**100.0**	**0**	**0.0**	**169**	**100.0**	**0**	**0.0**	**0**	**0.0**	**0**	**0.0**
32	Song Be	1	100.0	0	0.0	61	100.0	0	0.0	0	0.0	0	0.0
33	Tay Ninh	45	100.0	0	0.0	16	100.0	0	0.0	0	0.0	0	0.0
34	Dong Nai	2	100.0	0	0.0	92	100.0	0	0.0	0	0.0	0	0.0
	TOTAL VIETNAM	**149**	**65.3**	**79**	**34.6**	**616**	**79.5**	**159**	**20.5**	**3**	**75.0**	**1**	**25.0**

Table 11. Method of stake planting.

		Horizontal		Vertical		Slanted	
Code	Province/Region	No.of farms	(%)	No.of farms	(%)	No.of farms	(%)
A	**NORTH VIETNAM**	**336**	**76.4**	**9**	**1.9**	**104**	**21.7**
I	**North Mountainous Region**	**242**	**5.5**	**0**	**0.0**	**41**	**14.5**
04	Ha Tuyen	42	7.5	0	0.0	6	12.5
08	Hoang Lien Son	36	3.5	0	0.0	13	26.5
09	Bac Thai	72	100.0	0	0.0	0	0.0
11	Vinh Phu	48	8.6	0	0.0	22	31.4
12	Ha Bac	44	100.0	0	0.0	0	0.0
II	**Red River Delta**	**89**	**3.7**	**0**	**0.0**	**6**	**6.3**
14	Ha Son Binh	68	5.8	0	0.0	3	4.2
15	Hai Hung	21	7.5	0	0.0	3	12.5
III	**North Central Coast**	**35**	**3.6**	**9**	**8.9**	**57**	**56.4**
19	Nghe An/Ha Tinh	29	7.5	4	6.6	28	45.9
20	Quang Binh	6	5.0	5	12.5	29	72.5
B	**SOUTH VIETNAM**	**405**	**8.3**	**48**	**8.1**	**140**	**23.6**
IV	South Central Coast	177	4.8	22	8.1	74	27.1
23	Quang Nam - Da Nang	1	1.4	19	27.5	49	71.0
24-25	Quang Ngai/Binh Dinh	66	4.3	0	0.0	4	5.7
27	Khanh Hoa	56	8.9	2	3.2	5	7.9
28	Binh Thuan/Ninh Thuan	54	6.1	1	1.4	16	22.5
V	**Central Highlands**	**47**	**7.0**	**25**	**25.0**	**28**	**28.0**
29	Gia Lai/Kon Tum	25	100.0	0	0.0	0	0.0
30	Dac Lac	17	8.0	0	0.0	8	32.0
31	Lam Dong	5	0.0	25	50.0	20	40.0
VI	**Southeastern Region**	**181**	**2.3**	**1**	**0.4**	**38**	**17.3**
32	Song Be	59	3.6	1	1.6	3	4.8
33	Tay Ninh	63	100.0	0	0.0	0	0.0
34	Dong Nai	59	2.8	0	0.0	35	37.2
	TOTAL VIETNAM	**771**	**1.9**	**57**	**5.3**	**224**	**22.8**

in Quang Nam-Da Nang (71.01% of farmers), Quang Binh (72.5%), Nghe Tinh (45.9%) and Lam Dong (40%).

6. Plant Population and Spacing

Cassava is generally planted at various spacings depending on the region. Most of the farmers use a spacing between rows of 50-100 cm and between plants in the row of 50-100 cm **(Table 12)**. In some provinces, farmers adopt a wider spacing (in the North Mountainous Region and the Central Highlands) due to a thicker surface soil layer. In contrast, in some provinces such as Ha Bac, Tay Ninh, Quang Ngai, and Song Be, a closer spacing (50x50 to 100x50 cm) is used because of poor soils and a thinner surface soil layer. Therefore, the cassava plant density in these provinces increases up to 20,000-25,000 plants/ha **(Table 13)**, whereas in Ha Tuyen, Hoang Lien Son, Dac Lac, Lam Dong and Khanh Hoa a plant density of less than 15,000 plants/ha is generally used.

7. Fertilization

Cassava is a crop which is easy to grow, but to produce high yields requires a large amount of nutrients. To maintain high yields, it is necessary to maintain enough nutrients in the soil. Otherwise, with time soils will become poorer and cassava yields will decrease.

In some provinces of the Red River Delta and the Central Coastal Regions farmers apply 5-7 tons of manure per hectare **(Table 14)**. But in the other areas the amount of manure applied is generally much lower (less than 2 t/ha).

Fertilizer nitrogen (N) is applied to the cassava fields at a rate of 0-50 kg N/ha; highest rates are applied in the provinces of the Red River Delta, the South Central Coast and the Southeastern Region, especially in Tay Ninh.

The average potassium (K) application rate for the whole country is only about 19 kg K_2O/ha. However, a higher rate of 30-90 kg K_2O/ha is used in Ha Bac, Hai Hung, Ha Son Binh and Tay Ninh provinces. A rate of 50-100 kg K_2O/ha is generally needed to replace the K removed in the root harvest.

Due to the abundant availability of single superphosphate in the North, phosphorus (P) is applied to cassava at a fairly high rate of 15-30 kg P_2O_5/ha in some provinces of the North Mountainous Region, and in the Red River Delta and the North Central Coast. A similar P rate is also used in Tay Ninh province of the Southeastern Region. However, in other part of the North Mountainous Region, the South Central Coast and the Central Highlands, P application rates are very low.

In general, chemical fertilizers are applied to cassava fields at low rates. Due to lack of resources, farmers usually apply fertilizers only to other crops. When the cassava price fluctuates and their income from cassava production is not stable, they can not afford to apply large amounts of fertilizer to cassava.

Thus, the application of nutrients to cassava soils in the form of manure and by intercropping with grain legumes can play a significant role in increasing cassava yields.

8. Weed, Disease and Pest Control

Weeds cause a decrease in cassava yield by competing for nutrients, especially in the rainy season and at the early growth stage. Weed control is done one to four times, mainly by hand using a hoe **(Table 15)**. Most farmers weed 2-3 times during a crop season. Due to the high temperature all through the year in the South, the number of weedings in that region is slightly higher than in the North. The last weeding is done when cassava is about 4 months old and the crop canopy completely shades the ground. No herbicides are used to control weeds in cassava fields.

Table 12. Planting distance of cassava (as % of farmers).

Code	Province/Region	Between rows				Between plants			
		x≤ 0.5m	0.5<x≤1m	1<x≤1.5m	x> 0.5m	x≤ 0.5m	0.5<x≤1m	1<x≤1.5m	x> 0.5m
A	**NORTH VIETNAM**	**0.6**	**85.3**	**13.7**	**0.4**	**12.0**	**86.2**	**1.8**	**0.0**
I	**North Mountainous Region**	**0.7**	**89.9**	**9.4**	**0.0**	**7.7**	**91.3**	**1.0**	**0.0**
04	Ha Tuyen	0.0	100.0	0.0	0.0	4.2	95.8	0.0	0.0
08	Hoang Lien Son	0.0	63.3	36.7	0.0	0.0	95.9	4.1	0.0
09	Bac Thai	2.8	95.8	4.2	0.0	0.0	100.0	0.0	0.0
11	Vinh Phu	0.0	95.8	1.4	0.0	2.8	95.8	1.4	0.0
12	Ha Bac	1.0	89.1	10.9	0.0	39.1	60.9	0.0	0.0
II	**Red River Delta**	**1.4**	**75.0**	**22.9**	**1.0**	**22.9**	**75.0**	**2.1**	**0.0**
14	Ha Son Binh	0.0	84.7	13.9	0.0	8.3	88.9	2.8	0.0
15	Hai Hung	0.0	45.8	50.0	4.2	66.7	33.3	0.0	0.0
III	**North Central Coast**	**0.0**	**82.3**	**16.7**	**1.0**	**13.3**	**83.3**	**3.3**	**0.0**
19	Nghe An/Ha Tinh	0.0	72.1	27.9	0.0	11.1	83.6	5.3	0.0
20	Quang Binh	0.0	97.6	0.0	2.4	17.1	82.9	0.0	0.0
B	**SOUTH VIETNAM**	**9.9**	**62.6**	**23.6**	**3.9**	**36.7**	**60.0**	**3.3**	**0.0**
IV	**South Central Coast**	**4.4**	**71.1**	**24.5**	**0.0**	**34.7**	**62.5**	**2.8**	**0.0**
23	Quang Nam - Da Nang	0.0	43.5	56.5	0.0	59.4	48.6	0.0	0.0
24-25	Quang Ngai/Binh Dinh	17.1	82.9	0.0	0.0	57.1	42.9	0.0	0.0
27	Khanh Hoa	0.0	77.8	22.2	0.0	0.0	92.1	7.9	0.0
28	Binh Thuan/Ninh Thuan	0.0	80.3	19.7	0.0	31.0	66.2	2.8	0.0
V	**Central Highlands**	**0.0**	**65.0**	**18.0**	**17.0**	**16.0**	**76.0**	**8.0**	**0.0**
29	Gia Lai/Kon Tum	0.0	44.0	56.0	0.0	52.0	48.0	0.0	0.0
30	Dac Lac	0.0	24.0	8.0	68.0	0.0	68.0	32.0	0.0

Table 12. (Continued).

Code	Province/Region	Between rows				Between plants			
		x≤ 0.5m	0.5<x≤1m	1<x≤1.5m	x> 0.5m	x≤ 0.5m	0.5<x≤1m	1<x≤1.5m	x> 0.5m
31	Lam Dong	0.0	96.0	4.0	0.0	6.0	94.0	0.0	0.0
VI	**Southeastern Region**	**21.4**	**50.9**	**25.0**	**2.7**	**48.4**	**49.8**	**1.8**	**0.0**
32	Song Be	36.5	63.5	0.0	0.0	44.4	55.6	0.0	0.0
33	Tay Ninh	38.1	58.7	3.2	0.0	92.1	7.9	0.0	0.0
34	Dong Nai	0.0	37.2	56.4	6.4	23.4	72.3	4.3	0.0
	TOTAL VIETNAM	**5.7**	**72.8**	**19.1**	**2.3**	**25.6**	**71.8**	**2.6**	**0.0**

Table 13. Cassava plant density (plants/ha).

		< 15,000		15,000-20,000		20,000-25,000		> 25,000	
Code	Province/Region	No.of farms	(%)	No.of farms	(%)	No.of farms	(%)	No.of farms	(%)
A	**NORTH VIETNAM**	**351**	**73.0**	**96**	**20.0**	**23**	**4.8**	**11**	**2.3**
I	**North Mountainous Region**	**207**	**73.1**	**49**	**17.3**	**19**	**6.7**	**8**	**2.8**
04	Ha Tuyen	41	89.1	5	10.9	0	0.0	0	0.0
08	Hoang Lien Son	46	93.9	3	6.1	0	0.0	0	0.0
09	Bac Thai	53	74.6	18	25.3	0	0.0	0	0.0
11	Vinh Phu	56	77.8	8	11.1	1	1.4	7	9.7
12	Ha Bac	11	24.4	15	33.3	18	40.0	1	2.2
II	**Red River Delta**	**67**	**69.8**	**22**	**22.9**	**4**	**4.2**	**3**	**3.1**
14	Ha Son Binh	52	72.2	13	18.1	4	5.6	3	4.2
15	Hai Hung	15	62.5	9	37.5	0	0.0	0	0.0
III	**North Central Coast**	**77**	**75.5**	**25**	**24.5**	**0**	**0.0**	**0**	**0.0**
19	Nghe An/Ha Tinh	46	75.4	15	24.6	0	0.0	0	0.0
20	Quang Binh	31	75.6	10	24.4	0	0.0	0	0.0
B	**SOUTH VIETNAM**	**308**	**52.4**	**126**	**21.4**	**62**	**10.5**	**92**	**15.6**
IV	**South Central Coast**	**124**	**45.4**	**79**	**28.9**	**34**	**12.4**	**36**	**13.2**
23	Quang Nam - Da Nang	27	39.1	28	40.6	12	17.4	2	2.9
24-25	Quang Ngai/Binh Dinh	1	1.4	25	35.7	11	15.7	33	47.1
27	Khanh Hoa	61	96.8	2	3.2	0	0.0	0	0.0
28	Binh Thuan/Ninh Thuan	35	49.3	24	33.8	11	15.5	1	1.4
V	**Central Highlands**	**77**	**77.0**	**20**	**20.0**	**3**	**3.0**	**0**	**0.0**
29	Gia Lai/Kon Tum	9	36.0	16	64.0	0	0.0	0	0.0
30	Dac Lac	23	92.0	2	8.0	0	0.0	0	0.0
31	Lam Dong	45	90.0	2	4.0	3	6.0	0	0.0
VI	**Southeastern Region**	**107**	**49.8**	**27**	**12.6**	**25**	**11.6**	**56**	**26.0**
32	Song Be	34	54.0	4	6.3	13	20.6	12	19.0
33	Tay Ninh	2	3.4	2	3.4	10	17.2	44	75.9
34	Dong Nai	71	75.5	21	22.3	2	2.1	0	0.0
	TOTAL VIETNAM	**659**	**61.6**	**222**	**20.8**	**85**	**7.9**	**103**	**9.6**

Table 14. Amount and kind of fertilizer used for growing cassava.

Code	Province/Region	Total no.of farmers	Organic (kg/ha)	Chemical (kg/ha)				
				Urea	SA[1]	SSP[2]	KCl	NPK[3]
A	**NORTH VIETNAM**	**484**	**4,426**	**21**	**0**	**61**	**35**	**0**
I	**North Mountainous Region**	**286**	**2,389**	**15**	**0**	**37**	**15**	**0**
04	Ha Tuyen	48	2,655	12	0	0	0	0
08	Hoang Lien Son	49	131	8	0	7	19	0
09	Bac Thai	72	1,830	6	0	31	1	0
11	Vinh Phu	71	1,682	3	0	1	2	0
12	Ha Bac	46	6,484	57	0	170	70	0
II	**Red River Delta**	**96**	**7,452**	**40**	**0**	**79**	**93**	**0**
14	Ha Son Binh	72	6,851	23	0	76	87	0
15	Hai Hung	24	9,254	90	0	89	110	0
III	**North Central Coast**	**102**	**7,288**	**22**	**0**	**112**	**36**	**0**
19	Nghe An/Ha Tinh	61	7,557	21	0	163	21	0
20	Quang Binh	41	6,889	23	0	37	58	0
B	**SOUTH VIETNAM**	**579**	**2,543**	**31**	**38**	**4**	**15**	**5**
IV	**South Central Coast**	**273**	**4,690**	**33**	**55**	**2**	**20**	**1**
23	Quang Nam - Da Nang	69	5,219	38	40	7	21	0
24-25	Quang Ngai/Binh Dinh	70	7,370	55	46	0	1	0
27	Khanh Hoa	63	3,146	5	46	1	0	3
28	Binh Thuan/Ninh Thuan	71	2,903	30	88	0	55	0
V	**Central Highlands**	**100**	**172**	**8**	**0**	**0**	**0**	**0**
29	Gia Lai/Kon Tum	25	0	0	0	0	0	0
30	Dac Lac	25	180	0	0	0	0	0
31	Lam Dong	50	253	16	0	0	0	0
VI	**Southeastern Region**	**206**	**850**	**40**	**27**	**9**	**16**	**14**
32	Song Be	62	1,020	76	25	9	11	13
33	Tay Ninh	40	815	37	68	29	33	45
34	Dong Nai	94	615	15	11	0	11	0
2	Ho Chi Minh	10	2,151	72	18	10	21	21
	TOTAL VIETNAM	**1,083**	**3,400**	**27**	**19**	**30**	**24**	**3**

[1] SA = sulfate of ammonia.
[2] SSP = simple super phosphate.
[3] NPK = compound NPK fertilizer.

Table 15. Type and number of times of weed control for cassava (as % of farmers).

		Manual (hoe)				Animal			
Code	Province/Region	Number of times				Number of times			
		1	2	3	4	1	2	3	4
A	**NORTH VIETNAM**	**6.1**	**67.0**	**20.6**	**6.1**	**0.0**	**24.3**	**5.0**	**0.0**
I	**North Mountainous Region**	**2.5**	**79.0**	**13.6**	**4.7**	**0.0**	**41.2**	**0.0**	**0.0**
04	Ha Tuyen	2.1	97.9	0.0	0.0	0.0	0.0	0.0	0.0
08	Hoang Lien Son	0.0	97.9	0.0	2.1	0.0	0.0	0.0	0.0
09	Bac Thai	5.7	70.0	7.1	17.1	0.0	100.0	0.0	0.0
11	Vinh Phu	2.9	55.6	41.7	0.0	0.0	0.0	0.0	0.0
12	Ha Bac	0.0	90.9	9.1	0.0	0.0	100.0	0.0	0.0
II	**Red River Delta**	**11.7**	**32.2**	**43.3**	**12.7**	**0.0**	**0.0**	**25.0**	**0.0**
14	Ha Son Binh	5.6	38.0	39.4	16.9	0.0	0.0	0.0	0.0
15	Hai Hung	30.0	15.0	55.0	0.0	0.0	0.0	100.0	0.0
III	**North Central Coast**	**10.8**	**66.3**	**18.9**	**4.0**	**0.0**	**0.0**	**0.0**	**0.0**
19	Nghe An/Ha Tinh	0.0	81.4	15.2	3.4	0.0	0.0	0.0	0.0
20	Quang Binh	26.8	43.9	24.4	4.9	0.0	0.0	0.0	0.0
B	**SOUTH VIETNAM**	**3.2**	**49.7**	**39.6**	**7.2**	**0.0**	**0.1**	**1.2**	**8.7**
IV	**South Central Coast**	**0.7**	**61.2**	**30.4**	**7.6**	**0.0**	**1.4**	**2.7**	**19.0**
23	Quang Nam - Da Nang	0.0	65.2	30.4	4.3	0.0	0.0	0.0	0.0
24-25	Quang Ngai/Binh Dinh	2.9	54.3	40.0	2.9	0.0	0.0	0.0	0.0
27	Khanh Hoa	0.0	65.2	13.0	21.7	0.0	5.9	11.8	82.3
28	Binh Thuan/Ninh Thuan	0.0	60.6	36.6	2.8	0.0	0.0	0.0	0.0
V	**Central Highlands**	**10.0**	**55.0**	**30.0**	**4.0**	**0.0**	**0.0**	**0.0**	**0.0**
29	Gia Lai/Kon Tum	0.0	72.0	24.0	4.0	0.0	0.0	0.0	0.0
30	Dac Lac	40.0	24.0	36.0	0.0	0.0	0.0	0.0	0.0
31	Lam Dong	2.0	62.0	30.0	6.0	0.0	0.0	0.0	0.0
VI	**Southeastern Region**	**3.2**	**33.1**	**55.4**	**8.2**	**0.0**	**0.0**	**0.0**	**0.0**
32	Song Be	11.5	67.2	19.7	1.6	0.0	0.0	0.0	0.0
33	Tay Ninh	0.0	16.1	77.4	6.4	0.0	0.0	0.0	0.0
34	Dong Nai	0.0	22.1	64.2	13.7	0.0	0.0	0.0	0.0
	TOTAL VIETNAM	**4.5**	**57.5**	**31.0**	**6.7**	**0.0**	**11.3**	**2.9**	**4.8**

Diseases and insects are not very important in cassava and no serious damage to cassava production has been reported.

Most of the farmers do not report the presence of any insect pests in cassava (**Table 16**). Only mites are reported to damage young cassava plants in the Central Coastal Region of the North, but the area affected is limited.

Major diseases of cassava are cassava bacterial blight (caused by *Xanthomonas manihotis*) and *Cercospora* leaf spot (caused by *Cercospora sp.*). However, no good control means are available except the use of clean planting material and more resistant varieties.

A study in 1968 in Vietnam reported 19 diseases on cassava caused by different pathogens.

9. Intercropping

In the North, cassava is generally planted in monoculture. After many years of cassava monoculture, soil productivity is often reduced due to erosion and nutrient exhaustion and cassava yields decrease. Cassava-based intercropping systems in the North occupy less than 10% of the area **(Table 17)**, while in the South, this area reaches 30-40%. In Thuan Hai, Gia Lai-Kon Tum, Dac Lac and Dong Nai provinces, the area under intercropping with cassava is as high as 70-90%.

Generally, maize, groundnut and mungbean are used as intercrops with cassava. Besides these, vegetables, soybean, winged bean, and fruit trees are also intercropped with cassava, but to a lesser extent **(Table 18)**.

Althought we can show the good effect of cassava-based intercropping systems on soil conservation, farmers are mostly concerned only with the economic aspects of the intercropping systems.

10. Harvesting

Harvesting time is an important factor affecting cassava yield. If the farmer harvests too early, cassava is still young, and the starch content and yield are low. In the area where cassava is grown for fresh human consumption, farmers harvest from 6-7 months after planting up to complete maturity (at 11-12 months). When cassava is consumed as boiled fresh roots, farmers in some areas harvest cassava at less than 6 months after planting **(Table 19)**. However, the majority of cassava is harvested after 10-12 months, especially in the South, where the processing of cassava into different products requires a high starch content in the roots.

CONCLUSIONS AND RESEARCH PRIORITIES

With 1,076 questionaires collected from 45 districts in 20 cassava producing provinces of the country, this survey gives a general picture of the cultural practices used for cassava in Vietnam.

Table 16. Importance of pests and diseases in cassava.

		Diseases		Pests	
Code	Province/Region	No.of farms	(%)	No.of farms	(%)
A	**NORTH VIETNAM**	**78**	**16.1**	**15**	**3.1**
I	**North Mountainous Region**	**19**	**6.6**	**0**	**0.0**
04	Ha Tuyen	0	0.0	0	0.0
08	Hoang Lien Son	3	6.1	0	0.0
09	Bac Thai	14	19.4	0	0.0
11	Vinh Phu	0	0.0	0	0.0
12	Ha Bac	2	4.3	0	0.0
II	**Red River Delta**	**21**	**21.9**	**4**	**4.2**
14	Ha Son Binh	7	9.7	0	0.0
15	Hai Hung	14	58.3	4	16.7
III	**North Central Coast**	**38**	**37.2**	**11**	**10.8**
19	Nghe An/Ha Tinh	16	26.3	6	9.8
20	Quang Binh	22	53.7	5	12.2
B	**SOUTH VIETNAM**	**48**	**8.1**	**3**	**0.5**
IV	**South Central Coast**	**23**	**8.4**	**0**	**0.0**
23	Quang Nam - Da Nang	0	0.0	0	0.0
24-25	Quang Ngai/Binh Dinh	0	0.0	0	0.0
27	Khanh Hoa	0	0.0	0	0.0
28	Binh Thuan/Ninh Thuan	23	32.4	0	0.0
V	**Central Highlands**	**25**	**25.0**	**0**	**0.0**
29	Gia Lai/Kon Tum	0	0.0	0	0.0
30	Dac Lac	0	0.0	0	0.0
31	Lam Dong	25	50.0	0	0.0
VI	**Southeastern Region**	**0**	**0.0**	**3**	**1.4**
32	Song Be	0	0.0	3	4.8
33	Tay Ninh	0	0.0	0	0.0
34	Dong Nai	0	0.0	0	0.0
	TOTAL VIETNAM	**126**	**11.7**	**18**	**1.7**

Table 17. Area and cropping systems of cassava production according to farm size.

Code	Province/Region	Small scale (<0.6 ha)				Medium scale (0.6-1.05 ha)				Large-scale (>1.05 ha)			
		monoculture		intercropped		monoculture		intercropped		monoculture		intercropped	
		ha	(%)	ha	(%)	ha	(%)	ha	(%)	ha	(%)	ha	(%)
A	**NORTH VIETNAM**	**60.09**	**89.2**	**8.39**	**10.8**	**25.29**	**94.7**	**1.41**	**5.3**	**3.65**	**100.0**	**0.00**	**0.0**
I	**North Mountainous Region**	**43.65**	**91.6**	**3.99**	**8.4**	**8.64**	**96.6**	**0.30**	**3.4**	**1.15**	**100.0**	**0.00**	**0.0**
04	Ha Tuyen	7.42	100.0	0.00	0.0	2.16	100.0	0.00	0.0	0.00	0.0	0.00	0.0
08	Hoang Lien Son	9.27	91.3	0.88	8.7	2.05	100.0	0.00	0.0	0.00	0.0	0.00	0.0
09	Bac Thai	11.47	86.3	1.82	13.7	4.43	93.7	0.30	6.3	1.15	100.0	0.00	0.0
11	Vinh Phu	7.45	97.6	0.18	2.4	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
12	Ha Bac	8.04	87.9	1.11	12.1	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
II	**Red River Delta**	**10.95**	**87.7**	**1.53**	**12.3**	**8.30**	**90.6**	**0.86**	**9.4**	**1.30**	**100.0**	**0.00**	**0.0**
14	Ha Son Binh	9.05	86.4	1.42	13.6	8.30	90.6	0.86	9.4	1.30	100.0	0.00	0.0
15	Hai Hung	1.90	94.5	0.11	5.5	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
III	**North Central Coast**	**14.49**	**83.5**	**2.87**	**16.5**	**8.35**	**97.1**	**0.25**	**2.9**	**1.20**	**100.0**	**0.00**	**0.0**
19	Nghe An/Ha Tinh	9.33	95.0	0.49	5.0	7.75	96.9	0.25	3.1	1.20	100.0	0.00	0.0
20	Quang Binh	5.16	68.4	2.38	31.6	0.60	100.0	0.00	0.0	0.00	0.0	0.00	0.0
B	**SOUTH VIETNAM**	**50.03**	**66.1**	**25.62**	**33.9**	**61.70**	**56.3**	**47.90**	**43.7**	**72.27**	**69.4**	**31.84**	**30.6**
IV	**South Central Coast**	**32.78**	**84.1**	**6.20**	**15.9**	**18.07**	**88.9**	**2.25**	**11.1**	**7.11**	**100.0**	**0.00**	**0.0**
23	Quang Nam - Da Nang	8.46	98.3	0.15	1.7	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
24-25	Quang Ngai/Binh Dinh	11.20	99.1	0.10	0.9	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
27	Khanh Hoa	8.39	97.3	0.23	2.7	16.87	94.1	1.05	5.9	7.11	100.0	0.00	0.0
28	Binh Thuan/Ninh Thuan	4.73	45.3	5.72	54.7	1.20	50.0	1.20	50.0	0.00	0.0	0.00	0.0

Table 17. (Continued).

Code	Province/Region	Small scale (<0.6 ha)				Medium scale (0.6-1.05 ha)				Large-scale (>1.05 ha)			
		monoculture		intercropped		monoculture		intercropped		monoculture		intercropped	
		ha	(%)	ha	(%)	ha	(%)	ha	(%)	ha	(%)	ha	(%)
V	**Central Highlands**	**9.50**	**55.6**	**7.60**	**44.4**	**3.80**	**22.9**	**12.80**	**77.1**	**1.00**	**19.6**	**4.10**	**80.4**
29	Gia Lai/Kon Tum	2.50	53.2	2.20	46.8	1.80	25.0	5.40	75.0	1.00	32.3	2.10	67.7
30	Dac Lac	0.60	13.3	3.90	86.7	0.00	0.0	3.80	100.0	0.00	0.0	0.00	0.0
31	Lam Dong	6.40	81.0	1.50	19.0	2.00	35.7	3.60	64.3	0.00	0.0	2.00	100.0
VI	**Southeastern Region**	**7.75**	**39.6**	**11.82**	**60.4**	**39.83**	**54.8**	**32.85**	**45.2**	**64.16**	**69.8**	**27.74**	**30.2**
32	Song Be	6.55	65.8	3.40	34.2	6.80	56.2	5.30	43.8	6.30	62.4	3.80	37.6
33	Tay Ninh	0.00	0.0	0.00	0.0	30.73	95.3	1.50	4.6	55.30	91.7	5.00	8.3
34	Dong Nai	1.20	12.5	8.42	87.5	2.30	8.1	26.05	91.9	2.56	11.9	18.94	88.1
	TOTAL VIETNAM	**119.12**	**77.8**	**34.01**	**22.2**	**86.99**	**63.8**	**49.31**	**36.2**	**75.92**	**70.4**	**31.84**	**29.5**

Table 18. Intercropping other crops with cassava (% of farmers who intercrop).

Code	Province/Region	Total No.of farmers	Maize	Ground-nut	Mung-bean	Soybean	Other[1] beans	Vege-table	Fruit	Rubber	Other
A	**NORTH VIETNAM**	**70**	**4.3**	**21.4**	**8.6**	**7.1**	**7.1**	**7.1**	**2.9**	**0.0**	**41.5**
I	**North Mountainous Region**	**33**	**3.0**	**36.4**	**9.1**	**12.1**	**9.1**	**0.0**	**6.1**	**0.0**	**24.2**
04	Ha Tuyen	0	-	-	-	-	-	-	-	-	-
08	Hoang Lien Son	5	0.0	0.0	20.0	0.0	0.0	0.0	20.0	0.0	60.0
09	Bac Thai	11	0.0	0.0	18.2	18.2	9.1	0.0	9.1	0.0	45.5
11	Vinh Phu	2	50.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	Ha Bac	15	0.0	73.3	0.0	13.3	13.3	0.0	0.0	0.0	0.0
II	**Red River Delta**	**12**	**8.3**	**16.7**	**25.0**	**8.3**	**16.7**	**0.0**	**0.0**	**0.0**	**25.0**
14	Ha Son Binh	11	9.1	18.2	27.3	0.0	18.2	0.0	0.0	0.0	27.3
15	Hai Hung	1	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0
III	**North Central Coast**	**25**	**4.0**	**4.0**	**0.0**	**0.0**	**0.0**	**20.0**	**0.0**	**0.0**	**72.0**
19	Nghe An/Ha Tinh	5	0.0	20.0	0.0	0.0	0.0	20.0	0.0	0.0	60.0
20	Quang Binh	20	5.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0	75.0
B	**SOUTH VIETNAM**	**210**	**38.6**	**12.4**	**3.3**	**2.4**	**2.9**	**0.0**	**10.5**	**0.9**	**29.0**
IV	**South Central Coast**	**44**	**29.5**	**15.9**	**0.0**	**0.0**	**0.0**	**0.0**	**15.9**	**2.3**	**36.4**
23	Quang Nam - Da Nang	1	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24-25	Quang Ngai/Binh Dinh	1	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	Khanh Hoa	7	28.6	0.0	0.0	0.0	0.0	0.0	57.1	0.0	14.3
28	Binh Thuan/Ninh Thuan	35	31.4	14.3	0.0	0.0	0.0	0.0	8.6	2.9	42.9

Table 18. (Continued).

Code	Province/Region	Total No.of farmers	Maize	Ground-nut	Mung-bean	Soybean	Other[1] beans	Vege-table	Fruit	Rubber	Other
V	**Central Highlands**	**53**	**43.4**	**22.6**	**1.9**	**9.4**	**9.4**	**0.0**	**13.2**	**0.0**	**0.0**
29	Gia Lai/Kon Tum	18	0.0	66.7	5.5	0.0	27.8	0.0	0.0	0.0	0.0
30	Dac Lac	21	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	Lam Dong	14	14.3	0.0	0.0	35.7	0.0	0.0	50.0	0.0	0.0
VI	**Southeastern Region**	**113**	**39.8**	**6.2**	**5.3**	**0.0**	**0.9**	**0.0**	**7.1**	**0.9**	**39.8**
32	Song Be	24	0.0	8.3	0.0	0.0	4.2	0.0	0.0	4.2	83.3
33	Tay Ninh	5	0.0	40.0	0.0	0.0	0.0	0.0	40.0	0.0	20.0
34	Dong Nai	84	53.6	3.6	7.1	0.0	0.0	0.0	7.1	0.0	28.6
	TOTAL VIETNAM	**280**	**30.0**	**14.6**	**4.6**	**3.6**	**3.9**	**1.8**	**8.6**	**0.7**	**32.1**

[1] Winged beans, cowpea, black bean etc.

Table 19. Time to harvest of cassava crop.

Code	Province/Region	Average growing cycle (months)	<6 months		7-9 months		10-12 months		>12 months	
			No.of farms	(%)	No.of farms	(%)	No.of farms	(%)	No.of farms	(%)
A	**NORTH VIETNAM**	**10**	**18**	**3.7**	**183**	**37.8**	**258**	**53.3**	**25**	**5.2**
I	**North Mountainous Region**	**10**	**6**	**2.1**	**135**	**47.0**	**124**	**43.2**	**22**	**7.7**
04	Ha Tuyen	10	3	6.2	7	14.6	38	79.2	0	0.0
08	Hoang Lien Son	9	1	2.0	26	53.1	20	40.8	2	4.1
09	Bac Thai	13	0	0.0	28	38.9	24	33.3	20	27.8
11	Vinh Phu	8	1	1.4	71	98.6	0	0.0	0	0.0
12	Ha Bac	10	1	2.2	3	6.5	42	91.3	0	0.0
II	**Red River Delta**	**9**	**0**	**0.0**	**34**	**35.8**	**61**	**64.2**	**0**	**0.0**
14	Ha Son Binh	9	0	0.0	31	43.7	40	56.3	0	0.0
15	Hai Hung	10	0	0.0	3	12.5	21	87.5	0	0.0
III	**North Central Coast**	**10**	**12**	**11.8**	**14**	**13.7**	**73**	**71.6**	**3**	**2.9**
19	Nghe An/Ha Tinh	11	7	11.5	0	0.0	51	83.6	3	4.9
20	Quang Binh	10	5	12.2	14	34.1	22	53.7	0	0.0
B	**SOUTH VIETNAM**	**11**	**7**	**1.2**	**111**	**18.7**	**451**	**75.9**	**25**	**4.2**
IV	**South Central Coast**	**10**	**0**	**0.0**	**52**	**19.0**	**221**	**81.0**	**0**	**0.0**
23	Quang Nam - Da Nang	10	0	0.0	25	36.2	44	63.8	0	0.0
24-25	Quang Ngai/Binh Dinh	10	0	0.0	0	0.0	70	100.0	0	0.0

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Table 19. (Continued).

Code	Province/Region	Average growing cycle (months)	<6 months		7-9 months		10-12 months		>12 months	
			No.of farms	(%)	No.of farms	(%)	No.of farms	(%)	No.of farms	(%)
27	Khanh Hoa	10	0	0.0	0	0.0	63	100.0	0	0.0
28	Binh Thuan/Ninh Thuan	10	0	0.0	27	38.0	44	62.0	0	0.0
V	**Central Highlands**	**13**	**0**	**0.0**	**5**	**5.0**	**70**	**70.0**	**25**	**25.0**
29	Gia Lai/Kon Tum	10	0	0.0	0	0.0	25	100.0	0	0.0
30	Dac Lac	10	0	0.0	5	20.0	20	80.0	0	0.0
31	Lam Dong	15	0	0.0	0	0.0	22	50.0	25	50.0
VI	**Southeastern Region**	**10**	**7**	**3.2**	**54**	**24.4**	**160**	**72.4**	**0**	**0.0**
32	Song Be	10	3	4.8	9	14.3	51	80.9	0	0.0
33	Tay Ninh	10	4	6.3	13	20.6	46	73.0	0	0.0
34	Dong Nai	10	0	0.0	32	33.7	63	66.3	0	0.0
	TOTAL VIETNAM	**10**	**25**	**2.3**	**294**	**27.3**	**709**	**65.8**	**50**	**4.6**

Introduced to Vietnam almost two centuries ago, cassava still plays an important role in various regions of the country, due to its great adaptability and tolerance of harsh climatic and soil conditions.

Farmers have determined the most suitable cassava planting time for each region, as well as the method of land preparation (plowing, harrowing, ridging), planting method, plant spacings, plant density, etc.

With the release of new improved cassava varieties, developing an efficient way of multiplication of planting material is becoming important, as well as the improvement of stake storage and planting methods.

At present, due to economic reasons, the rate of fertilizer application is still too low. However, to improve cassava yield and production, it is necessary to increase the fertilizer application rate.

Various intercropping systems with cassava are practiced, mainly in South Vietnam, with maize, mungbean and peanut being the most commonly used crops.

At present, insect pests and diseases are not serious problems; nevertheless, with an increase in fertilizer application, a change in cropping patterns and the use of new varieties, we have to be vigilant about the possible occurence and the damage caused by insects and diseases.

With respect to these problems, research on cassava cultural practices in the future should include the following:

- Research on erosion control, especially in cassava fields in the North.
- Research on the kind, method and rate of fertilizer application for intensive cassava cultivation.
- Research on the maintenance and improvement of soil fertility through the application of organic manures and compost, or the use of intercrops, green manures, cover crops, alley cropping and crop rotations.
- Research on the technical and economic efficiency of various cassava-based intercropping systems.
- Development of better techniques for rapid multiplication of planting material of new varieties.
- Determination of the most important cassava insect pests and diseases, the estimation of their occurence and the damage caused, and the development of a sound Integrated Pest Management (IPM) methodology.

CASSAVA PROCESSING IN NORTH VIETNAM

Quach Nghiem[1]

ABSTRACT

In Vietnam, cassava, with an estimated output of about 3 million tons/year, is a crop that is traditionally considered only as a food source for humans and livestock, either in fresh form or as dry slices. This situation shows that cassava processing has not yet developed. Cassava used to be grown in remote areas with poor transportation facilities and other infrastructure. Recent surveys show that cassava is planted predominantly by poor rather than by rich farmer households. Poor farmers, however, are less capable of effective organization in cassava processing.

In Vietnam, cassava is cultivated in only small areas. Thus, the amount of commercially available cassava is not so large. Only in some areas is the average area of land per household dedicated to cassava cultivation larger than 1 ha. However, this is seldom the case in North Vietnam. It is mainly the production status and distribution of cassava production, and the infrastructure and socio-economic conditions in cassava growing areas, which have determined the formation of cassava processing systems in Vietnam's rural areas.

During the last ten years, cassava processing has increased due to the improvement of rice provision in the country and by the solving of various technological and energy problems, as well as those concerning processing organization and marketing.

This report presents some recently developed processing technologies appropriate for rural conditions, such as fresh cassava processing into starch without the necessity of drying cassava after harvest, HCN-free pellets of fermented animal feed, maltose, noodles and chips. These technologies have been effectively used at the village level.

Finally, the report discusses the main problems requiring further investigation as related to cassava technology and production organization.

INTRODUCTION

Cassava is traditionally an important food crop in Vietnam. It is used for animal feed and for human consumption, either in fresh form or as dried slices. This root crop is grown in almost every province in the country. The development potential of cassava is still enormous.

Until now, the economic value of cassava has been low. The consumption market has not yet developed and is affected by various external economic and social

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factors. In a self-supplied agricultural-based economy, root crops are mostly used in the farmers' own household. Only a part of cassava production is used as a raw material for industrial processing. In order to develop cassava production, more efficient techniques for processing, utilization and marketing should be developed. Furthermore, this needs to be supported by government policies that stimulate the development of root and tuber crop production and utilization. This would help to provide a stable income for cassava farmers and processors.

Under the present situation in Vietnam, on-site processing systems at the farmer household and at the village level need to be developed. The village level processing system plays an important role and is a way to guarantee the supply of intermediate products for the effective operation of industrial scale processings systems.

Some simple technologies of fresh root processing, such as the removal of milk sap to enhance cassava preservation, and the production of protein-enriched animal feed, which are appropriate to the farmer household and village conditions, have been developed and are being promoted in Vietnam.

SOME FACTORS DETERMINING CASSAVA PROCESSING IN VIETNAM

Cassava Production and Distribution

Table 1 shows that cassava production in Vietnam has decreased slighty since 1980, and is now at a level of about 2.5 million t/year.

Table 1. Cassava production ('000 t) in Vietnam 1980 - 1992.

	1980	1985	1987	1988	1990	1992
North	1,426	1,450	1,296	1,393	1,180	1,374
South	1,853	1,490	1,442	1,446	1,096	1,194
Total	3,279	2,939	2,738	2,839	2,276	2,568

Table 2 indicates the main cassava cultivation regions in Vietnam. The North Mountainous Region and the South Central Region produce 57.7% of total cassava output in Vietnam and are the two biggest cassava growing areas of the country. Nearly all of the cassava areas are concentrated on the poorest soils. Cassava processing and consumption also face many difficulties, such as a hot and humid climate; lack of sunshine during harvesting, making processing and preservation difficult; raw material supplies are dispersed and spoil rapidly; infrastructure is poorly developed (only 300 m

of roads per km^2 in the lowlands and 100 m per km^2 in the highlands); fluctuating markets; and lack of price and consumption policies for cassava development.

Table 2. Food production situation in the main cassava cultivation regions.

Region	Cassava		Rice and corn output/ inhabitant (kg)
	'000 t	% of total	
1. North Mountainous Region	818	31.0	191.5
2. Red River Delta (without Hanoi capital)	141	-	241.8
3. North Central Coast	337	12.7	176.8
4. South Central Region	704	26.7	229.0
5. South Mid-elevation Region	404	15.3	174.7
6. Mekong Delta	127	-	453.0

Due to the above constraints, there have been three principal processing forms in Vietnam. Fresh cassava roots are mainly processed by farmers' families or "Village enterprises" into intermediate products, such as dry slices, wet starch and maltose. Village enterprise-based cassava processing at the communal level has developed successfully in Vietnam. This allows the production of semi-processed products and other local consumer products in a greater amount, with low investments and strong competition in the market. Industrial-based cassava processing, using centralized management, process mainly intermediate cassava products into end products. Some factories also use fresh cassava to produce these end products.

In conclusion, rural processing, especially village enterprise and industrial-based processing are complementary and combine to form a cassava processing system that is suitable to Vietnam's conditions.

Marketing Demand and Marketing System of Fresh Roots and Intermediate Products of Cassava

In Vietnam the marketing of foods is much affected by the shortage of transport and storage facilities, by the fluctuation in supply and demand, and by the small purchasing power of processors.

Up till now the marketing of cassava roots in Vietnam has been unstable, even in rural areas. The price of roots has been dependent on the price of rice as root crops play only a supporting role in the general food supply. In years when rice production is abundant, the root price drops drastically. During the past years the price of rice in Vietnam was held artifically low by government subsidies on fertilizer. As a result, the price of roots was low and income of root producers was inadequate for any investment in the cultivation of cassava. The price of roots relative to that of rice was abnormally high due to these subsidies, and, therefore, consumers generally preferred to consume rice rather than cassava.

However, since the middle of 1990 the price situation has changed drastically. The price of rice and paddy was increased to be equivalent to the international price. In the local market, consumers have come back to using root crops, and it is expected that demand for root crops will increase. Demand for cassava for the confection and fermentation industries and for animal feed will increase at a rate of 8-15% per year by our estimation.

Because the cane-sugar price is relatively high in Vietnam (one kg of sugar equals 2.5-3.5 kg rice), low cost cassava malt is mainly used in the confectionery and fermentation industries (1 kg malt = 1 kg rice). The price of cassava chips is much lower than the price of rice and wheat flour, so cassava chips or milksap-free cassava flour will be an economical raw material for the foodstuff, textile and paper industries.

Climatic Factors

In Vietnam cassava is produced in a tropical, hot and humid climate. Cassava roots contain about 60-65% water, and in less than six days after being harvested the roots have completely deteriorated. In North Vietnam cassava is essentially harvested during the winter months. The conventional method of drying chipped cassava roots by using charcoal is very expensive.

The use of solar energy for drying cassava chips in North Vietnam is often difficult because of high air humidity and short periods of sunshine during the harvest in winter time. This results in a high percentage of low-quality products (more than 30%). Furthermore, the high relative humidity also results in re-absorbtion of water by the dry cassava chips, causing mold formation and rotting. It has been shown (Quach Nghiem, 1992) that the rate of conversion from fresh cassava to dry chips reaches its highest level in November and December of each year.

At present, about 45-62% of total cassava production is processed into cassava chips. However, large losses occur during the drying and storage of cassava chips. Frequently 8 to 12% of cassava chips rot during storage.

Thus, the lack of energy and unfavorable weather conditions during the period of harvesting are the greatest problems in processing cassava in North Vietnam. So, the technology for processing and preservation must be appropriate for these conditions. It is therefore necessary to develop technologies that have low energy consumption, low investment and high efficiency.

CASSAVA PROCESSING SYSTEMS IN VIETNAM

We have seen above that there are basically three types of cassava processing systems in Vietnam:

- Family-scale or on-site processing in cassava growing areas.
- Communal-scale or "village enterprise" processing.
- Industrial-scale processing.

In terms of products, the first two types produce mainly intermediate-products with the aim to reduce losses while preserving and increasing the value and consumption of cassava in local and national markets and even for export.

The root storage and processing system has been suitable for the small, scattered cultivation areas of the farmers in Vietnam.

However, for a long time, the factors that determine the methods and scale of processing technology, as well as the organization of root processing, were not adequately considered. Because of that, although a range of equipment and technologies were introduced, only a few of these were accepted by processors. The problem of storage and packing have also not been solved. The organization of linking the local processing with industrial processing becomes very important, but the priority has been to develop the storage and processing network at the village level and at semi-industrial scale.

During the last ten years, small-scale cassava processing has developed well. The experiences obtained have shown that in those villages where farmers are involved in agro-product processing, the incomes are much higher than in villages where farmers deal only with cassava production (**Table 3**).

I. On-site Processing at the Farmer Household Level

Traditionally, cassava has been the farmers' strategic reserve food and was consumed in the case of a rice crop failure. Until recent years, about 80% of cassava was consumed and marketed only between rural areas. Cassava was mainly used in the form of fresh or dried chips as animal feed and for human consumption.

Table 3. Comparison between a village with and without root crop processing.

	Que Duong village (mainly processing)	Phung Thuong village (mainly farming)
Cultivated area (ha)	280	480
Rice yield (t/ha/year)	10	10
Population density (people/ha)	35	19
Total income (%)	160	100
-Cropping	18-22	70-76
-Livestock	25-28	18-20
-Processing	45	8

Home processing of cassava into food: Cassava can be cooked together with rice, or it can be used for the production of various kinds of cakes, desserts and other traditional dishes.

In general, in the main cassava cultivation regions, maize and paddy rice production per capita is low (170-240 kg/inhabitant) (**Table 2**).

In the central part of Vietnam, where root crops account for about 30% of total food production, the local people have a tradition of using root crops as a daily food for human consumption. There are many different and tasty dishes made from cassava. The home processing of root crops is well developed in several provinces of central Vietnam. In order to provide a balanced nutrition, cassava is often eaten with mungbean, black bean, sesame and fish.

In the other regions, where the home-processing of root crops was not so well developed, fresh roots or dried slices are traditionally consumed by the people in boiled or cooked form together with rice for breakfast or dinner. Due to the improvement of rice provision in the country during the last three years, the proportion of root crops used directly for human consumption has reduced.

Cassava chipping and drying: 40-60% of cassava production is processed into dried cassava chips. At present, there is a severe shortage of fire wood in the cassava production zones, so cassava chips are dried in the sun. Because of the lack of sunshine during the harvest period, cassava roots must be thinly sliced, after which it takes about 2 to 3 days to dry. Frequent changes of the weather (rain or a sudden increase in temperature) result in substandard quality of dried cassava chips and large losses due to rotting. Various kinds of chipping machines have been introduced. But the average cultivated area of cassava per household is very small (<0.5 ha), so Vietnamese farmers prefer to use a simple chipping-knife; cassava processing plants have been uneconomical.

During the past year the price of cassava chips has been very low and it was difficult to sell cassava. Therefore, cassava producers often have to process cassava chips for long time preservation and sale. These activities often did not provide adequate income to producers.

Because the amount of cassava produced per farmer household is small, family-scale cassava processing has not been well-developed in cassava growing areas. Use of fresh cassava and dry slices are still popular. There have also been some other processing, such as the production of acohol, starch, noodles, etc. Compared to "village enterprise" processing organizations, the invidually-operated small processors produce only small quantities and at low investment. Their processing efficiency is lower than that of small processors involved in the "village enterprise".

Besides cassava dry chips, family-scale processors also make other products, such as alcohol, noodles and different kinds of cakes, which are essentially made for selling in the local market. The small household processors operate individually. Their scale of production is small and discontinuous, because the small processors have to be directly involved in raw material supply as well as in product sale. The small processors use local raw materials and directly sell their products to customers in the village.

II. Communal-scale Cassava Processing: Model of a "Village Enterprise"

Since the agricultural area of each household is very small, agriculture can only supply about 50% of work for the people. So, many communes and villages of Vietnam are obliged to introduce some non-agricultural activities, creating the so-called "village enterprise".

The main characteristics of these processing models are the organization of production and consumption of products at the communal scale.

Village enterprises were formed because of the particular market, capital and labor conditions in the rural areas of Vietnam. Within it, all activities, such as raw material supply, processing, technical services and product consumption, have been arranged in an integrated network of labor division and other elements in the form of businesses and services. This helps to make optimal use of investment and labor resources, creating a larger amount of commodities at reasonable prices and with competitive potentials in the market. **Figure 1** shows the production arrangement.

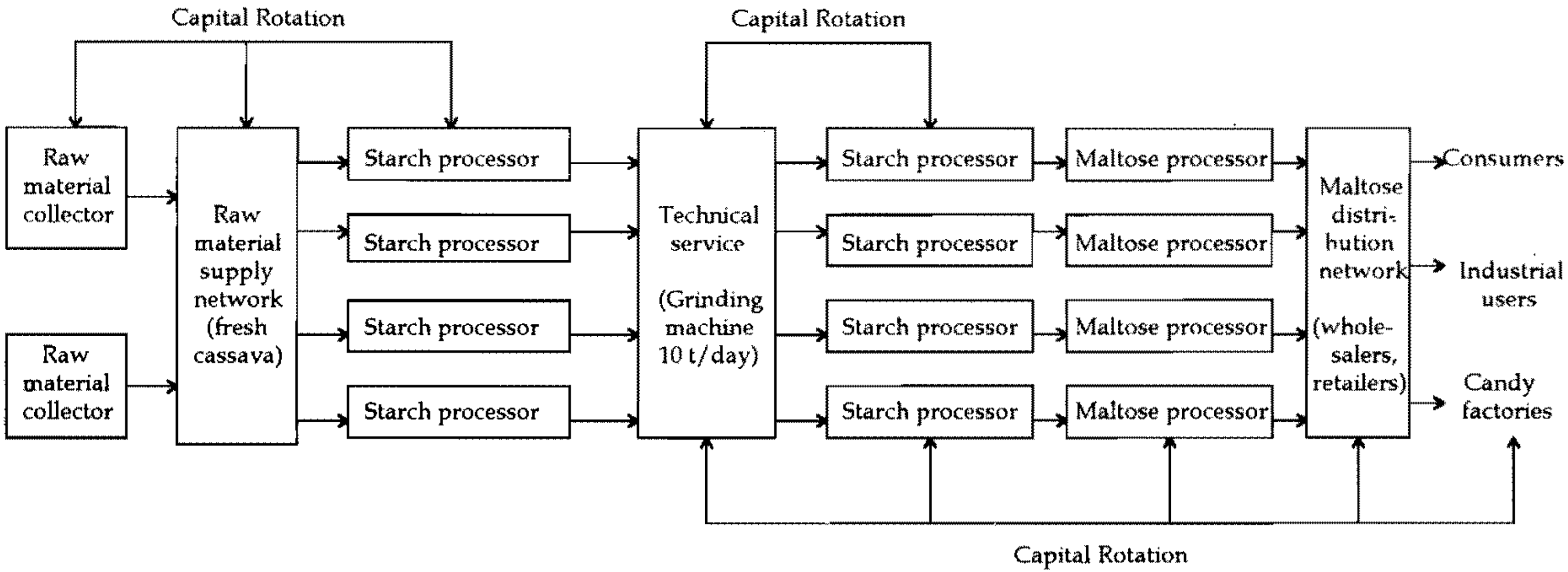

Figure 1. Model of production arrangement at a "village enterprise" involved in processing cassava starch and maltose in North Vietnam.

There are hundreds of small processors in a village enterprise. They concentrate their activities on the processing of one or two main kinds of products: starch, alcohol, noodle, maltose etc.

The investment level of the small processors is low. They apply a suitable technology and are engaged in competion to lower the price of products and to improve the technology. Their production is essentially continuous (120-200 days/year).

The production and yield of products made by the village enterprises are quite large. Sometimes their quantity of products are greater than that made by the industrial factories. For instance, Duong Lieu and La Phu are two village enterprises producing from 2600 to 3900 ton malt, while the industrial factory of Son Tay only produces 1800 ton malt per year. Similarly, Van Ha is a village enterprise specialized in the production of alcohol from cassava chips; it consumes about 2800 to 3200 ton cassava chips/year.

Processed cassava products made by village enterprises are sold in the whole region. The radius of the activities of the material supply and products consumption in these communes is from 30 to 300 km, and occasionally as far away as 1000 km.

The village enterprise is a dynamic agro-processing system and is adaptable to changes in market prices and raw materials supply. Small processors use various sources of labor, including seasonal labor from neighborhood communes; they use less capital, less investment and have low-cost production. In case of low benefits, the small processors can temporarily stop their production.

The system of technical services supply and product consumption has created power in the market, which allows a concentration of capital and reduction in distribution costs.

Over the last ten years, those villages with a certain level of socio-economic conditions have seen the success of the model of the "village enterprise", but the introduction of this technology has failed in cassava growing areas. The main reason is the difficulty in technical and supply services and the formation of a product consumption network. For instance, in Caothuong, the local small processors have to be directly involved in raw material supply as well as product consumption. Generally, the amount of product is small, while costs for raw material supplies and product consumption are high; moreover, they themselves could not form effective marketing channels.

The 1991 processing survey showed that the amount of processing in the cassava production village was only about 8-20% of that produced by small processors around Hanoi. Despite the fact that raw material costs are lower, market prices of products are higher, while their incomes remain low (**Table 3**).

Almost all the cassava processing village enterprises are not located in the region of raw materials supply, but instead, are nearly all in the region close to consumption markets.

III. Industrial-scale Cassava Processing

Before 1975, the government of Vietnam had programs of establishing dozens of cassava and sweet potato processing factories in provinces (about 10-50 tons of roots per day). Now, most of these enterprises are closed. Part of the reason is the price system, but the main reason is that these enterprises run only two months per year and their product quality and price were not competitive. The lesson drawn here is the importance of an appropriate relationship between raw material supply and the output capacity of each plant. In Vietnam, the amount of cassava from each peasant household is still low. The root crops are grown over a wide area throughout the country and harvesting is seasonal. Transport is also a great problem. This results in problems of raw material supply for large-scale processing factories.

Some cassava-based industries are involved in cassava processing into dry chips, starch and flour, which are mainly used to make animal feed, and by fermentation to produce alcohol, MSG, etc. The production of animal feed from cassava chips is constrained due to cassava's high HCN content and nutritional imbalance (low protein content). Cassava flours, however, are often used to produce cakes etc., on a small-scale in some towns, and also to make glue for the packing industy. And increasing amounts of cassava starch are required by the paper, textile and pharmaceutical factories.

APPROPRIATE CASSAVA PROCESSING TECHNOLOGIES DEVELOPED IN VIETNAM

I. Fresh Cassava Preservation by Removing the Milk Sap

This technology was developed by the Department of Biochemistry and Food Technology of INSA (Vietnam Institute of Agricultural Sciences) in 1989, with the objective of substituting the method of processing cassava chips, which is not very suitable under the climatic conditions of North Vietnam.

Cassava milk sap is a good medium for the growth of micro-organisms as its protein content fluctuates between 6-9%. For that reason, a technology was developed for removing the milk sap from cassava, as this will allow the processing and preservation of fresh cassava under different climatic and socio-economic conditions.

The technical procedure of processing and preservation of fresh cassava by removing the milk sap is as follows:

a. Peeling and washing of fresh cassava roots (by hand or machine)

b. Grinding cassava into very fine particles (grinding machine operated by motor or by hand)

c. Isolating the milk sap by a chemical mixture (milksap contains proteins, lipids, tannins, polyphenoles etc., which are soluble in water)

d. Dewatering by pressure-equipment

e. Preservation of wet cassava without the milk sap under anaerobic conditions from 1-6 months

f. Extraction of starch by filtration through a polyester cloth or production of cassava flour pellets

g. Solar drying of cassava starch, or HCN-free pellets or flour

h. Packaging

This technology permits the producer to process cassava under all weather conditions and to reduce wastage. Milk sap-free cassava is easy to preserve with only a minimal microbial infection; it is also free of HCN, does not have the taste of cassava, and can be easily used for different purposes (Quach Nghiem, 1992).

The milk sap-free cassava is a valuable material for producing cassava pellets. Because it has just been put into the pilot production stage this year, we can not yet produce economically relevant data relating to this technology. However, a comparison can be made between the prices of three semi-finished products of cassava:

Cassava chips	50-70 US$/ton
Cassava pellets	120-130 US$/ton
Cassava starch	220 US$/ton

II. Wet Starch Processing and Preservation

The technology for processing and preserving filtered wet cassava starch in Vietnam has been developed and completely perfected prior to 1984. With this new technology the amount of recovered filtered starch is twice as high as before. This is due to a more efficient grinding and filtering technique. The simultaneous application of the technology used for anaerobic preservation of fresh starch made it possible to substitute cassava starch for rice in producing malt, candy and cakes, and created a good market for this branch of processed cassava starch.

The present process of producing filtered starch from cassava is as follows:

a. Peeling and cleaning of cassava roots
b. Grinding with a grinding machine
c. Filtration of the starch liquid through a cloth (by hand or machine)
d. Wet starch with 35% moisture can be preserved underground under anaerobic conditions for about a year
e. Drying of starch when weather conditions are more favorable
f. Waste is used for animal feed.

The recovery of wet starch with a water content of 35% is about 40-60 kg per 100 kg fresh cassava. There are three important points concerning this technology:

1. The cassava roots are ground into very fine particles by a rapidly rotating wooden cylinder with 14-18 rows of embedded fine cable steel wire (6-8 rem); the rotation speed is 4000-4500 rpm. When the cylinder is rotating, the fine cable steel wire embedded in the wooden cylinder will destruct and break cassava pulp into very fine particles, which results in a highly efficient extraction of starch. The capacity of the grinding machines is about 10 t fresh roots per day, while the consumption of diesel oil is about 3.2 kg/ton fresh roots.
2. To purify the starch, the liquid is sieved through a polyester cloth (valide). A layer of 30-35 cm of water is maintained on top of the starch (15-10 cm), which is deposited in a 40 cm deep basin. The surface layer of starch containing the milk sap (6-9% protein, 0.5% lipid, etc) is used as a pig feed without cooking.
3. The purified starch deposited at the bottom of the tank is white and forms a hard layer.

Wet starch preservation: the starch particles which are covered with amylose are insoluble in water. When this wet starch is stored underground, there is a certain amount of water-insoluble starch particles, which can be pressed hard to eliminate air bubbles.

If the plastic is disinfected with aluminum sulfate before filling with starch, the starch can be preserved underground for at least one year.

The cost of preservation is about 3-5% of the value of the starch. Losses are estimated at 3%. Purified starch production from cassava is essentially at the family and small-scale workshop level.

III. Small-scale Maltose Production from Cassava Starch

There are two factories producing maltose and glucose sugar from cassava starch by the method of acid hydrolysis; their production, however, satisfies only one fourth of the market demand.

Because the cane-sugar price is high in Vietnam, low-cost cassava starch and malt are mainly used in the confectionery industry (price of 1 kg malt = 1 kg rice; 1 kg dry starch = 1 kg rice). Therefore, small-scale maltose production units were recently set up in rural areas.

The maltose production technology is as follows:

a. Mixing of wet starch with boiling water to form a glue
b. Fermentation by amylase (from germinated rice seeds)
c. Incubation (hydrolysis) overnight
d. Filtration
e. Concentration of maltose by heating (45-60 min/batch)

One village located in the suburbs of Hanoi consists of 300 families producing maltose with a total capacity of 4000 t/year, and each household produces 13 t/year on average.

The income of one laborer involved in maltose production is about 8-10 times higher than that of a laborer in farming.

IV. Noodle Production Technology from Cassava Starch

Low-cost noodles can be produced from cassava starch, but their quality is not very high. These cassava noodles are produced in family-owned shops with a capacity of 50 to 300 kg of noodles per day.

The cassava noodle production process (applied since 1980) is as follows:

a. Pretreatment of wet cassava starch with aluminum sulfate
b. Pasting (mixing to form a glue)
c. Heating of a thin starch sheet with steam (100°C, 5 min)

d. Solar semi-drying of starch sheets on bamboo screens
e. Cutting into strands
f. Solar drying of noodles
g. Packaging

V. Cassava Starch Chip Production Without Cooking

In 1987 INSA developed a process for making cassava chips (similar to krupuk) without cooking oil by using old gas bottles as pressure ovens to obtain a volume expansion of 40 times. The volume expansion of chips depends on: the quality of starch paste, the water content of chips, the total air tightness of the barrel cover, and the pressure inside the barrel oven (7-8 atm).

The cassava chip processing steps are as follows:

a. Formation of paste from cassava starch or flour
b. Cutting of chips
c. Steam treatment (100°C, 5 min)
d. Solar drying to 14% and oven drying to 10% water content
e. High pressure treatment at 8 atm by heating in an old gas barrel oven (15 min for 3-4 kg chips)
f. Volume expansion of 30-40 times when pressure is reduced to 1 atm
g. Packaging of chips

ECONOMIC ASPECTS OF CASSAVA PROCESSING IN VIETNAM

A survey on cassava processing, production and marketing was conducted in 1991 by the Vietnamese Root Crop Program in collaboration with CIAT. Due to the fact that large amounts of cassava had not been consumed in 1990, many areas did not grow cassava in 1991 and this resulted in a higher price of cassava than the usual average price. Considering the survey results on cassava processing, we can make the following observations:

- The investment level in cassava processing in rural areas is generally low, especially in the case of individual small-scale processors. With an average area of 0.27 ha of cassava/household, almost no farmers invest in processing cassava chips, which gives a low economic benefit compared to other processing forms. This situation is partially caused by the fluctuating prices in the market and the low value of cassava, and consequently, there are no large-scale cassava chip processing facilities in Vietnam.

The highest investment level is needed for starch production and lower investments are required for production of maltose, alcohol, etc.

The survey showed that the investment in small cassava processing workshops is between 156,000 and 11 million VND. Obviously, cassava processing is a major activity in some "village enterprises". The processor households seem to invest more capital than the others, particularly much more than the small individual processor households in the areas of cassava production.

The economic efficiency is quite clear: villages involved in cassava processing have received more income than those which are not involved in processing (**Table 3**).

Results obtained in 1989 also indicate that households involved in cassava starch, maltose and noodle processing have much higher incomes than those who practice rice cultivation (Quach Nghiem, 1992). Further more-detailed economic data about processing and its products have been included in Binh *et al.* (this Proceedings)

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SOCIO-ECONOMIC ASPECTS OF CASSAVA PRODUCTION, MARKETING AND RURAL PROCESSING IN VIETNAM

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INTRODUCTION

In Vietnam, most agricultural data focuses on primary crops such as rice. Secondary data on cassava for most provinces is limited to average areas, yields and production figures. Secondary data on socio-economic aspects of cassava production and processing is virtually non-existent. Recently, however, several studies have included cassava, while the crop of specific interest was sweet potato (Binh and Bottema, 1991). In addition, Nghiem (1992) has documented current post-harvest and processing aspects of cassava.

In light of the scarcity of primary and secondary information on the socio-economic aspects of cassava production and processing in Vietnam, the current study was included as part of the Vietnamese Cassava Benchmark Study, as described in an earlier paper (Henry, this Proceedings).

This paper aims to characterize and analyze socio-economic aspects of cassava production and rural (on-farm) processing. As with the other papers presented in this workshop, the data have been generated through household surveys conducted throughout Vietnam in 1990-92. The paper is divided as follows: first, the surveyed farm households are characterized; secondly, the inter-relationships between cassava production and processing are analyzed; and thirdly, the resource use in cassava production and processing is analyzed. This is followed by a discussion on the efficiency of the crop. Next, cassava (product) marketing is described, followed by a discussion on the major constraints in production and marketing.

Although the detailed surveys have generated thousands of data, most data used for discussions in this paper are either aggregated for zones or for farm sizes. It is hoped that this will benefit the flow of analysis and understanding.

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CASSAVA PRODUCTION

Cassava farm characteristics

Other papers in this workshop have already extensively described cassava farming in Vietnam; as such, only some supplementary data will be presented here.

In line with several other SE Asian countries, farm sizes in Vietnam are small and do not vary much among locations. But, cassava farms in the Southeast (average 0.85 ha) are double the size of those on average in North Vietnam. Cassava area for all of Vietnam subsequently is small as well and averages 0.27 ha, with extremes for the Southeast (0.85 ha) and the North Mountainous Region (0.20 ha), as can be appreciated from **Tables 1** and **2**.

When farm sizes are classified, it can be shown that 31.6% of the sampled farms are smaller than 0.6 ha, 35.5% are between 0.6-1.05 ha, and the remaining 33% are (slightly) larger than 1.05 ha. In subsequent analysis, this farm classification is indicated as small, medium, and large farms, respectively (**Table 2**).

While before 1988-89 most farm land was state controlled, currently most farms are privately "owned". The data shows that still 14.4% of the surveyed cassava farms are state-run in Vietnam. The majority of these state farms are situated in the North Mountainous Region and the Red River Delta. In South Vietnam only 4.8% are state farms (**Table 1**). Because of the decreasing importance of state farms (or cooperatives) no special comparison will be made between state and private farms.

The majority of cassava farms own and fatten pigs, which is an important source of cash income during pre-harvest periods and is an efficient way of value-adding low quality products and by-products (including cassava). **Table 1** shows an average of 2.25 pigs per household, which does not vary significantly over regions.

Ownership of cattle on cassava farms in Vietnam is a major indication of draft power (oxen) use. The average number of head per farm is 1.36 (**Table 1**). Depending on the level of tractorization, the number of cattle is as low as 0.62 in the Southeastern Region, or as high as 2.53 in the North Central Coast.

The majority of cassava farmers have a large experience in cassava farming. Data shows that 66.7% of surveyed farmers have more than 10 years experience. Only 4.8% have recently started cassava production (over last 1-3 years).

Table 1. Characteristics of surveyed households in Vietnam, 1991.

Indicator	Unit	North Vietnam				South Vietnam				Total Vietnam
		North Mount. Region	Red River Delta	North Central Coast	Sub total	South Central Coast	Central High-lands	South-eastern Region	Sub total	
Number of households surveyed		287	96	102	485	273	100	220	593	1,078
Number of provinces surveyed		5	2	2	9	4	3	3	10	19
Average cassava area/hh	ha	0.20	0.24	0.25	0.22	0.25	0.39	0.85	0.50	0.27
Small size farms (<0.6 ha)	%	47.74	40.86	15.69	39.63	39.78	16.00	10.55	25.00	31.60
Medium size farms (0.6-1.05 ha)	%	41.11	44.09	51.96	43.98	36.15	25.00	20.64	28.55	35.50
Large size farms (>1.05 ha)	%	11.15	15.05	32.35	16.39	24.09	59.00	68.81	46.45	33.00
Private households	%	64.69	79.17	95.05	73.91	91.21	96.00	100.00	95.22	85.59
Cooperative households	%	35.31	20.83	4.95	26.09	8.79	4.00	0.00	4.78	14.41
Experience of farmer <3 years	%	0.70	13.54	7.84	4.74	1.83	0.00	10.91	4.89	4.82
Experience of farmer 4-5 years	%	2.79	6.25	3.92	3.71	5.13	8.80	9.55	7.25	5.66
Experience of farmer 6-10 years	%	17.42	15.63	21.57	17.94	16.48	44.00	31.82	26.81	22.82
Experience of farmer >10 years	%	79.09	64.58	66.67	73.61	76.56	48.00	47.73	61.05	66.70
Average pigs/household	head	2.66	2.27	2.79	2.61	1.93	2.54	1.70	1.95	2.25
Average cattle/household	head	1.48	1.42	2.53	1.69	1.38	1.28	0.62	1.08	1.36
Average chickens/household	head	26.48	16.99	20.05	23.25	7.81	11.18	10.40	9.34	15.60

Table 2. Cassava farm size in Vietnam, 1991.

				Small farm[1]		Medium farm[2]		Large farm[3]	
Code	Province/Region	No.	Av. (ha)	No.	%	No.	%	No.	%
A	**NORTH VIETNAM**	**485**	**0.22**	**191**	**39.63**	**212**	**43.98**	**79**	**16.39**
I	**North Mountainous Region**	**287**	**0.20**	**137**	**47.74**	**118**	**41.11**	**32**	**11.15**
04	Ha Tuyen	48	0.20	30	62.50	17	35.42	1	2.08
08	Hoang Lien Son	49	0.23	16	32.65	23	46.94	10	20.41
09	Bac Thai	72	0.29	22	30.56	35	48.61	15	20.83
11	Vinh Phu	72	0.11	51	70.83	20	27.78	1	1.39
12	Ha Bac	46	0.18	18	39.13	23	50.00	15	32.61
II	**Red River Delta**	**96**	**0.24**	**38**	**40.86**	**41**	**44.09**	**14**	**15.05**
14	Ha Son Binh	72	0.29	20	27.78	36	50.00	14	19.44
15	Hai Hung	24	0.09	18	75.00	5	20.83	0	0.00
III	**North Central Coast**	**102**	**0.25**	**16**	**15.69**	**53**	**51.96**	**33**	**32.25**
19	Nghe An/Ha Tinh	61	0.28	4	6.59	36	59.02	21	34.43
20	Quang Binh	41	0.19	15	29.27	17	41.46	12	29.27
B	**SOUTH VIETNAM**	**593**	**0.50**	**148**	**25.00**	**169**	**28.55**	**275**	**46.45**
IV	**South Central Coast**	**273**	**0.25**	**109**	**39.78**	**99**	**36.15**	**66**	**24.09**
23	Quang Nam - Da Nang	69	0.12	47	68.12	19	27.54	3	4.35
24-25	Quang Ngai/Binh Dinh	70	0.16	39	55.71	28	40.00	3	4.29
27	Khanh Hoa	63	0.55	8	12.70	31	49.21	24	38.10
28	Binh Thuan/Ninh Thuan	71	0.18	15	21.13	21	29.58	36	50.70
V	**Central Highlands**	**100**	**0.39**	**16**	**16.00**	**25**	**25.00**	**59**	**59.00**
29	Gia Lai/Kon Tum	25	0.60	0	0.00	0	0.00	25	100.00
30	Dac Lac	25	0.33	6	24.00	10	40.00	9	36.00
31	Lam Dong	50	0.31	10	20.00	15	30.00	25	50.00
VI	**Southeastern Region**	**220**	**0.85**	**23**	**10.55**	**45**	**20.64**	**150**	**68.81**
32	Song Be	63	1.50	7	11.11	14	22.22	42	66.67
33	Tay Ninh	63	1.52	0	0.00	4	6.35	57	90.48
34	Dong Nai	94	0.64	16	17.02	27	28.72	51	54.26
	TOTAL VIETNAM	**1,078**	**0.27**	**339**	**31.60**	**381**	**35.50**	**354**	**33.00**

[1] <0.6 ha

[2] 0.6-1.05 ha

[3] >1.05 ha

Cassava yields

Cassava yields in Vietnam, according to the data in **Table 3**, average 12.36 t/ha for the whole country. Variation across zones (and also in time) is significant and ranges from a low of 6.76 t/ha in Gia Lai-Kon Tum province to 20.16 t/ha in Ha Bac province. It is a surprise to note that the northern provinces on the average show higher yields (14.54 t/ha) than the southern provinces (10.60 t/ha). However, this will be explained in a later paper by Henry *et al.* (this Proceedings). It can be already said that the main factors influencing yield (besides climate and soil) include fertilizer, labor, variety, density and farm size.

Table 3. Average cassava yields (t/ha) in Vietnam in 1991, segregated by farm size and rice area.

Code	Province/Region	Average yield (t/ha)	By farm size			By rice area		
			Small	Medium	Large	Small	Medium	Large
A	**NORTH VIETNAM**	**14.54**	**14.08**	**14.75**	**15.15**	**19.47**	**14.24**	**14.56**
I	**North Mountainous Region**	**16.27**	**15.27**	**16.89**	**18.61**	**19.47**	**16.75**	**16.06**
04	Ha Tuyen	17.02	17.33	16.43	15.00	-	16.78	17.07
08	Hoang Lien Son	12.65	11.62	11.37	17.18	-	13.21	12.11
09	Bac Thai	20.14	19.77	20.85	19.18	17.63	18.53	20.41
11	Vinh Phu	11.85	12.30	11.95	8.50	-	17.33	11.35
12	Ha Bac	20.16	17.20	22.42	22.50	25.00	20.66	19.64
II	**Red River Delta**	**11.47**	**11.46**	**11.78**	**10.73**	-	**11.53**	**11.44**
14	Ha Son Binh	12.03	12.32	12.30	10.93	-	12.88	11.74
15	Hai Hung	9.78	10.26	8.42	8.00	-	8.06	10.49
III	**North Central Coast**	**12.45**	**10.89**	**12.26**	**13.75**	-	**11.87**	**12.79**
19	Nghe An/Ha Tinh	13.49	11.29	12.79	15.45	-	12.41	14.35
20	Quang Binh	10.90	10.67	11.12	10.92	-	10.54	11.03
B	**SOUTH VIETNAM**	**10.61**	**9.68**	**9.93**	**11.53**	**11.33**	**10.41**	**10.22**
IV	**South Central Coast**	**9.95**	**9.47**	**9.99**	**10.73**	**10.85**	**10.60**	**9.14**
23	Quang Nam - Da Nang	10.06	9.80	11.06	8.67	-	10.50	9.79
24-25	Quang Ngai/Binh Dinh	8.47	9.04	7.66	7.33	20.00	8.65	7.70
27	Khanh Hoa	11.91	10.72	11.77	12.66	13.30	13.02	10.17
28	Binh Thuan/Ninh Thuan	9.54	8.80	9.55	10.01	8.91	10.94	8.60
V	**Central Highlands**	**8.54**	**9.09**	**9.15**	**8.16**	**8.48**	**8.43**	**8.84**
29	Gia Lai/Kon Tum	6.76	-	-	6.76	-	6.42	8.10
30	Dac Lac	8.40	8.50	8.22	8.50	7.50	8.37	8.69
31	Lam Dong	9.49	9.45	9.75	9.37	8.68	9.99	10.00
VI	**Southeastern Region**	**12.37**	**10.82**	**10.24**	**13.24**	**11.90**	**14.30**	**12.65**
32	Song Be	10.82	9.73	11.37	10.95	11.45	5.50	10.76
33	Tay Ninh	16.28	-	16.00	16.30	15.52	19.67	16.92
34	Dong Nai	10.84	11.45	8.71	11.60	10.32	14.40	6.55
	TOTAL VIETNAM	**12.36**	**12.15**	**12.62**	**12.34**	**11.52**	**11.87**	**12.90**

When stratifying by farm size (**Table 3**), it can be seen that the hypothesis that larger farms have higher yields than smaller farms, holds for certain zones and provinces, like the North Mountainous Region, in Ha Bac and Nghe Tinh provinces, and in the Southeastern Region. However, in certain provinces we can see the reverse: smaller farmers have higher yields (Ha Tuyen, Vinh Phu and Ha Son Binh). This phenomenon must be further analyzed through production function analysis by region.

A further hypothesis, that a smaller (also percentage-wise) rice area would mean more emphasis on cassava and subsequently higher cassava yields than a larger rice area, was checked in **Table 3**. A qualitative assessment of the data would indicate that this hypothesis may hold, especially in northern Vietnam. This means that when, in terms of area, cassava becomes more important relative to rice, cassava will receive more inputs and yield subsequently more.

An earlier workshop paper by Nguyen Van Thang (this Proceedings) presented secondary data on cassava production, area and yield by agro-ecological zone and province. It was demonstrated that average yields for cassava in Vietnam in 1991 were 8.98 t/ha. However, when analyzing the 1991 Vietnamese survey data, the average cassava yield is 12.36 t/ha or 38% more than shown by the secondary data. It must be admitted that the estimation of yields in a farmers' survey is a difficult exercise, that may generate over and under-estimations. In addition, problems may arise from the fact that cassava growing cycles sometimes exceed 10-12 months. However, a 38% difference seems exaggerated. It must also be noted that cassava yields, like those of any other crops, are much affected by climatological factors, which vary over seasons and years. For that reason, in general, three-year moving averages are generally a more reliable estimation of yields than a 1991 snapshot as generated by these surveys.

As such, these absolute values must be interpreted with great caution and mainly serve to show and compare yield differences between regions and farm sizes. In addition they are useful in further analyses of production functions and factor efficiency, as shown by Henry *et al.* (this Proceedings).

Cassava production costs and revenues

In most cassava producing areas around the world, labor represents the majority (40-70%) of cassava production costs. In the case of Vietnam this also holds. **Tables 4** and **5** show that on average labor accounts for 60.70%. In some regions like the Red River Delta and the North Central Coastal this may be as low as 49.5 and 57.3%, respectively. In other zones, like the Central Highlands, this may be as high as 80.6%.

In terms of absolute labor demand, it can be seen in **Table 6** that there is a very large variation in this. For Vietnam the average labor demand is 204 mdays/ha. The data shows that on average, significantly more labor is required in the North (322 mdays) than in the South (175 mdays), with even a larger variation among different provinces. This is both in absolute terms and as a percentage of total production costs, as can be seen in **Figure 1**. In a later paper (this Proceedings), we will present the results from cassava production function and input efficiency analyses that to some extent explains these large differences, and shows the most limiting factors in cassava production by region.

If we analyze the source of labor in cassava farming, we see that on the average 75.5% consists of family labor, while hired and exchange labor constitute 23 and 1.5%, respectively (**Table 6**). Again, there is some variation by region. In the North Mountainous Region family labor constitutes 83%, while in the larger farms of the Southeastern Region this is only 68%. It will be obvious that larger farms will require more hired labor than smaller farms, as shown by the data.

The second largest cassava production cost item is fertilizer, constituting 15.6% on the average (**Tables 4 and 5**). However, the range in fertilizer application costs is very wide, from only 1% in the Central Highlands to 28.1% in the Red River Delta. It is also of interest to note that in general cassava farmers in the North have a higher percentage-wise fertilizer cost than farmers in the South.

Contrary to Latin American countries, the cost item "land rent" has a relatively low value (4.8%) on a Vietnamese average, which is the result of the Vietnamese Socialist system philosophy. In addition, it can be observed that "animal power" plays an important role in Vietnam compared to tractor power, which account for 6.3 and 0.5% of total costs, respectively. As such, it can be concluded that variable costs are virtually the majority of total costs in Vietnam. When looking at the absolute production costs (in terms of 1991 US$) we see in **Table 7** that the average for Vietnam of US$154/ha (US$12.44/ton)seems rather low when compared to for example Thailand, which for that same period was approximately US$300/ha (US$21.6/ton) (Titapiwantanakun, 1995). However, we can see a wide variation of costs between areas. In the larger farms of the Southeastern Region (Tay Ninh and Dong Nai provinces) production costs are US$156.41 and US$108.85/ha, respectively, while for example the average in the North Central Coast is US$207.82/ha. **Figure 2** shows relative cassava yields and production costs by region.

Cassava profitability

Much caution must be exercised in analyzing the costs and benefits of cassava production (or any other crop or product for that matter) because of the high prevailing rate of inflation in Vietnam. Prices and revenues from different time periods in real (or US$) terms will be quite different. During 1991 the inflation rate was approximately 50%. The data in **Table 8** was put in US$, applying an average US$ = 7,000 VND exchange rate (VND = Vietnamese dong). As shown in **Table 8** and **Figure 3**, the aggregated Vietnam average profit is US$172.55/ha, but varies widely across regions. Given an average cassava cultivated area of 0.27 ha, this would give US$46.58 per household (hh). In absolute terms this seems rather low. However, what does profit mean? It can be described as returns to management; then, how high is the opportunity cost of a small-scale farmer on a poor piece of cassava land? If we look at the returns to labor (**Table 8**) it can be shown that this amounts to US$0.86 and US$1.43/day for North and South Vietnam, respectively. Again, these aggregations hide wide fluctuations between regions. If we assume that the average (rural) day wage is approximately US$1, depending on the proximity to urban areas where wages (opportunities) are higher, cassava cultivation on the average in the South is a profitable alternative. Even if the return to labor is equal to the average daily wage rate, cassava farming is a marginal, but, at least, an opportunistic source of income, especially for isolated areas with marginal soils that offer very few alternatives. In addition, the opportunity cost of agricultural labor during non-harvest or non-planting (off) season, may at times approach zero (no jobs available). Also, it must be kept in mind that cassava returns are calculated in terms of average fresh root prices, which does not include the value addition of processing. When comparing the return to labor estimates with similar measures for sweet potato and rice production in Giong Rieng, Chan Thanh and Thu Duc districts in South Vietnam, we can conclude that cassava production is a viable crop alternative, since estimates for these districts range between US$1-US$2/day (Binh and Bottema, 1991).

Table 4. Cassava production costs (US$/ha) for total cropping cycle by province and region in Vietnam in 1991.

Code	Province/Region	Total cost	Labor	Mate-rials	Ferti-lizer	Animal power	Trac-tor	Pac-king	Other	Land rent	Credit	Imple-ment
A	**NORTH VIETNAM**	**179.69**	**107.31**	**12.78**	**34.60**	**9.72**	**0.34**	**3.25**	**0.26**	**6.82**	**0.61**	**4.00**
I	**North Mountainous Region**	**154.65**	**101.83**	**9.98**	**26.98**	**5.64**	**0.27**	**4.10**	**0.27**	**2.38**	**0.00**	**3.20**
04	Ha Tuyen	138.79	89.64	9.26	24.01	4.06	0.00	6.62	0.00	0.00	0.00	5.20
08	Hoang Lien Son	128.21	107.60	0.35	5.40	0.59	0.00	3.27	0.99	5.41	0.00	4.60
09	Bac Thai	134.22	126.33	1.35	1.49	0.66	0.00	2.18	0.25	0.74	0.02	1.20
11	Vinh Phu	169.17	70.66	20.19	47.50	17.12	1.09	7.53	0.00	5.08	0.00	0.00
12	Ha Bac	201.07	118.86	18.54	60.86	2.49	0.00	0.06	0.21	0.00	0.00	0.05
II	**Red River Delta**	**224.83**	**111.36**	**15.19**	**63.19**	**12.57**	**0.00**	**0.15**	**0.42**	**12.04**	**3.01**	**6.90**
14	Ha Son Binh	217.36	102.63	15.77	54.49	16.76	0.00	0.20	0.56	15.95	3.90	7.10
15	Hai Hung	245.29	137.53	13.48	89.32	0.00	0.00	0.00	0.00	0.31	0.35	4.30
III	**North Central Coast**	**207.82**	**119.06**	**18.49**	**30.24**	**18.63**	**0.83**	**3.66**	**0.08**	**14.59**	**0.14**	**2.10**
19	Nghe An/Ha Tinh	202.07	110.09	16.09	26.12	21.36	0.63	5.65	0.00	19.13	0.00	3.00
20	Quang Binh	216.53	132.40	22.06	36.38	14.58	1.11	0.70	0.21	7.84	0.35	0.90
B	**SOUTH VIETNAM**	**133.09**	**82.16**	**12.48**	**15.81**	**9.58**	**1.24**	**0.36**	**1.92**	**7.72**	**0.02**	**1.80**
IV	**South Central Coast**	**146.57**	**85.11**	**10.13**	**22.55**	**12.77**	**0.16**	**0.78**	**1.71**	**10.46**	**0.00**	**2.90**
23	Quang Nam - Da Nang	147.93	88.93	9.94	28.88	13.07	0.00	0.84	2.61	2.66	0.00	1.00
24-25	Quang Ngai/Binh Dinh	162.98	102.42	10.25	21.28	15.06	0.00	1.64	0.50	8.93	0.00	2.90
27	Khanh Hoa	148.18	78.76	6.36	15.00	14.53	0.00	0.07	0.09	26.47	0.00	6.90
28	Binh Thuan/Ninh Thuan	127.99	70.19	13.51	24.32	8.73	0.59	0.52	3.43	5.40	0.00	1.30

Table 4. (Continued).

Code	Province/Region	Total cost	Labor	Mate-rials	Ferti-lizer	Animal power	Trac-tor	Pac-king	Other	Land rent	Credit	Imple-ment
V	**Central Highlands**	**131.84**	**106.23**	**6.82**	**1.27**	**6.58**	**3.21**	**0.00**	**0.07**	**7.26**	**0.00**	**0.40**
29	Gia Lai/Kon Tum	103.56	57.14	10.23	0.00	14.71	0.00	0.00	0.03	21.43	0.00	0.02
30	Dac Lac	90.32	81.64	2.16	0.17	3.60	0.86	0.00	0.00	1.89	0.00	0.00
31	Lam Dong	166.52	143.07	7.44	2.45	4.00	6.00	0.00	0.00	2.86	0.00	0.70
VI	**Southeastern Region**	**116.69**	**67.47**	**18.00**	**14.00**	**6.97**	**1.71**	**0.01**	**3.05**	**4.52**	**0.08**	**0.90**
32	Song Be	89.79	66.44	6.93	5.47	5.34	2.08	0.00	0.00	3.37	0.16	0.00
33	Tay Ninh	156.41	54.52	39.70	35.33	14.11	2.81	0.00	3.68	6.23	0.03	0.00
34	Dong Nai	108.85	76.47	11.42	5.98	3.46	2.75	0.02	4.67	4.18	0.00	1.90
	TOTAL VIETNAM	**153.84**	**93.42**	**12.62**	**24.22**	**9.64**	**0.83**	**1.65**	**1.17**	**7.31**	**0.28**	**2.70**

Note: 1 US$ = 7,000 VND.

Table 5. Share of cassava production costs for total cropping cycle by province and region in Vietnam in 1991.

Code	Province/Region	Total cost (US$/ha)	Labor	Mate-rials	Ferti-lizer	Animal power	Trac-tor	Pac-king	Other	Land rent	Credit	Imple-ment
			<				%					>
A	**NORTH VIETNAM**	**179.69**	**60.00**	**7.00**	**19.00**	**5.40**	**0.20**	**2.00**	**0.10**	**4.00**	**0.30**	**2.00**
I	**North Mountainous Region**	**154.65**	**65.80**	**6.50**	**17.40**	**3.60**	**0.20**	**2.60**	**0.20**	**1.50**	**0.02**	**2.10**
04	Ha Tuyen	138.79	64.60	6.70	17.30	2.90	0.00	4.80	0.00	0.00	0.00	3.70
08	Hoang Lien Son	128.21	83.90	0.30	4.20	0.50	0.00	2.60	0.80	4.20	0.00	3.50
09	Bac Thai	134.22	94.10	1.00	1.10	0.50	0.00	1.60	0.20	0.60	0.04	0.90
11	Vinh Phu	169.17	42.00	12.00	28.06	10.00	0.50	4.50	0.00	3.00	0.00	0.00
12	Ha Bac	201.07	59.10	9.20	30.30	1.20	0.00	0.03	0.10	0.00	0.00	0.02
II	**Red River Delta**	**224.83**	**49.50**	**6.80**	**28.10**	**5.60**	**0.00**	**0.07**	**0.20**	**5.40**	**2.29**	**3.03**
14	Ha Son Binh	217.36	47.20	7.20	25.20	7.80	0.00	0.09	0.20	7.30	2.81	3.20
15	Hai Hung	245.29	56.10	5.50	36.40	0.00	0.00	0.00	0.00	0.10	0.29	1.80
III	**North Central Coast**	**207.82**	**57.30**	**8.90**	**14.50**	**9.00**	**0.40**	**1.80**	**0.03**	**7.00**	**0.10**	**1.00**
19	Nghe An/Ha Tinh	202.07	54.50	8.00	12.80	10.60	0.30	2.80	0.00	9.50	0.00	1.50
20	Quang Binh	216.53	61.10	10.30	16.80	6.70	0.50	0.30	0.10	3.60	0.37	0.40
B	**SOUTH VIETNAM**	**133.09**	**61.70**	**9.40**	**11.80**	**7.20**	**0.90**	**0.30**	**1.40**	**5.80**	**0.01**	**1.40**
IV	**South Central Coast**	**146.57**	**58.10**	**6.90**	**15.40**	**8.70**	**0.10**	**0.50**	**1.20**	**7.10**	**0.00**	**2.00**
23	Quang Nam - Da Nang	147.93	60.01	6.70	19.50	8.80	0.00	0.60	1.80	1.80	0.00	0.70
24-25	Quang Ngai/Binh Dinh	162.98	62.08	6.30	13.10	9.20	0.00	1.00	0.30	5.50	0.00	1.80
27	Khanh Hoa	148.18	53.20	4.30	10.10	9.80	0.00	0.05	0.05	17.90	0.00	4.60
28	Binh Thuan/Ninh Thuan	127.99	54.80	10.60	19.00	6.80	0.50	0.40	2.70	4.20	0.00	1.00

Table 5. (Continued).

Code	Province/Region	Total cost (US$/ha)	Labor	Mate-rials	Ferti-lizer	Animal power	Trac-tor	Pac-king	Other	Land rent	Credit	Imple-ment
			<				%					>
V	**Central Highlands**	**131.84**	**80.60**	**5.20**	**1.00**	**5.00**	**2.40**	**0.00**	**0.05**	**5.50**	**0.00**	**0.30**
29	Gia Lai/Kon Tum	103.56	55.20	9.90	0.00	14.20	0.00	0.00	0.03	20.70	0.00	0.02
30	Dac Lac	90.32	90.40	2.40	0.20	4.00	1.00	0.00	0.00	2.00	0.00	0.00
31	Lam Dong	166.52	85.90	4.50	1.50	2.40	3.60	0.00	0.00	1.70	0.00	0.40
VI	**Southeastern Region**	**116.69**	**57.80**	**15.40**	**12.00**	**5.90**	**1.50**	**0.05**	**2.60**	**3.90**	**0.05**	**0.80**
32	Song Be	89.79	74.00	7.70	6.10	6.00	2.30	0.00	0.00	3.70	0.20	0.00
33	Tay Ninh	156.41	34.80	25.50	22.60	9.00	1.80	0.00	2.30	4.00	0.02	0.00
34	Dong Nai	108.85	70.20	10.50	5.50	3.10	0.70	0.03	4.30	3.80	0.00	1.80
	TOTAL VIETNAM	**153.84**	**60.70**	**8.20**	**15.60**	**6.30**	**0.50**	**1.10**	**0.80**	**4.80**	**0.20**	**1.80**

Note: 1 US$ = 7,000 VND.

Table 6. Cassava production costs (US$/ton fresh roots) for total cropping cycle by province and region in Vietnam in 1991.

Code	Province/Region	Total cost	Labor	Mate-rials	Ferti-lizer	Animal power	Trac-tor	Pac-king	Other	Land rent		Credit	Imple-ment
A	**NORTH VIETNAM**	**15.33**	**8.43**	**1.19**	**3.70**	**0.84**	**0.03**	**0.17**	**0.01**	**0.64**	**0.06**	**0.21**	
I	**North Mountainous Region**	**9.83**	**6.37**	**0.65**	**1.78**	**0.37**	**0.01**	**0.27**	**0.01**	**0.18**	**0.00**	**0.14**	
04	Ha Tuyen	8.15	5.27	0.54	1.41	0.24	0.00	0.39	0.00	0.00	0.00	0.30	
08	Hoang Lien Son	10.12	8.50	0.03	0.43	0.05	0.00	0.26	0.08	0.43	0.00	0.34	
09	Bac Thai	6.68	6.27	0.07	0.07	0.03	0.00	0.11	0.01	0.04	0.01	0.07	
11	Vinh Phu	14.25	5.96	1.70	4.00	1.44	0.09	0.63	0.00	0.43	0.00	0.00	
12	Ha Bac	9.96	5.89	0.92	3.02	0.12	0.00	0.00	0.00	0.00	0.00	0.01	
II	**Red River Delta**	**21.28**	**11.28**	**1.34**	**6.69**	**0.69**	**0.00**	**0.01**	**0.02**	**0.67**	**0.18**	**0.37**	
14	Ha Son Binh	17.70	8.52	1.31	4.25	1.39	0.00	0.02	0.05	1.32	0.32	0.52	
15	Hai Hung	24.86	14.05	1.38	9.13	0.00	0.00	0.00	0.00	0.03	0.04	0.23	
III	**North Central Coast**	**14.90**	**7.65**	**1.60**	**2.64**	**1.46**	**0.07**	**0.24**	**0.01**	**1.07**	**0.01**	**0.14**	
19	Nghe An/Ha Tinh	9.97	3.16	1.19	1.94	1.58	0.05	0.42	0.00	1.42	0.00	0.21	
20	Quang Binh	19.84	12.14	2.02	3.34	1.34	0.10	0.06	0.02	0.72	0.03	0.07	
B	**SOUTH VIETNAM**	**12.92**	**8.43**	**1.08**	**1.15**	**0.95**	**0.13**	**0.02**	**0.13**	**0.86**	**0.00**	**0.10**	
IV	**South Central Coast**	**14.93**	**8.72**	**1.03**	**2.29**	**1.30**	**0.01**	**0.08**	**0.17**	**1.02**	**0.00**	**0.29**	
23	Quang Nam - Da Nang	14.70	8.84	0.99	2.87	1.30	0.00	0.08	0.26	0.26	0.00	0.10	
24-25	Quang Ngai/Binh Dinh	19.21	12.08	1.20	2.51	1.78	0.00	0.19	0.06	1.05	0.00	0.34	
27	Khanh Hoa	12.43	6.61	0.53	1.26	1.22	0.00	0.00	0.00	2.22	0.00	0.59	
28	Binh Thuan/Ninh Thuan	13.41	7.36	1.42	2.55	0.91	0.06	0.05	0.36	0.57	0.00	0.13	

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Table 6. (Continued).

Code	Province/Region	Total cost	Labor	Materials	Fertilizer	Animal power	Tractor	Packing	Other	Land rent	Credit	Implement
V	**Central Highlands**	**14.53**	**11.08**	**0.85**	**0.09**	**1.01**	**0.24**	**0.00**	**0.00**	**1.23**	**0.00**	**0.02**
29	Gia Lai/Kon Tum	15.31	8.45	1.51	0.00	2.18	0.00	0.00	0.00	3.17	0.00	0.00
30	Dac Lac	10.75	9.72	0.26	0.02	0.43	0.10	0.00	0.00	0.22	0.00	0.00
31	Lam Dong	17.53	15.07	0.78	0.26	0.42	0.63	0.00	0.00	0.30	0.00	0.07
VI	**Southeastern Region**	**9.30**	**5.51**	**1.37**	**1.07**	**0.56**	**0.14**	**0.00**	**0.22**	**0.35**	**0.00**	**0.00**
32	Song Be	8.29	6.14	0.64	0.51	0.49	0.19	0.00	0.00	0.31	0.01	0.00
33	Tay Ninh	9.61	3.35	2.44	2.17	0.87	0.17	0.00	0.23	0.38	0.00	0.00
34	Dong Nai	10.02	7.05	1.05	0.55	0.32	0.07	0.00	0.43	0.38	0.00	0.00
	TOTAL VIETNAM	**14.12**	**8.43**	**1.13**	**2.42**	**0.89**	**0.08**	**0.09**	**0.07**	**0.75**	**0.03**	**0.15**

Note: 1 US$ = 7,000 VND.

Table 7. Average labor utilization in cassava production in Vietnam, 1991.

Code	Province/Region	Total mdays /ha	Hired		Family		Exchange	
			mdays	%	mdays	%	mdays	%
A	**NORTH VIETNAM**	**322**	**57**	**17.57**	**263**	**81.68**	**3**	**0.75**
I	**North Mountainous Region**	**300**	**47**	**15.56**	**250**	**83.33**	**4**	**1.11**
04	Ha Tuyen	297	53	17.76	244	82.15	1	0.09
08	Hoang Lien Son	246	41	16.83	192	78.05	13	5.12
09	Bac Thai	308	36	11.61	272	88.31	0	0.00
11	Vinh Phu	301	80	26.42	222	73.75	0	0.00
12	Ha Bac	534	114	21.34	420	78.65	0	0.00
II	**Red River Delta**	**414**	**75**	**18.25**	**338**	**81.64**	**0**	**0.00**
14	Ha Son Binh	373	60	16.16	313	83.91	0	0.00
15	Hai Hung	650	164	25.26	486	74.77	0	0.00
III	**North Central Coast**	**318**	**78**	**24.62**	**240**	**75.47**	**0**	**0.00**
19	Nghe An/Ha Tinh	270	63	23.22	207	76.67	0	0.00
20	Quang Binh	451	121	26.93	329	72.95	0	0.00
B	**SOUTH VIETNAM**	**175**	**45**	**25.58**	**127**	**72.57**	**3**	**1.85**
IV	**South Central Coast**	**296**	**63**	**21.27**	**232**	**78.38**	**1**	**0.35**
23	Quang Nam - Da Nang	468	144	30.75	322	68.80	2	0.45
24-25	Quang Ngai/Binh Dinh	461	112	24.25	349	75.70	0	0.00
27	Khanh Hoa	208	27	13.16	179	86.06	1	0.78
28	Binh Thuan/Ninh Thuan	325	81	24.84	244	75.08	0	0.08
V	**Central Highlands**	**232**	**45**	**19.27**	**181**	**78.02**	**6**	**2.71**
29	Gia Lai/Kon Tum	206	49	23.79	157	76.21	0	0.00
30	Dac Lac	180	41	22.60	127	70.56	12	6.84
31	Lam Dong	281	46	16.23	231	82.21	4	1.56
VI	**Southeastern Region**	**131**	**39**	**30.09**	**89**	**67.94**	**3**	**1.97**
32	Song Be	240	73	30.59	166	69.17	1	0.24
33	Tay Ninh	90	41	45.61	46	51.11	3	3.28
34	Dong Nai	162	26	16.24	132	81.48	4	2.28
	TOTAL VIETNAM	**204**	**47**	**23.06**	**154**	**75.49**	**3**	**1.45**

Source: *Vietnam Cassava Benchmark Study, 1991.*

Table 8. Cassava production costs and revenues in Vietnam, 1991.

Code	Province/Region	Growing cycle (months)	Labor (mdays /ha)	Production cost (US$/ha)[1]	Yield (t/ha)[2]	Farmgate price (US$/t)	Gross output (US$/ha)[3]	Profit (US$/ha)[4]	Profit/ cost (US$)[5]	Gross return to labor (US$/md)[6]
A	**NORTH VIETNAM**	**10**	**359**	**179.69**	**14.54**	**24.10**	**350.44**	**170.75**	**0.95**	**0.98**
I	**North Mountainous Region**	**10**	**343**	**154.65**	**16.26**	**23.62**	**384.05**	**229.40**	**1.48**	**1.12**
04	Ha Tuyen	10	307	138.79	17.02	22.86	389.08	250.29	1.80	1.26
08	Hoang Lien Son	9	343	128.21	12.65	22.85	289.08	160.87	1.25	0.84
09	Bac Thai	13	375	134.22	20.14	23.58	474.92	340.70	2.54	1.27
11	Vinh Phu	8	295	169.17	11.85	22.18	262.83	93.66	0.55	0.89
12	Ha Bac	10	406	201.07	20.16	25.91	522.31	321.24	1.60	1.28
II	**Red River Delta**	**9**	**393**	**224.83**	**11.47**	**24.86**	**285.10**	**60.27**	**0.27**	**0.72**
14	Ha Son Binh	9	377	217.36	12.03	24.30	292.36	75.00	0.35	0.77
15	Hai Hung	10	442	245.29	9.78	25.61	250.52	5.23	0.02	0.57
III	**North Central Coast**	**10**	**371**	**207.82**	**12.45**	**24.99**	**311.18**	**103.36**	**0.50**	**0.84**
19	Nghe An/Ha Tinh	11	315	202.07	13.49	25.71	346.87	144.80	0.72	1.10
20	Quang Binh	10	455	216.53	10.90	24.29	264.73	48.20	0.22	0.58
B	**SOUTH VIETNAM**	**11**	**215**	**133.09**	**10.61**	**28.41**	**301.43**	**168.34**	**1.26**	**1.40**
IV	**South Central Coast**	**10**	**248**	**146.57**	**9.95**	**26.14**	**260.10**	**113.53**	**0.77**	**1.05**
23	Quang Nam - Da Nang	10	272	147.93	10.06	27.14	273.05	125.12	0.85	1.00
24-25	Quang Ngai/Binh Dinh	11	289	162.98	8.47	27.14	229.90	66.92	0.41	0.79
27	Khanh Hoa	10	232	148.18	11.91	25.70	306.06	157.88	1.06	1.32
28	Binh Thuan/Ninh Thuan	10	201	127.99	9.54	24.30	231.81	103.82	0.81	1.15
V	**Central Highlands**	**13**	**191**	**131.84**	**8.54**	**32.42**	**276.90**	**145.06**	**1.10**	**1.45**
29	Gia Lai/Kon Tum	10	136	103.56	6.76	32.86	222.11	118.55	1.14	0.63
30	Dac Lac	10	187	90.32	8.40	32.88	276.23	185.91	2.06	1.48

31	Lam Dong	15	221	166.52	9.49	30.71	291.49	124.97	0.75	1.32

Table 8. (Continued).

Code	Province/Region	Growing cycle (months)	Labor (mdays /ha)	Production cost (US$/ha)[1]	Yield (t/ha)[2]	Farmgate price (US$/t)	Gross output (US$/ha)[3]	Profit (US$/ha)[4]	Profit/ cost (US$)[5]	Gross return to labor (US$/md)[6]
VI	**Southeastern Region**	**10**	**185**	**116.69**	**12.37**	**27.92**	**345.37**	**228.68**	**1.96**	**1.87**
32	Song Be	10	178	89.79	10.82	27.85	301.36	211.57	2.36	1.69
33	Tay Ninh	10	142	156.41	16.28	27.67	450.48	294.07	1.88	3.17
34	Dong Nai	10	217	108.85	10.84	28.33	307.07	198.22	1.82	1.41
	TOTAL VIETNAM	**10**	**280**	**153.84**	**12.36**	**26.41**	**326.39**	**172.55**	**1.12**	**1.16**

[1] from Table 4,
[2] from Table 3,
[3] Yield × fresh root price,
[4] Gross output – Production cost,
[5] Profit/Production cost,
[6] Gross output/mdays.

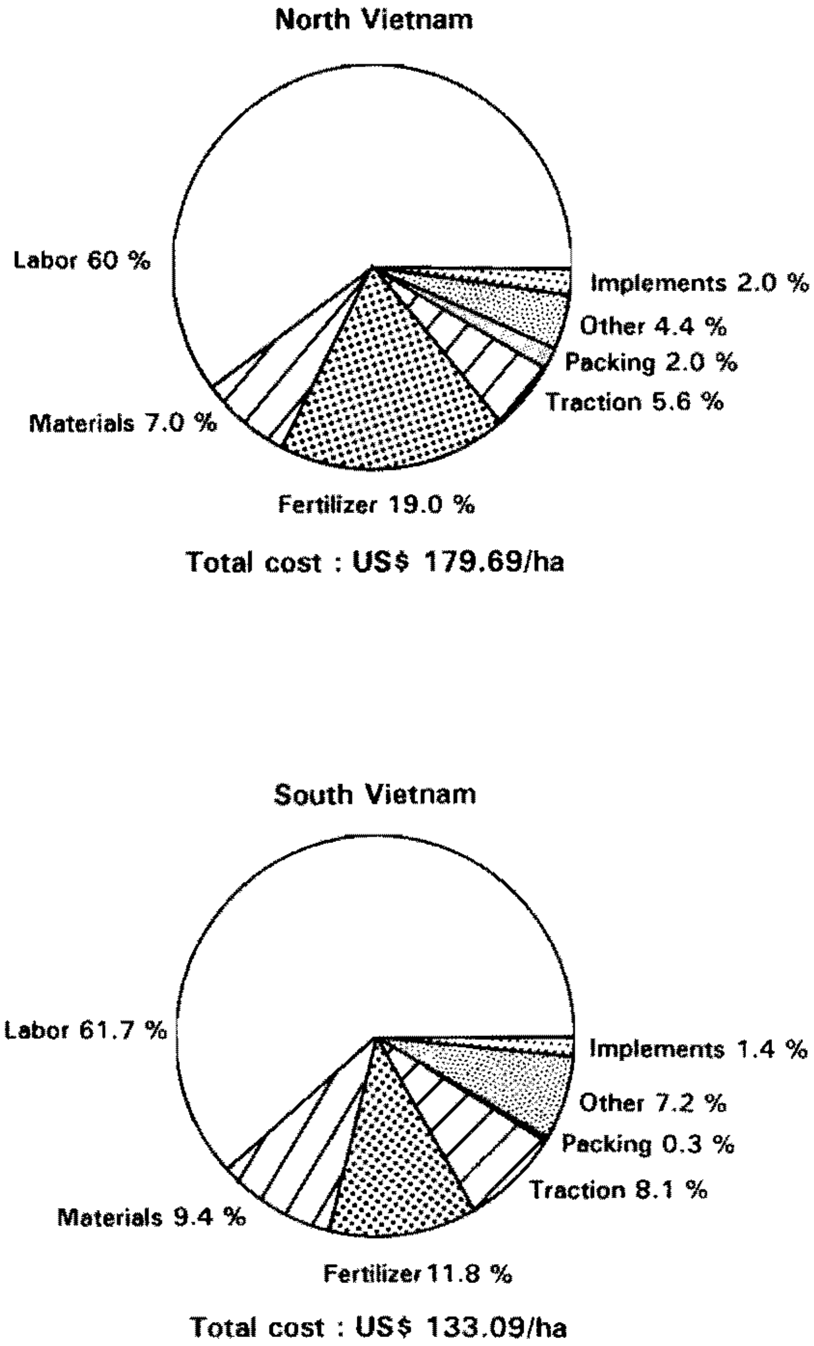

Figure 1. Relative cassava production cost shares in North and South Vietnam in 1991.

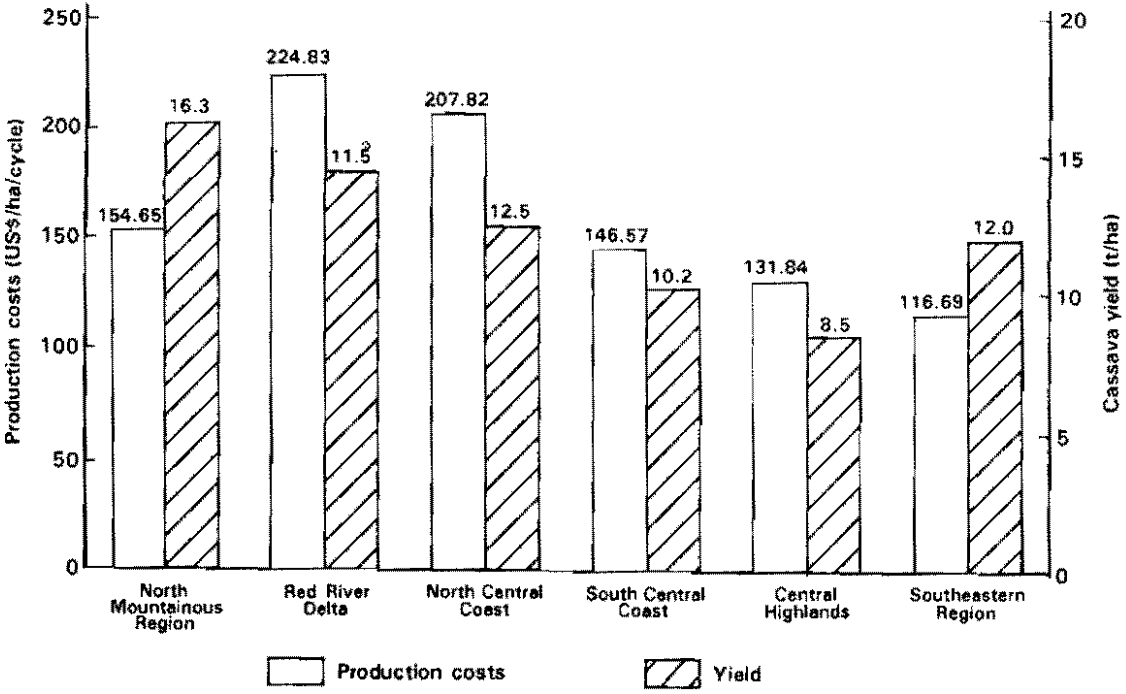

Figure 2. Cassava yield and production costs for different agro-ecological regions in Vietnam, 1991.
***Source**: Vietnam Cassava Benchmark Study, 1991.*

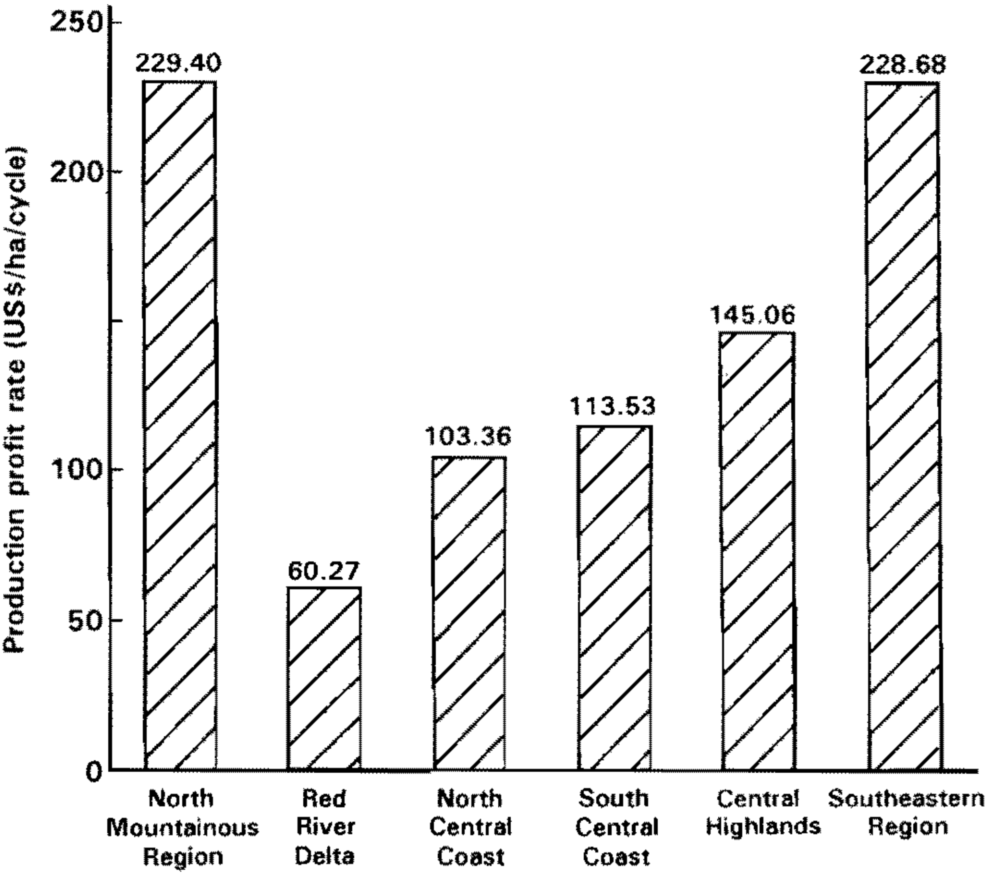

Figure 3. Cassava production profit rates for different agro-ecological regions in Vietnam, 1991.
***Source:** Vietnam Cassava Benchmark Study, 1991.*

Constraining factors in cassava production

It is difficult to aggregate a qualitative assessment of current cassava constraints. **Table 9** shows a relative ranking of constraints by province. A first glance shows that, in general farmers hardly "complain" about low yield, typhoon damage or high labor requirements. Highest ranking constraints are large price variation, market (demand) problems, low profitability and low soil fertility.

Highest scores for low soil fertility were in northern provinces (like Hoang Lien Son), which is in line with other information. Most southern provinces typically show a high rating for large price variations. This to a certain extent makes sense since southern farmers are much more (in volume) market dependent than northern farmers. Low (or fluctuating) demand, which is strongly related to fluctuating prices, is a constraint for both northern and southern farmers. However, again, this constraint is ranked much higher in the South than in the North.

Table 9. Relative importance[1] of constraints to cassava production in Vietnam, 1991.

Code	Province	Low yields	Low soil fertility	Typhoon damage	High labor requirement	Marketing	Price variation	Profitability
04	Ha Tuyen	1.00						
08	Hoang Lien Son	4.00	1.00			2.00		3.00
09	Bac Thai						1.00	
11	Vinh Phu	1.00		2.00	3.00		4.00	
12	Ha Bac	2.00	1.00					
14	Ha Son Binh		1.00	3.00		4.00	2.00	
15	Hai Hung				1.00		2.00	
19	Nghe An/Ha Tinh	3.00	4.00	3.00	2.00	1.00	5.00	
20	Quang Binh		1.00			2.00		1.00
30	Dac Lac					1.00		
31	Lam Dong	1.00				2.00		
32	Song Be	4.00			2.00	1.00	3.00	
33	Tay Ninh				2.00	1.00	3.00	
34	Dong Nai				1.00	2.00		

[1] High importance = 1, low importance = 5.

Source: *Vietnamese Cassava Benchmark Study, 1991.*

CASSAVA PROCESSING

Effects of cassava processing on cassava production

In the previous section, we have shown the role of cassava production with respect to cassava processing. Here, we will describe the role of cassava processing on cassava production. Cassava production supplies raw materials for cassava processing; at the same time, rural cassava processing represents a strong demand among markets of cassava production. The higher the demand for different kinds of processed products the stronger the development of cassava production. Cassava processing will force cassava planting development. If the opposite, it will constrain the increase of cassava area and the investment of cassava production.

The relationship between cassava production and processing is as follows: Processing capacity is still constrained regarding technological investment as well as differences in processed products. Most available machines and other equipment are old and out-of-date. Processors have not matched the existing demand for different kinds of products. They produce a limited number of products. This is one of the major constraining factors. It impedes the development of cassava production. On the other hand, cassava production and processing also depend very much on cropping and harvesting seasons. Fluctuation of raw material supplies, both over- and under-supplies, in addition, constrain the investment level and processing efficiency. It requires more research to solve this problem in order to find out how to improve cassava production and processing in Vietnam.

Cassava processing costs

Investment for equipment depends on local traditional processing characteristics, as well as on inherent differences among products.

a. Equipment investment for dried chips processing

Equipment for production of dried chips is very basic; only a few tools are used (knife, chipper; storage basin, etc.). The value of equipment for dried chip processing is very low, because this is a simple process with the purpose of slowing down cassava deterioration. The dried chips can be used for further processing.

b. Equipment investment for starch processing

Starch processing is a much more complicated process. Processors have invested in expensive equipment (e.g. operating machines, generators, etc.) for this activity. A big difference between equipment value in various provinces exist. For example, in Lam Dong, this amount is 4,734,000 VND/hh, in Dongnai this is 4,339,000 VND/hh, while in Tay Ninh it is 7,407,000 VND/hh. These provinces have big processing centers. In these provinces, starch processing is the main traditional activity, e.g. in Tra Co (Dong Nai), Don Duong (Lam Dong), Hoa Thanh (Tay Ninh). Equipment investment levels in other provinces are very low (Vinh Phu: 2,200,000 VND/hh, Bac Thai 759,000/hh, Ha Son Binh: 156,000 VND/hh). In these provinces starch processing is done mainly manually. Machines are only used for few processing steps. The processors have a lot of difficulties with investment capital and marketing.

c. Equipment investment for noodle processing

According to the survey data, noodle processing is a developed, professional activity in Dong Nai and Quang Nam - Da Nang. In Dong Nai, noodle processing households invest in expensive equipment, with a value of 1,522,000 VND/hh. In Quang Nam-Da Nang, the value of equipment is low (991,000 VND/hh). The main power source in Dong Nai are engines; in Quang Nam - Da Nang this is manual power.

d. <u>Equipment investment for maltose and alcohol processing</u>

Maltose and alcohol processing still have several difficulties in some provinces such as Ha Bac and Ha Son Binh. The problems are low raw material quality, raw material supplies and the demand of the market. As such, processors only operate with a limited level of investments.

Operating costs

a. <u>Operating costs for dried-chips processing</u>

Dried chip processing follows the most simple techniques among all kinds of products made from cassava. The processing equipment consist of simple tools, e.g. knifes, chipper, storage baskets, etc. Thus, the main costs in dried chip processing are raw materials and labor.

As shown in **Table 10**, average production costs of dried chips is 854 VND/kg, including raw material cost, packaging, labor, and other costs. Raw materials account for the biggest part (81.1%). Thus, fluctuations of the raw material price will decide the differences of production cost. Production cost per 1 kg of dried-chips varies for different regions. The highest production cost is 1,225 VND/kg (in Lam Dong), and the lowest cost is 515 VND/kg (in Hoang Lien Son). The raw material cost is the most important reason. The price of fresh roots in Lam Dong is 350 VND/kg, and in Hoang Lien Son it is only 171 VND/kg.

b. <u>Investment for starch processing</u>

The costs for production of 1 kg starch are shown in **Table 10**. Similar to dried-chips, the costs for 1 kg starch is affected mainly by the fluctuations in raw material price and labor cost. Raw material cost accounts for 86.6%; labor cost 6.4% of total production costs. The average price of 1 kg of starch for the whole of Vietnam is 1,180 VND. The highest production costs are in Tay Ninh (1,587 VND/kg) and the lowest in Quang Ngai/Binh Dinh (892 VND/kg). The main reason is the fluctuation of fresh root prices. The cassava price in Tay Ninh is 350 VND/kg, in Quang Ngai/Binh Dinh this is 200 VND/kg.

c. <u>Operating costs for alcohol, noodle and maltose processing</u>

- <u>Alcohol</u>: Data gathered in two provinces, Ha Bac and Ha Son Binh, show that average production costs for 1 liter of alcohol is 1,080 VND (**Table 10**). This includes raw material 75%, labor 13.4%, and energy 6.6%. These are the main expense items. When comparing between two provinces, we see that the production cost for 1 liter of alcohol varies. The main reason is the fluctuation of raw material price. The raw material cost for processing in Ha Bac is 967 VND/kg, in Ha Son Binh is 603 VND/kg.

- Noodles: Data about noodle processing was gathered in two southern provinces, Quang Nam-Da Nang and Dong Nai (**Table 10**). Average production costs for 1 kg of noodle is 1,690 VND. If compared between two provinces, these production costs vary considerably. The main reason for this is the large differences in raw material costs. This fluctuates because of the different raw material prices in each province.
- Maltose: Data for Ha Bac province (**Table 11**) show that total production cost for 1 kg of maltose is 1,901 VND/kg. Raw material cost occupied 60.6%, labor cost 25.9%, energy: 5.7%. These are the main parts in the total cost of 1 kg of maltose.

Cassava processing conclusions

Capital investment for processing of various products made from cassava is effected by many factors. But the raw material cost is the most important. The fluctuation of processing costs depends mainly on raw material cost and the rate of conversion in each region.

RESULTS AND EFFICIENCY OF CASSAVA PRODUCTION AND PROCESSING

Comparison of efficiency between cassava production and cassava processing

Revenues per production cost (net return) of fresh root production (1.12) is higher than for processing maltose (0.54), alcohol (0.51), noodle (0.21) and starch (0.21), as shown in **Table 12**. Although the efficiency of cassava production is high, because cassava production does not require high capital investments like in processing, there is no value-adding as in processed products. Capital per total gross output of fresh root production is only 0.43; for noodle it is 0.82, while for starch it is 0.91. On the other hand, the fresh root price is increasing continuously and fluctuates significantly.

Although the cassava fresh root production efficiency is high, the income per year is still low in comparison with cassava processing. Particularly, household average income for root production is only 326,060 VND/year. The average income of a noodle processing household is 26,850,900 VND/year, starch processing per household is 52,616,800 VND/year (**Table 12**). The average income of a cassava production household is low because the average area of cassava is very small. The most important factor constraining cassava production development is limited demand for cassava.

Table 10. Production cost (dong/kg product) for cassava chipping, as well as starch, noodle, alcohol and maltose processing in selected provinces in Vietnam,1991.

Code	Province	Raw material		Total labor		Energy		Depreciation of machines		Packaging		Loan interest		Other		Total	
		VND/kg	%	VND/kg	%	VND/kg	%	VND/kg	%	VND/kg	%	VND/kg	%	VND/kg	%	VND/kg	%
DRIED CHIPS																	
04	Ha Tuyen	450	78.0	110	19.1	0	0.0	2	0.3	4	0.7	0	0.0	11	1.9	577	100
08	Hoang Lien Son	408	79.2	100	19.4	0	0.0	2	0.4	2	0.4	0	0.0	3	0.6	515	100
09	Bac Thai	432	77.7	115	20.7	0	0.0	1	0.2	0	0.0	0	0.0	8	1.4	556	100
11	Vinh Phu	443	74.5	109	18.3	0	0.0	1	0.2	33	4.7	0	0.0	9	1.5	595	100
12	Ha Bac	448	69.7	150	23.3	0	0.0	5	0.8	30	4.7	0	0.0	10	1.6	643	100
14	Ha Son Binh	502	74.4	124	18.4	0	0.0	7	1.0	36	5.3	0	0.0	6	1.0	675	100
19	Nghe An/Ha Tinh	579	76.0	180	23.6	0	0.0	3	0.4	0	0.0	0	0.0	0	0.0	762	100
20	Quang Binh	478	75.6	150	23.7	0	0.0	1	0.2	3	0.5	0	0.0	0	0.0	632	100
30	Dac Lac	758	81.9	138	14.9	0	0.0	30	3.2	0	0.0	0	0.0	0	0.0	926	100
31	Lam Dong	1,081	88.2	122	10.0	0	0.0	22	1.8	0	0.0	0	0.0	0	0.0	1,225	100
32	Song Be	1,049	86.4	143	11.8	0	0.0	22	1.8	0	0.0	0	0.0	0	0.0	1,214	100
34	Dong Nai	1,044	87.1	129	10.8	0	0.0	26	2.2	0	0.0	0	0.0	0	0.0	1,119	100
STARCH																	
09	Bac Thai	1,000	79.4	158	12.5	29	2.3	47	3.7	0	0.0	18	1.4	7	0.5	1,259	100
11	Vinh Phu	1,125	80.4	150	10.7	100	7.1	13	0.9	4	0.3	0	0.0	8	0.6	1,400	100
14	Ha Son Binh	700	77.8	130	14.4	0	0.0	12	1.3	0	0.0	22	2.4	36	4.0	900	100
24-25	Quang Ngai/Binh Dinh	777	87.1	65	7.3	10	1.1	15	1.7	3	0.3	0	0.0	22	2.5	892	100
27	Khanh Hoa	750	83.4	64	7.1	30	3.3	20	2.2	5	0.6	0	0.0	30	3.3	899	100
31	Lam Dong	1,284	81.0	73	4.3	16	1.0	104	6.6	0	0.0	56	3.6	33	2.1	1,566	100
32	Song Be	1,221	87.0	84	6.0	12	0.9	14	1.0	0	0.0	2	0.1	70	5.0	1,403	100
33	Tay Ninh	1,392	87.7	80	5.0	20	1.3	25	1.6	0	0.0	4	0.3	66	4.2	1,587	100
34	Dong Nai	1,267	89.6	67	4.7	11	0.8	19	1.3	7	0.5	6	0.4	37	2.6	1,414	100

Table 10. (Continued).

Code	Province	Raw material		Total labor		Energy		Depreciation of machines		Packaging		Loan interest		Other		Total	
		VND/kg	%	VND/kg	%	VND/kg	%	VND/kg	%	VND/kg	%	VND/kg	%	VND/kg	%	VND/kg	%
ALCOHOL																	
12	Ha Bac	967	77.3	139	11.1	73	5.8	44	3.5	10	0.8	0	0.0	18	1.4	1,251	100
14	Ha Son Binh	603	70.4	152	17.8	72	8.4	29	3.4	0	0.0	0	0.0	0	0.0	856	100
NOODLE																	
23	Quang Nam - Da Nang	950	87.6	65	6.0	10	0.9	10	0.9	5	0.5	0	0.0	45	4.1	1,085	100
34	Dong Nai	2,250	87.9	78	3.0	174	6.8	34	1.3	0	0.0	0	0.0	25	1.0	2,561	100
MALTOSE																	
12	Ha Bac	1,156	60.6	490	25.9	108	5.7	119	6.3	25	1.3	0	0.0	3	0.2	1,901	100

Note: 1 US$ = 7,000 VND in January 1991, but increased to about 12,000 VND in December 1991.

Source: *Vietnamese Cassava Benchmark Study.*

Table 11. Efficiency of cassava dried chips, starch, noodle, alcohol and maltose processing in selected provinces of Vietnam in 1991.

Code	Province	Labor (mdays/ton)	Production cost/ton ('000 VND)	Capital/ton ('000 VND)	Gross output/ton ('000 VND)	Profit/ton ('000 VND)
DRIED CHIPS						
04	Ha Tuyen	22.00	577	650.85	600.00	23.00
08	Hoang Lien Son	11.70	515	480.14	683.33	168.33
09	Bac Thai	13.00	556	464.73	700.00	144.00
11	Vinh Phu	41.90	595	720.48	737.50	142.50
12	Ha Bac	30.00	643	640.05	600.00	-43.00
14	Ha Son Binh	24.80	675	768.32	784.44	109.44
19	Nghe An/Ha Tinh	16.00	762	919.14	1,200.00	438.00
20	Quang Binh	10.00	632	470.76	500.00	-132.00
30	Dac Lac	27.50	926	897.36	1,100.00	174.00
31	Lam Dong	24.30	1,225	1,205.46	1,350.00	125.00
32	Song Be	28.60	1,214	1,193.27	1,330.00	116.00
34	Dong Nai	25.88	1,199	1,177.56	1,300.00	101.00
STARCH						
09	Bac Thai	31.70	1,259	1,232.57	1,500.00	241.00
11	Vinh Phu	50.00	1,400	1,569.82	1,900.00	500.00
14	Ha Son Binh	26.00	900	871.79	950.00	50.00
24-25	Quang Ngai-Binh Dinh	11.00	892	848.34	1,000.00	108.00
27	Khanh Hoa	12.70	899	878.71	1,000.00	101.00
31	Lam Dong	14.50	1,566	1,405.23	1,120.00	-446.00
32	Song Be	16.80	1,403	1,388.94	1,800.00	397.00
33	Tay Ninh	15.98	1,587	1,563.11	1,800.00	213.00
34	Dong Nai	13.44	1,414	1,391.39	1,819.05	405.05
ALCOHOL						
12	Ha Bac	27.80	1251	1,208.00	1,392.30	141.30
14	Ha Son Binh	30.40	856	826.90	1,930.00	1,074.00
NOODLE						
23	Quang Nam-Da Nang	13.00	1,085	1,085.29	1,480.00	395.00
34	Dong Nai	15.67	2,561	2,673.99	3,000.00	439.00
MALTOSE						
12	Ha Bac	98.00	1,901	1,790.16	2,925.00	1,024.00

Note: 1 US$ = 7,000 VND.

***Source:** Vietnamese Cassava Benchmark Study, 1991.*

Table 12. Comparison of economic returns between cassava production and processing activities in Vietnam, 1991.

Parameter	Fresh roots	Dried chips	Cassava starch	Alcohol	Maltose	Noodle
	Relative processing efficiency compared to cassava root production					
Gross return[1]	2.12	1.09	1.21	1.51	1.54	1.21
Gross return to labor[2]	1.16	1.91	5.58	2.32	1.55	7.32
Net return[3]	1.12	0.10	0.21	0.51	0.54	0.21
Net return to labor[4]	0.62	0.17	0.98	0.54	0.54	1.28
Income/household[5]	46.58	346.42	7,516.68	2,089.54	3,155.66	3,835.84

[1] = gross output/total production cost (ratio).

[2] = gross output/labor (US$/mdays).

[3] = profit/total production cost (ratio).

[4] = profit/labor (US$/mdays).

[5] = income (US$/year).

Note: 1 US$ = 7,000 VND.

Economic efficiency comparison among different processed products

According to data in **Tables 11** and **12** the benefit/production cost ratio (net return) of different kinds of processed products is high. The highest is maltose (0.54), the second is alcohol (0.51), then cassava starch (0.21) and the lowest is dried chips (0.10). However, farmers in most provinces must process cassava into dried chips to conserve the roots for further processing or to store it for a longer time period. Our data shows that the efficiencies of maltose and alcohol processing are very high. The reason is that benefits per ton of maltose are high (1,023,750 VND), while that for cassava starch is only 273,700 VND/ton and noodle is 359,750 VND/ton. The households that process maltose have high benefits because they can sell maltose at a high price. During surveying, the maltose average price was 2,925 VND/kg, while cassava starch fluctuated from 1000 to 1800 VND/kg (especially at Ha Son Binh, cassava starch was only 950 VND/kg).

Processing maltose and alcohol in the countryside does not require a high investment. The capital gross output of maltose is 0.61, alcohol 0.64, cassava starch 0.91, and noodles 0.82.

Investments for processing alcohol and maltose are low because equipment for processing these products does not require as high an investment as noodle and starch processing. Equipment costs for processing alcohol and maltose are: 350,000-500,000 VND/household. But a factory which processes starch has to invest in equipment:

3,000,000-8,000,000 VND. Some households in Tay Ninh province invested in equipment about 11,000,000 VND. Although efficiency of alcohol and maltose production is high, these two activities are developed in small size units. In some provinces, such as Ha Bac, Ha Son Binh, the big problems are market demand, raw material supplies and quality.

Market demand for noodles and starch is quite good. These are the two products that have many uses in processing together with cereals. Moreover, starch is also the material for industrial processing and export.

It can be concluded that cassava production and processing are connected with each other. Cassava distribution of production areas and quality has a big effect on processing efficiency. Concurrently, size and distribution of cassava processing factories decide cassava fresh root marketing.

CASSAVA PRODUCTS MARKETING

It must be evident that cassava markets and product flows are quite complicated due to the large variety of different cassava-based products and different processing and consumption areas. As such, the marketing analysis has been divided into four parts:

1. On-farm processing and sales
2. Cassava flour marketing channel
3. Cassava starch marketing channel
4. Cassava further-processed products and consumption.

For the purpose of the workshop it must suffice to characterize the market flows with diagrams that depict the major flows, market places, trading points and destinations, and distill the major constraints in cassava marketing.

On-farm cassava processing and sales

Cassava on-farm utilization can be divided into auto-consumption (humans and animals), further processing (and sales), and sales of fresh roots. **Table 13 and Figure 4** show the shares of utilization by region and province. For Vietnam, more than one third is on-farm consumed and the remainder is on-farm processed (16.80%) or sold as fresh roots (48.60%, mainly for processing).

A qualitative assessment clearly shows that northern cassava farmers have a much larger on-farm consumption (for humans and animals) than southern cassava farmers.

Basically, this relates to relative distances to consumption (urban) centers. This als indicates that cassava farmers in more isolated (highland) areas depend on cassava as subsistence crop, while farmers nearer to urban (processing and consumption) centers ar much more market oriented. The latter is clearly demonstrated in the case of Dong Na and Tay Ninh provinces, which sell as fresh roots 78.4% and 99.2%, respectively, o total production.

Table 13 also clearly shows that in certain provinces cassava farmers conduc much more on-farm cassava processing activities than others. For example, Ha Bac Khanh Hoa, Dac Lac and Lam Dong show shares of on-farm processing of 7.5% 71.1%, 48.7% and 44.9%, respectively.

a. Fresh roots: Only a small percentage (depending on the region) of harvested roots i consumed by the (human) household. However, a much larger percentage is fed on-farm to (mostly) pigs. This may be in some processed form (cooked or chipped and dried) The amount of fresh roots that are sold can go to various destinations: (1) to local starc processors, mostly collected at the farm by the processor or trader; (2) to the loca market, where it is sold directly to consumers (marketing margin: 4-5%); and (3) to larg (semi-urban) starch factories through several middlemen and assemblers (**Figure 5**). Th average fresh root price is 220 VND/kg, as can be seen in **Table 14**.

b. Cassava dried chips: On-farm chipping and drying fulfills two functions. First, t have a storable source of cassava for on-farm human and animal consumption. Secondly for on-farm value adding and subsequent sales. The dried chip price is 750-800 VND/k (**Table 14**).

Table 13. Relative shares (%) of on-farm cassava utilization in Vietnam, 1991.

Code	Province/Region	Human consumption	Animal feed	Further processed	Sold	Total on-farm consumed	Further processed and sold
A	**NORTH VIETNAM**	**19.10**	**34.90**	**7.00**	**39.00**	**54.00**	**46.00**
I	**North Mountainous Region**	**15.40**	**39.40**	**6.50**	**38.70**	**54.80**	**45.20**
04	Ha Tuyen	22.60	42.90	8.80	25.70	65.50	34.50
08	Hoang Lien Son	18.70	38.40	14.70	28.20	57.10	42.90
09	Bac Thai	11.60	40.20	1.10	47.10	51.80	48.20
11	Vinh Phu	37.90	46.90	10.50	4.70	84.80	15.20
12	Ha Bac	6.90	30.80	7.50	54.80	37.70	62.30
II	**Red River Delta**	**22.00**	**23.80**	**3.40**	**50.80**	**45.80**	**54.20**
14	Ha Son Binh	21.70	22.90	3.70	51.70	44.60	55.40
15	Hai Hung	29.70	32.30	0.30	37.70	62.00	38.00
III	**North Central Coast**	**27.50**	**28.80**	**11.20**	**32.50**	**56.30**	**43.70**
19	Nghe An/Ha Tinh	23.90	31.10	13.00	32.00	55.00	45.00
20	Quang Binh	39.20	21.80	5.30	33.70	61.00	39.00
B	**SOUTH VIETNAM**	**6.70**	**13.70**	**24.40**	**55.20**	**20.40**	**79.60**
IV	**South Central Coast**	**10.90**	**19.40**	**40.00**	**29.70**	**30.30**	**69.70**
23	Quang Nam - Da Nang	14.90	32.70	0.00	52.40	47.60	52.40
24-25	Quang Ngai/Binh Dinh	31.10	22.10	0.00	46.80	53.20	46.80
27	Khanh Hoa	4.80	5.50	71.10	18.60	10.30	89.70
28	Binh Thuan/Ninh Thuan	12.90	51.80	0.10	35.20	64.70	35.30
V	**Central Highlands**	**2.10**	**12.20**	**32.70**	**53.00**	**14.30**	**85.70**
29	Gia Lai/Kon Tum	3.60	15.50	0.00	80.90	19.10	80.90
30	Dac Lac	1.60	10.40	48.70	39.30	12.00	88.00
31	Lam Dong	0.40	11.10	44.90	43.60	11.50	88.50
VI	**Southeastern Region**	**5.20**	**11.80**	**8.80**	**74.20**	**17.00**	**83.00**
32	Song Be	5.10	17.20	26.40	51.30	22.30	77.70
33	Tay Ninh	0.80	0.00	0.00	99.20	0.80	99.20
34	Dong Nai	5.90	11.80	3.90	78.40	17.70	82.30
	TOTAL VIETNAM	**12.20**	**22.40**	**16.80**	**48.60**	**34.60**	**65.40**

Table 14. Prices of cassava and cassava - based products at different stages of the marketing channels in South Vietnam, 1992.

Product	Destination	Producer/ processor price (VND/kg)	Retail or wholesale price (VND/kg)
On-farm production			
Cassava roots	Farm-gate	220	-
Dry chips	Local use	750-800	-
Dry chips	"Export" to N-Vietnam	800	1,230
Dry chips	"Export" to S-Vietnam	800	975
Starch	City	1,300	1,440
Alcohol	Local	2,200	2,500
Rural area			
Flour	Local market	950	970
Flour	Semi-urban market	950	970
Cassava noodles	Local	2,300	2,500
Semi-urban area			
Flour	Further processor	950	1,050
Flour	City wholesaler	950	1,300
Type I starch	City wholesaler	1,800	1,900
Type I starch	City export company	1,800	1,880
Type II starch	City trader	1,600	1,700
By-products	City trader	700	780
Urban area			
Noodles	City consumption	2,400	2,700
Maltose	City consumption	2,900	3,250

Note: 1 US$ = 12,000 VND.

***Source:** Cassava marketing survey for South Vietnam, data base, 1991/92.*

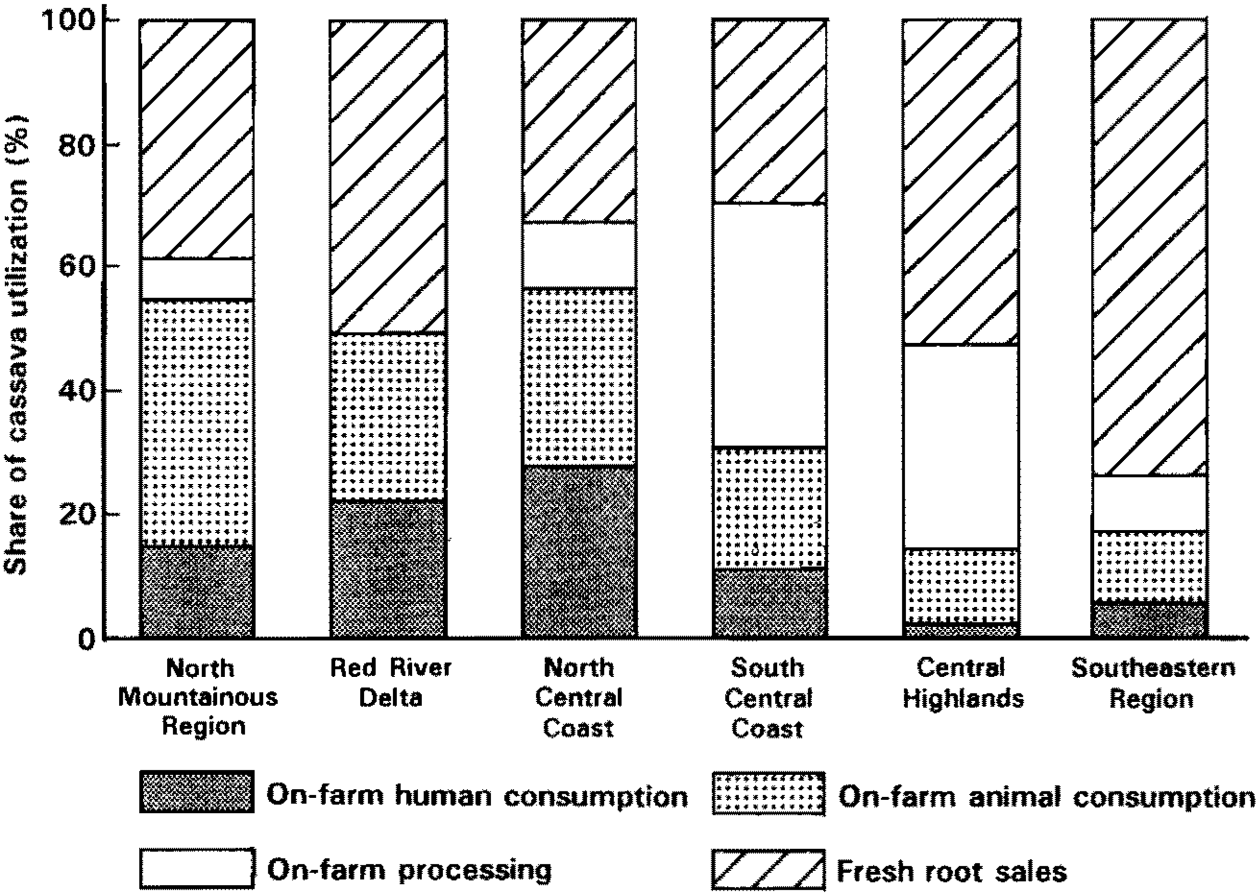

Figure 4. Relative shares (%) of on-farm cassava utilization by agro-ecological regions in Vietnam, 1991.

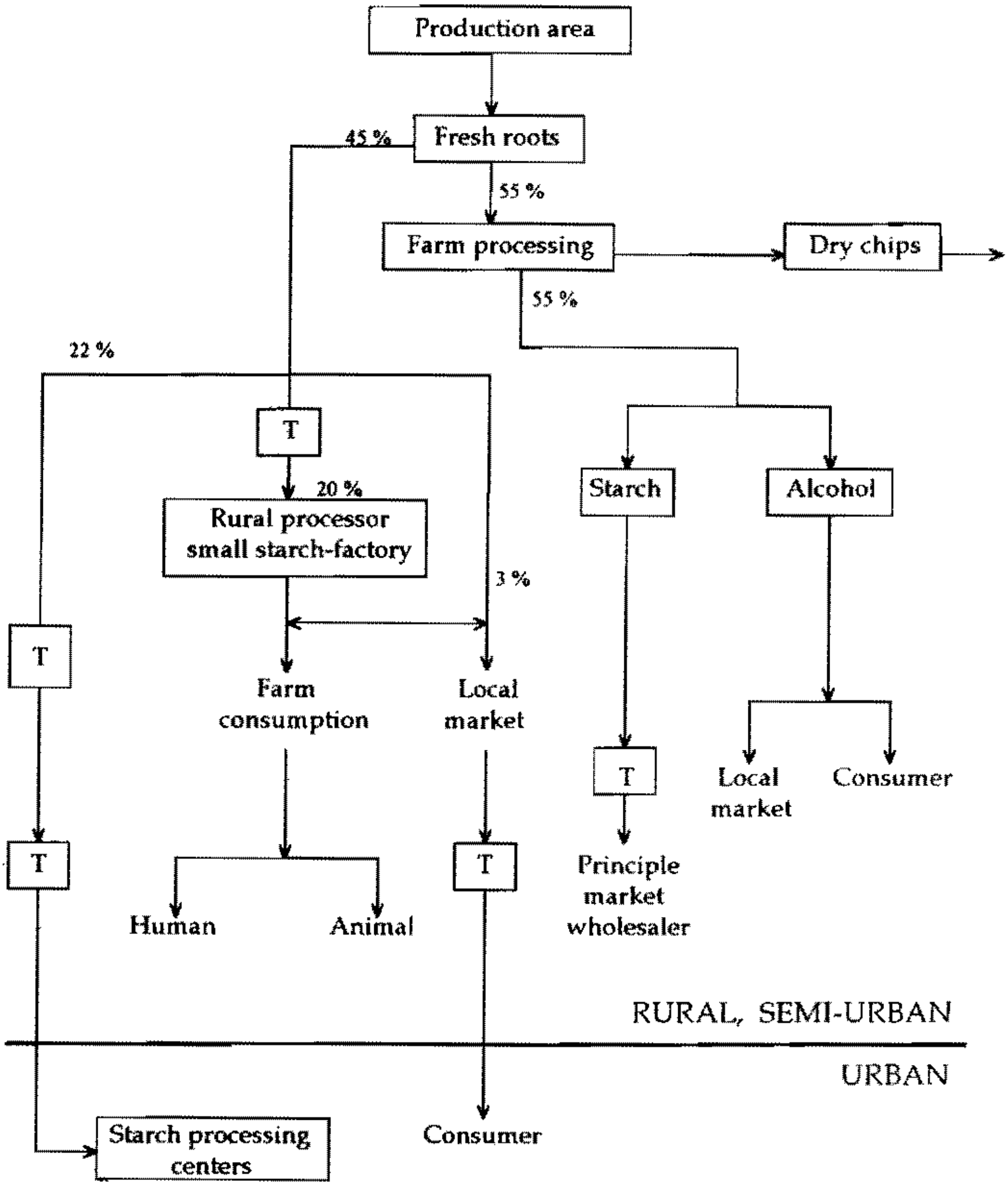

Figure 5. Fresh cassava roots marketing channels in South Vietnam, 1991.
T = transport.

Figure 6 depicts the various destinations for dry chips after leaving the farm. The most important include: local markets, local flour processors, principal (provincial) markets, (semi) urban areas, and exporters. Depending on the distance and market the number of pricing points (and middlemen) vary between 2 and 6.

It is of interest to note that dried chips from South Vietnam at times are exported to south China. For a distance of 1,400-1,500 km by large truck the marketing margin between the farm and the exporter at the border is only 50-60%. There are currently two main export outlets in Vietnam. First in the North to China, secondly, in the South to the EC, Cambodia, Korea, Taiwan and Singapore. In the South some data suggest that export companies pay a cost of US$75-95/t, port delivered.

c. <u>On-farm starch</u>: Especially in isolated highland areas roots are processed into (low quality) starch. Starch is typically collected on the farm by traders, who transport and resell to wholesalers or provincial markets where it is further traded as depicted in **Figure 5**. Farm gate price of starch is 1,300 VND/kg (**Table 14**).

d. <u>On-farm alcohol</u>: In South Vietnam only in Dong Nai province there is on-farm alcohol processing. This is basically for local consumption and the farm gate price is 2,200 VND/litre (**Table 14**).

Cassava flour marketing

As can be seen in **Figures 6** and **7**, cassava flour is either produced and utilized in rural areas or produced in semi-urban areas and utilized in both semi-urban and urban areas. The majority of flour (80%) processed in rural areas is traded to further-processing factories in other provinces. **Figure 8** shows that the majority of semi-urban flour is traded to wholesalers for further processing. Rural flour price is 950 VND/kg (**Table 14**). Depending on the purpose of the use (and further processing), flour can be classified into three quality classes (I,II,III as shown in **Figures 9, 10** and **11**). The price premiums can vary significantly.

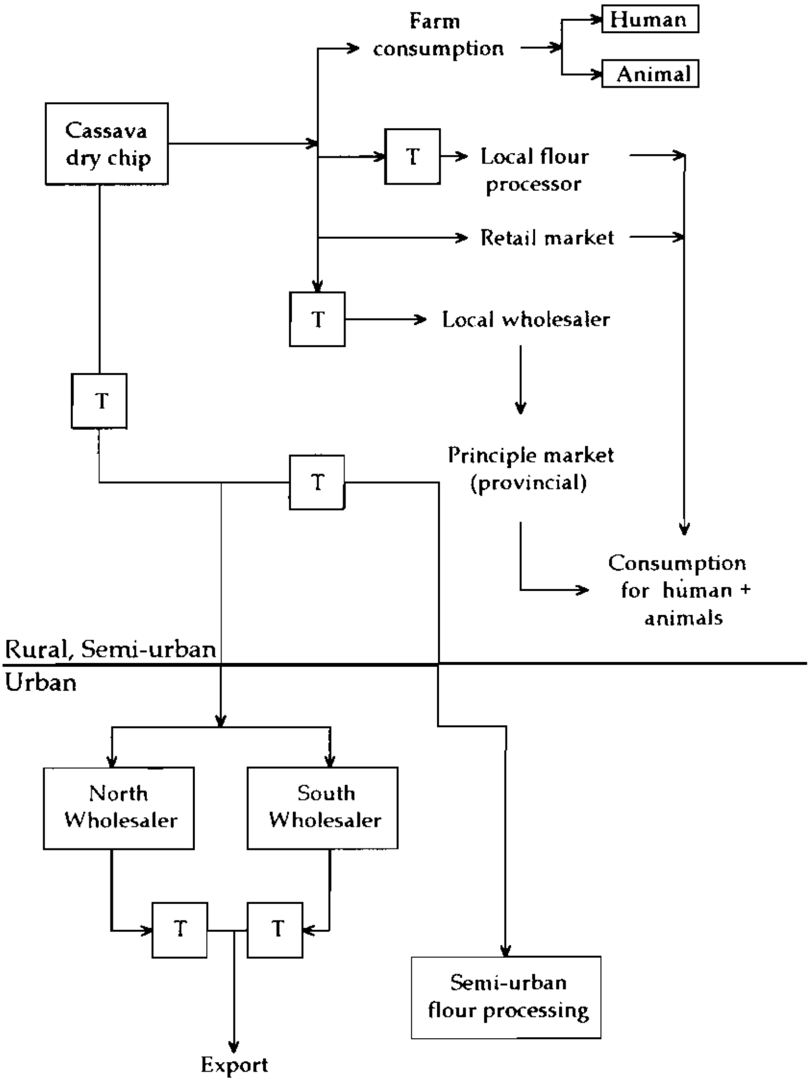

Figure 6. Cassava dry chips marketing channels in South Vietnam, 1991.
T = transport.

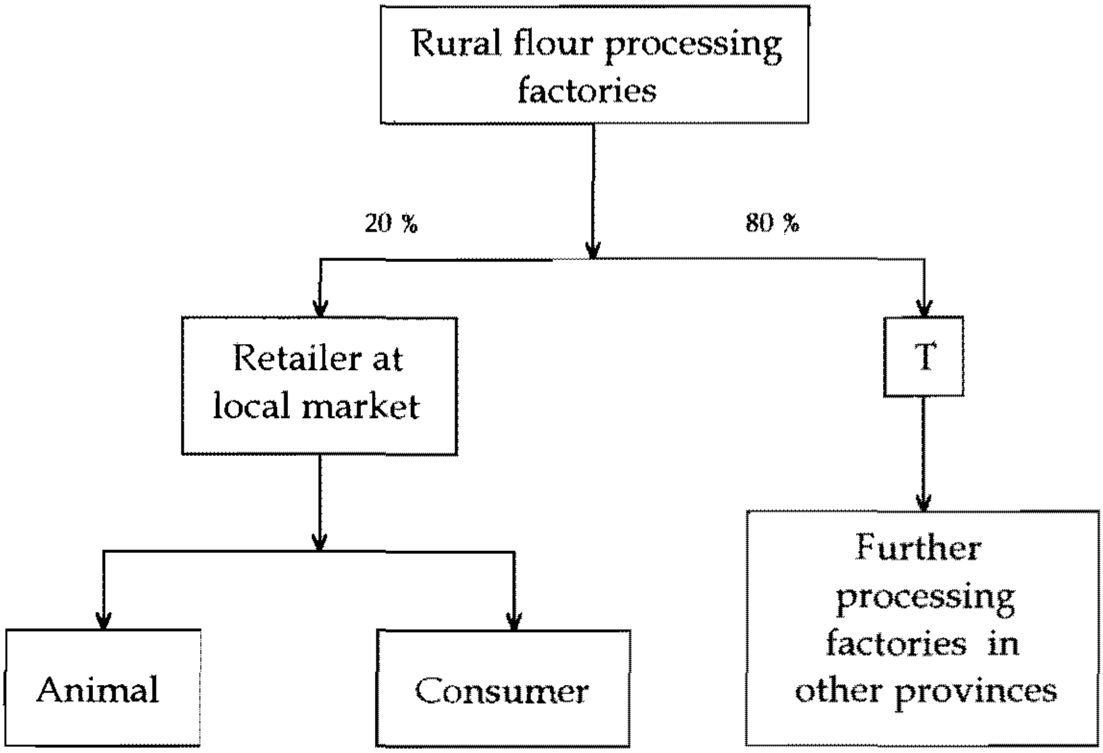

Figure 7. Cassava flour rural marketing channels in South Vietnam, 1991.
T = transport.

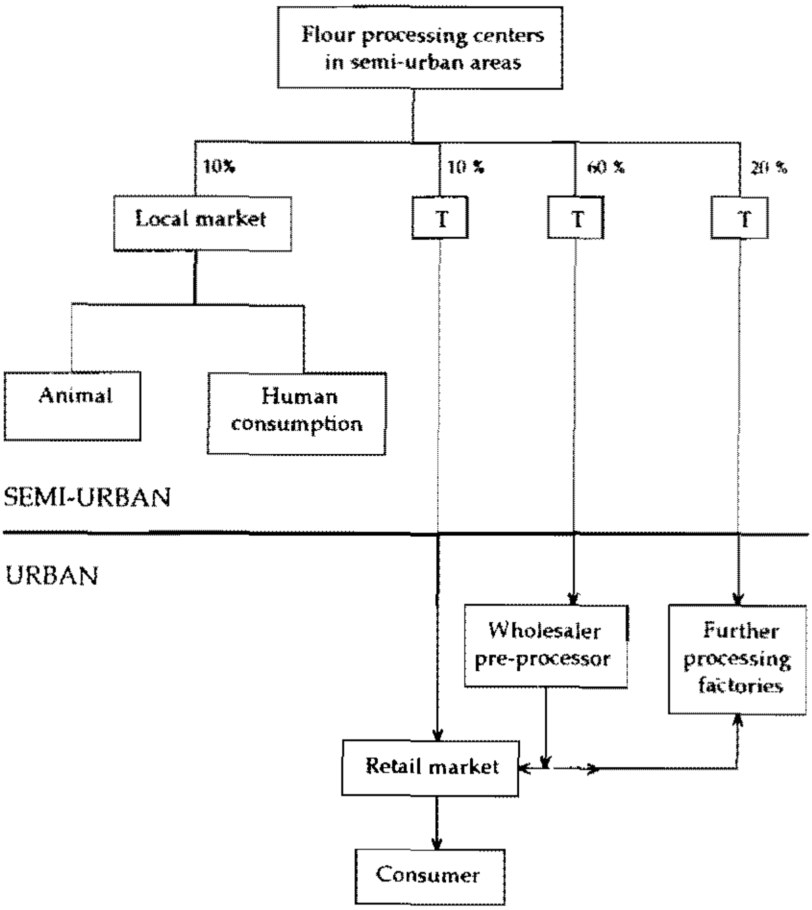

Figure 8. Cassava flour marketing channels in (semi)-urban areas of South Vietnam, 1991. T = transport.

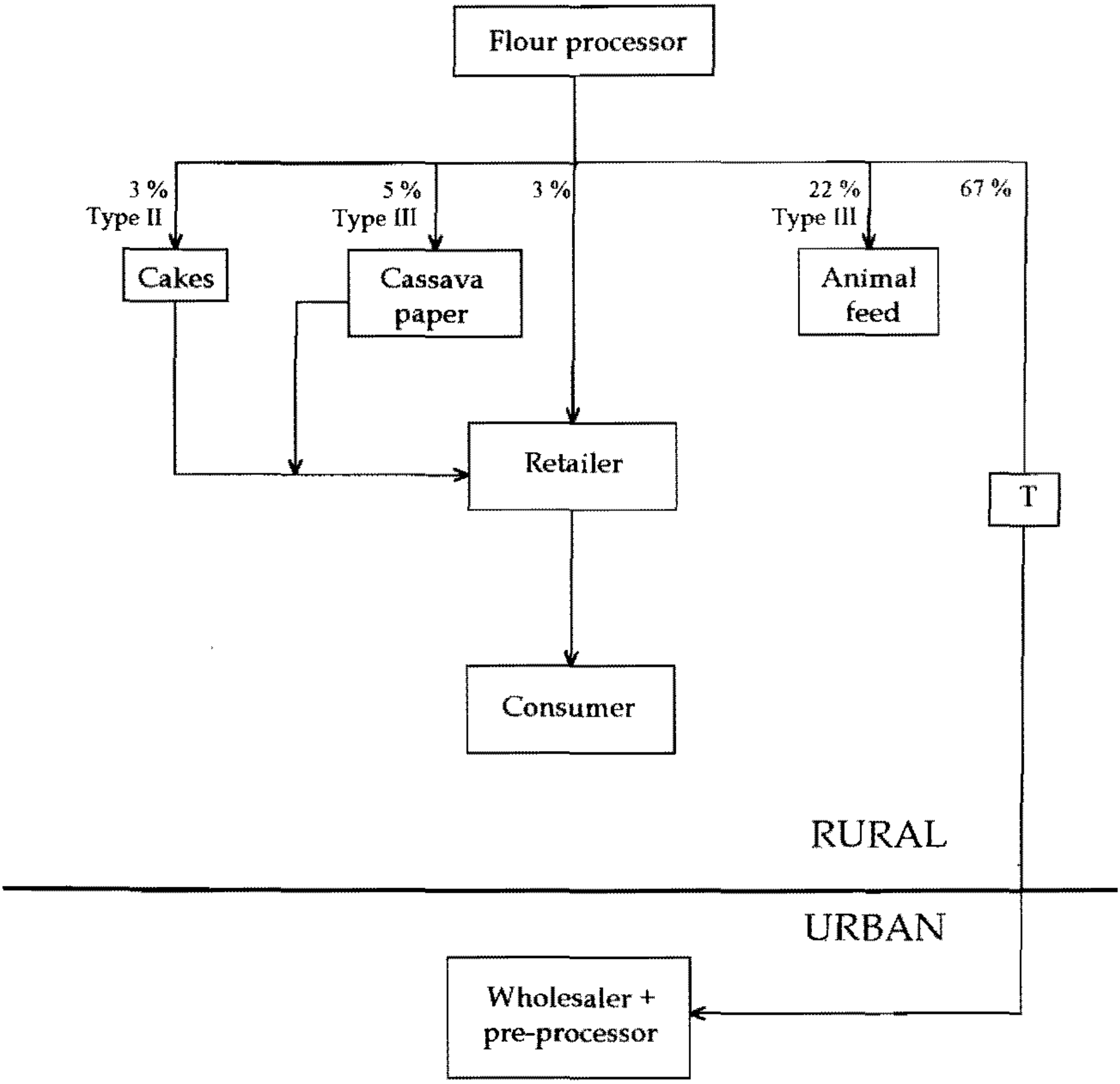

Figure 9. Cassava flour further-processed products marketing channels in rural South Vietnam, 1991. T = transport.

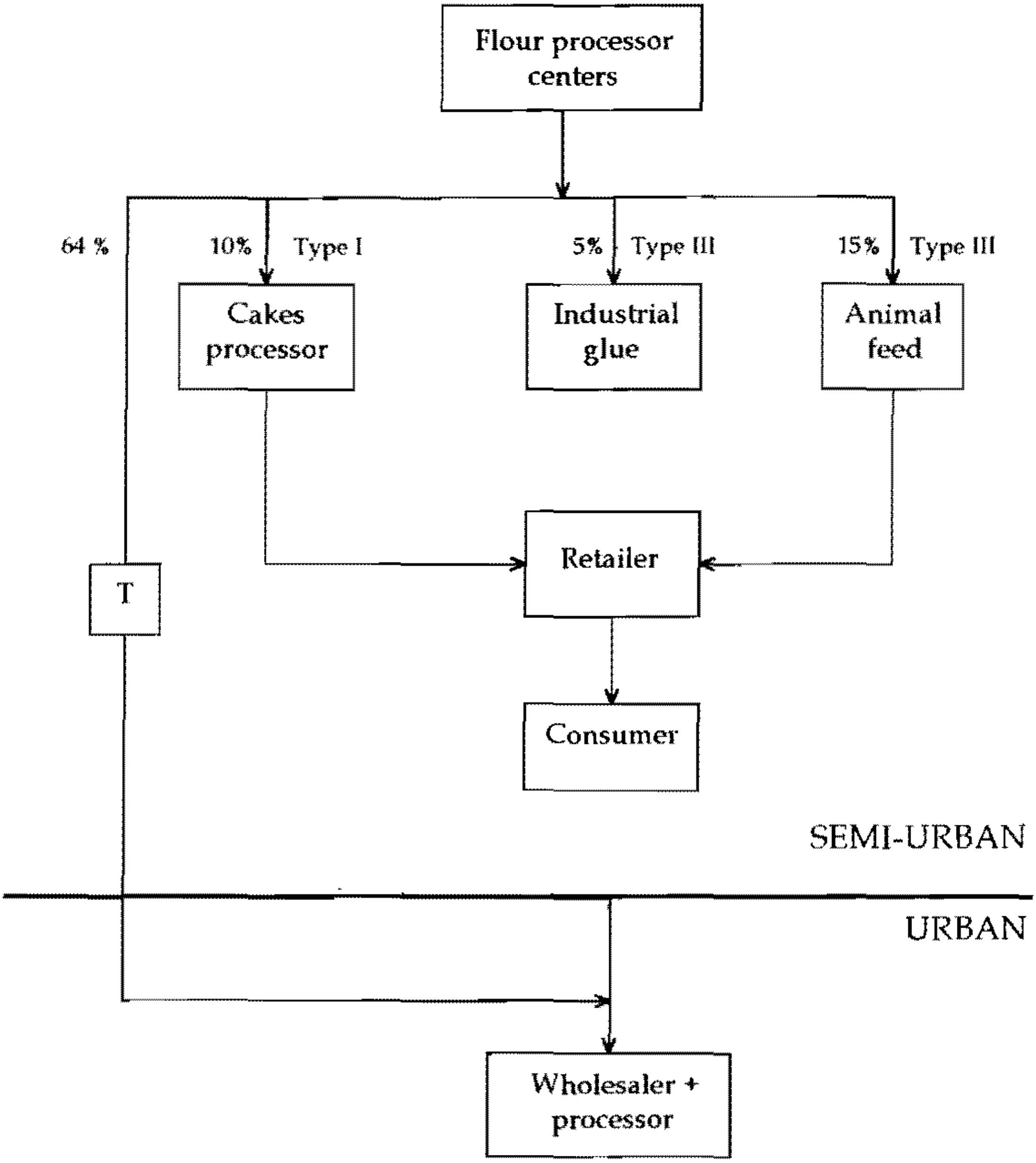

Figure 10. Cassava flour further-processed products marketing channels in (semi) urban South Vietnam, 1991. T = transport.

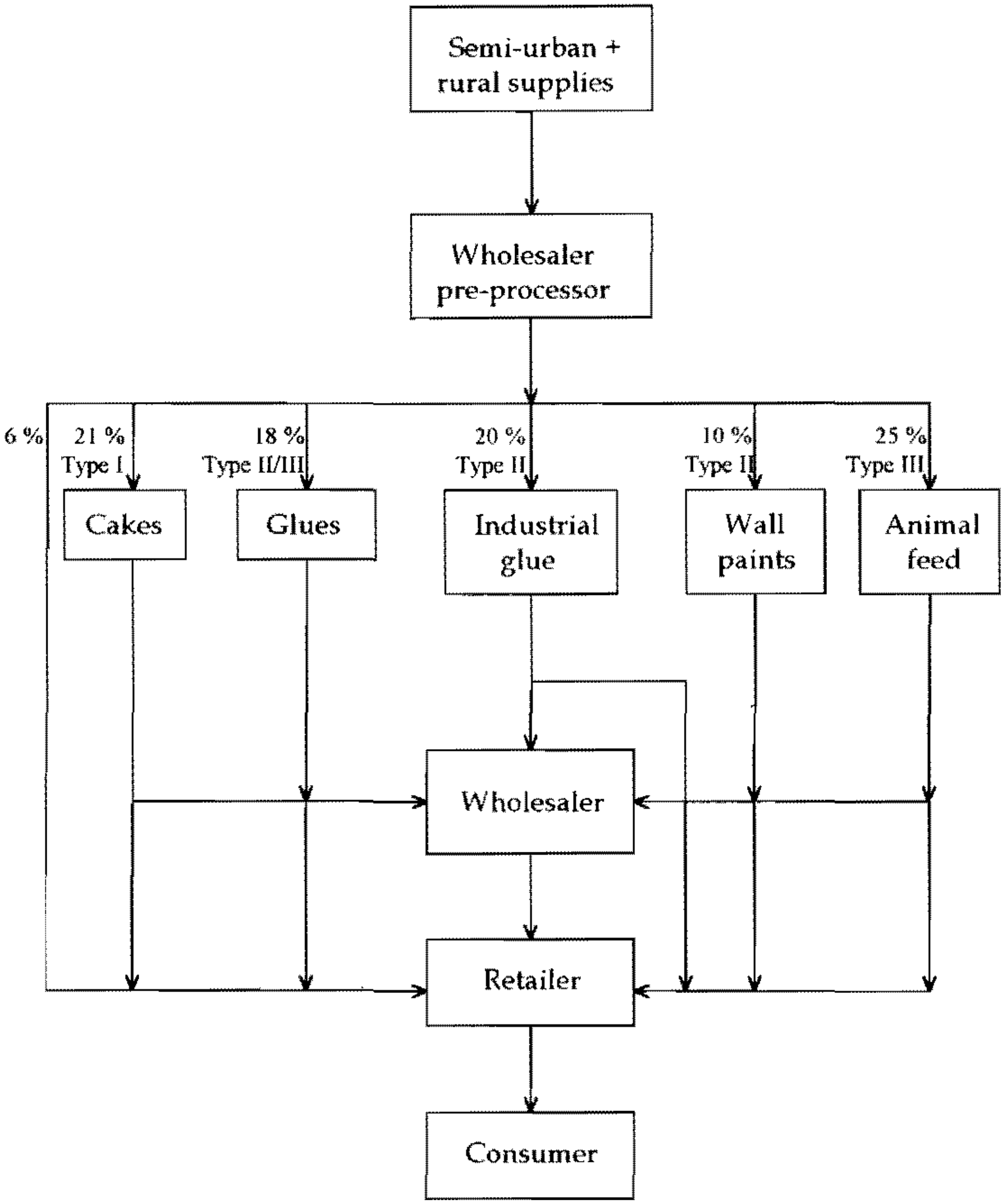

Figure 11. Cassava flour further-processed products marketing channels in urban South Vietnam, 1991. T = transport.

Cassava starch marketing

As was shown before, only a small volume of low quality starch is on-farm processed. This is often further processed to upgrade quality and then further utilized (in other areas). The majority of starch is processed in rural and semi-urban villages and factories, or, as shown in **Figure 12**, semi-urban processing centers.

Cassava starch processing generates the following products: (a) wet starch (b) dry starch divided into three quality classes; and (c) by-products, which are the peel, cellulose and latex, as can be seen in **Figure 12**.

a. Wet cassava starch marketing: This is either used for local processing into "Bot bang", "Bot khoai" and low quality noodles, or it is traded for further processing in the area.

b. Dry starch marketing: This constitutes at least 80% of total starch production. Type I starch with the highest quality is usually reserved for exports to Singapore, USSR and Taiwan, and is traded from HCM city. Semi-urban factory price is 1,800 VND/kg (**Table 14**). Data shows that export companies sell type I cassava starch for US$156/t (exclusive taxes, etc.).

Type II starch, of a lesser quality, can be traded to local further-processors (cheap noodles, etc.) for further processing into type I starch, or further processed and/or exported from HCM city. The factory price of Type II starch is 1,600 VND/kg. Type II-starch is mainly "exported" to southern provinces like the Mekong Delta. Type III starch, like wet starch, is mainly utilized for local processing of traditional food items including noodles.

c. Starch by-products utilization: Cassava latex is utilized (in dry powder form) by provincial feed factories or is traded to wholesalers in HCM city for further distribution to animal feeders. Cost price of dried crushed latex is about 700 VND/kg (**Table 14**). Most of the latex incorporated into animal feed rations go to pork, poultry and egg production. It is not entirely clear what mixtures of cassava products (flour, latex and cellulose) feed manufacturers utilize, but cost prices approximate 700-750 VND/kg, which substitutes about 15% of rice bran costing 1,000-1,200 VND/kg.

Cellulose in either dry or wet form goes to either local animal production or is traded to urban wholesalers. It seems that with this product, the marketing margin is relatively high (±200%).

Cassava peel is basically used as a source of fuel when dried or as a cheap supplement fed to oxen and buffaloes on-site.

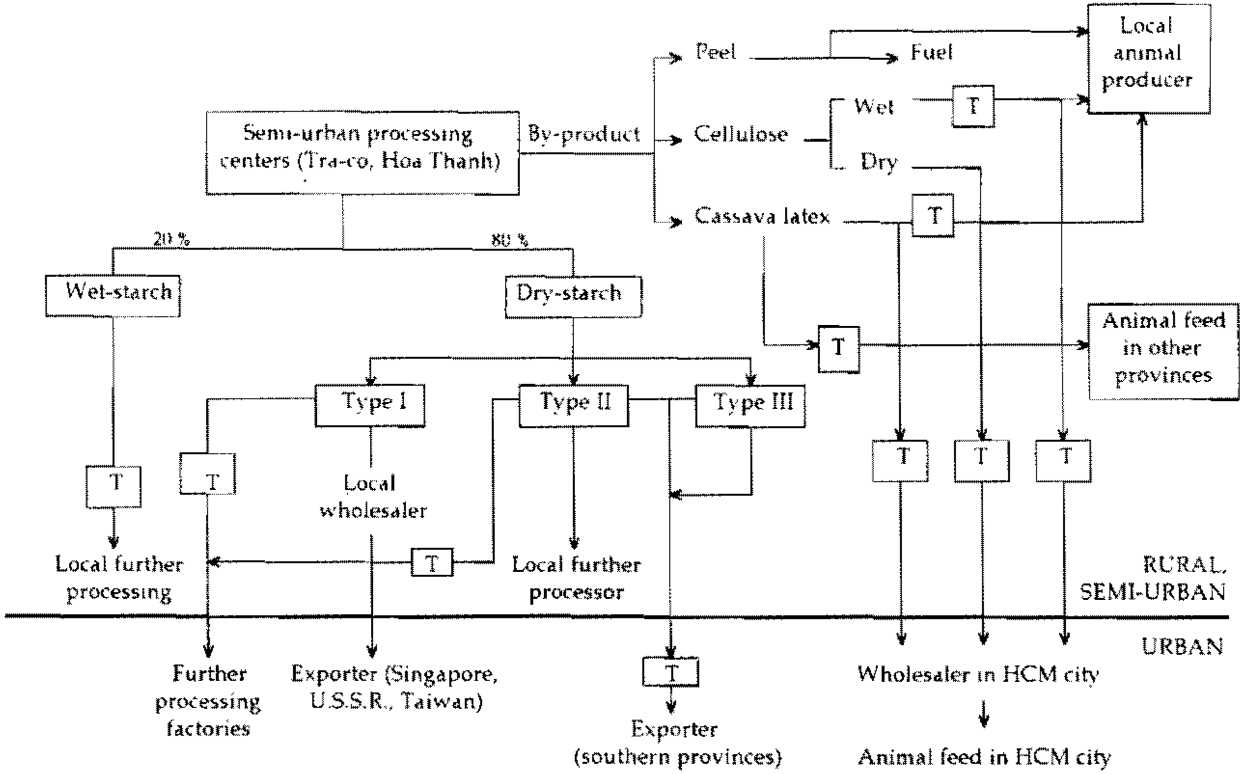

Figure 12. Cassava starch marketing channels in (semi) urban and rural South Vietnam, 1991. T = transport.

Cassava further-processed products marketing

For the further-processing of cassava-based products, cassava flour and starch are the main raw materials.

In the rural areas flour is further-processed (depending on the quality) into animal feed, cassava paper and cassava cakes, or is traded for local consumption (**Figure 9**). However, some two-thirds of the rural flour production is traded to wholesalers in HCM city (**Figure 10**).

Semi-urban cassava flour producers sell flour to be utilized in the manufacturing of animal feed (type II, III), cakes, candy and industrial glues. Animal feed containing 15% cassava flour is bought at cost for 1,400 VND/kg and traded to retailers with a 18% marketing margin (only). However, again the majority of semi-urban produced cassava flour (2/3) is traded to the city wholesalers (**Figure 9**).

Urban factories (small and medium-scale) buy cassava flour for the production of animal feed, cakes and candies, industrial glues, other glues, and building color (**Figure 11**).

Besides cassava flour, cassava starch is used in rural areas for further processing into noodles and cassava paper. These products are destined for local markets and consumption. Average cost price of noodles at the factory is 2,400 VND/kg and the marketing margin cost at the retailer is (only) 8%. It must be noted that distances traded are rather short (10-15 km).

Cassava starch (type II, III) in semi-urban areas is mainly used for the production of foods like noodles for local markets.

Cassava starch in urban areas is mainly used for high quality cakes, noodles and for pharmaceutical industries. Marketing margins for noodles in the city are somewhat higher than in rural areas. The production of cassava maltose is also in the city. The factory cost price is approximately 2,900 VND/kg and the marketing margin at the retailer is 12% (**Table 14**).

Table 15 shows producer and wholesale prices for processed products in North Vietnam. Although prices may differ from the South, it is important to observe that marketing margins are quite low on average, indicating that within the North the market seems quite efficient. There may be a problem of price transmission between the North and the South.

Table 15. Average cassava product prices at different levels in the marketing channel in North Vietnam, 1992.

Cassava products	Producer/ processor price (US$/ton)	1991 Price variation (%)	Consumer price (US$/ton)	Marketing margin (%)
Fresh roots	27.32	30	32.83	20
Dry chips	79.93	8	101.10	26
Dry roots	71.17	15	84.93	19
Wet starch	94.61	53	106.85	13
Maltose	198.70	65	288.89	45
Alcohol	197.40	30	221.69	12
Noodle	393.18	21	409.15	4

Note: 1 US$ = 12,000 VND.

Source: *Vietnamese Cassava Benchmark Study, 1992 (preliminary data).*

Cassava marketing conclusions

In order to evaluate the efficiency of the different cassava marketing channels in Vietnam, one needs to have a thorough understanding and analysis of volumes, prices, pricing points, market agents and marketing margins for all products throughout the country. In the preceding section we basically described the complexity of marketing flows, destinations, and relative prices in South Vietnam. Although our information may not be representative nor complete, the following conclusions may be drawn:

- It is relatively easy to conclude that cassava, in comparison with sugarcane, rice, potato or sweet potato, has a extremely complicated marketing system, due to its large variety of intermediate and final (processed) products. In addition, production and consumption areas differ significantly by product and process.
- In the majority of marketing channels the number of pricing points (middlemen) is rather high, although the marketing margins do not seem to be too high. Typically marketing margins in urban areas are significantly higher than in rural areas.
- An obvious lack of local and regional (frequent) public price information offers intermediaries opportunities to make sizeable profits. In addition, product supplies and demands are not in equilibrium. This has a negative effect, resulting in large price fluctuations and market inefficiencies, which is a cost for producers, processors and consumers.

- Official (vs. smuggled) exports loose a relative cost edge due to lack of up-to-date (world) price information, various taxes, and trading inefficiencies. If all cassava product exports would be traded under a "free market" system, inefficiencies would be reduced.
- Theoretically, the large portfolio of cassava products for different end products and markets should make the overall cassava market relatively stable. However, the lack of price (and volume) information implies market inefficiencies. The alleviation of this constraint could make several cassava-based products more competitive, which subsequently will strengthen demand.

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ANALYSIS OF THE CURRENT AND FUTURE CASSAVA STARCH MARKET IN VIETNAM

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INTRODUCTION

After rice and maize, cassava is the third most important crop in Vietnam accounting for 30% to 40% of secondary food production (Thang, this Proceedings). In 1992 cassava was planted in 277,200 ha and total production was 2.47 million tons of fresh roots (Statistical Yearbook of Vietnam, 1993). The Vietnamese government has shown interest in this root crop as a cheap raw material for further processing.

In 1990, a Vietnamese Root and Tuber Research Program was founded as the first step toward strategically reorganizing root crop research in Vietnam. In the past, most efforts in agricultural research and development in Vietnam have concentrated on the production side and little was known about consumer and user needs. From 1990 onward, with CIAT's assistance, a series of cassava production, processing and marketing surveys were conducted in Vietnam aimed at identifying and analyzing constraints and opportunities for the cassava sector. The Cassava Benchmark Study, conducted in 1990/91, included household-level surveys focussing on cassava production, on-farm processing, use and consumption, as well as rural, semi-urban and urban marketing. Processing surveys, focusing on both technical and socio-economic aspects of different products processed and major marketing channels, were also included.

Henry *et al.* (this Proceedings) analyzed the main constraints to cassava production, productivity, processing, and marketing. These results can serve as a basis for strategic research planning in Vietnam. From this study it was concluded that cassava-based products can be potentially quite significant in the future. Henry *et al.* (this Proceedings) also reviewed the products and market opportunities of cassava in Vietnam, but this was based on very sketchy data and incomplete information. For decisions regarding future cassava research and development in Vietnam, additional in-depth studies are required that analyze current and future potential demand for different cassava-based products. Research on market demand is important since consumer needs

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(including industry, on-farm use, etc.) should first be assessed and then production, processing and marketing technologies geared to address the specific opportunities identified.

This study aims: first, to analyze current use and starch shares of different end products; second, to estimate starch demand of these products for the future; and third, to recommend issues for future cassava research and development activities.

METHODOLOGY

Data was collected by interviewing different processors, traders, personnel from export companies and different producers that use cassava starch as a raw material in their production. With producers the interview format included questions on production level, current inclusion ratio of cassava starch, production technology, technical requirements for cassava starch, its growth rate and future demand. Time series data available on cassava starch consumption of each end product and on production of some products are neither reliable nor consistent. Therefore, future cassava starch demand has been estimated using a simple method based on population and income growth.

CURRENT CASSAVA USE

Cassava roots have been used for different purposes such as animal feed (flour),starch production (wet and dry starch), fresh roots for human consumption, dry chips for export and other home processing.purposes such as production of maltose and alcohol. **Table 1** shows the estimated division of fresh roots for different types of consumption. Cassava consumption for animal production, both in fresh root and flour form (both at the farm and by industry) account for most (73.1%) of the total cassava production in Vietnam. Total production of pigs was 13.88 million head and of poultry 124.5 million head, representing a use of almost 1.43 million tons of cassava roots.

Cassava starch production is the second largest usage, representing about 20% of total production. Cassava in the form of fresh roots for human consumption accounts for 12.2%, as chips for export 4.9%, and for other home processing purposes (dry chips not included) 6.0% (**Table 1**).

Currently, cassava dry starch is used for different purposes: in food processing, home consumption, exports and for several industrial purposes, such as textiles, pharmaceuticals, cardboard, monosodium glutamate (MSG), glucose, maltose and plywood. The total demand for cassava roots for starch production (both wet and dry starch) was about 395,077 tons in 1992. About 20% of this was used for wet starch production, mostly for local processing into low quality noodles (Binh *et al.*, this Proceedings).

Table 1. Cassava use in Vietnam, 1992.

Use	Quantity of fresh roots	
	(t)	(%)
Fresh roots (human consumption)	301,377	12.2
Animal feed (by farmers and industry)	1,503,846	60.9
Dry chips for export	120,000	4.9
Starch	395,077	16.0
-Dry starch (80%)	316,062	
-Wet starch (20%)	79,015	
Home processing (dry chips and starch not included)	150,000	6.0
Total	2,470,300	100.0

Source*: *Vietnam Cassava Benchmark Survey, 1991.

CASSAVA STARCH PROCESSING AND MARKETING

During the Vietnamese Cassava Benchmark Survey conducted in 1991, cassava starch processing was found to be practiced in most of the provinces surveyed. But the largest cassava starch processing areas are in the provinces of Dong Nai, Tay Ninh and Ho Chi Minh City. Cassava starch is produced in two forms, dry with about 80% of the total starch production, and wet with 20% (Binh *et al.*, this Proceedings).

The majority of cassava starch production takes place at the household or village level. It is restricted by: traditional technology (low conversion rates), limited and fluctuating root supplies, seasonality, constrained capital and poor market organization. These lead to low profit rates and fluctuating quality and supplies. Some large processing factories also use old technologies. Currently, there is an interest in investing in cassava starch processing to improve processing technologies.

Current Cassava Starch Use

Table 2 summarizes current cassava starch use. The largest usages of dry starch are for home consumption (56.95%) and the food processing industry (35.60%). Other uses account for only 7.45% of total dry starch consumption.

Table 2. Current cassava use and starch shares by end products and estimated potential demand by the year 2000.

End products	Starch consumption in 1992 (t)	Starch consumption in 1992 (%)	Potential demand in 2000 (t)	Potential demand in 2000 (%)	Growth rate (%)
Dry starch	**70,236**	**100.00**	**181,720**	**100.00**	**159**
-Home consumption	40,000	56.95	45,000	24.76	13
-Food processing	25,000	35.60	30,000	16.51	20
-Textiles	1,550	2.21	2,000	1.10	29
-MSG	0	0.00	90,000	49.53	very large
-Cardboard	600	0.85	1,200	0.66	100
-Glue for other purposes	50	0.07	150	0.08	200
-Plywood	96	0.14	120	0.07	25
-Maltose	40	0.06	100	0.06	150
-Glucose	1,800	2.56	3,000	1.65	67
-Pharmaceutical products	100	0.14	150	0.08	50
-Export	1,000	1.42	10,000	5.50	900
Wet starch	**17,599**		**18,000**		**3**
-Cakes					
-Noodles					
Total starch consumption	87,795		199,720		127
Equivalent fresh roots consumption	395,077		898,740		127

Home consumption and food processing

Home consumption accounts for the largest share (about 40,000 t/year) of cassava starch usage; it is used to make different kinds of cakes and cookies, to fry meat and fish, and to make soups in the traditional Vietnamese diet. Cassava starch is transported from processing centers to wholesalers in local markets and to urban marketing centers, and reaches consumers through retailers.

In the food processing industry, cassava starch is an ingredient used in bread making and for making rice chips and other kinds of cakes. For example, in making rice chips about 30% of total starch used is from cassava. Industries using cassava starch for food processing make a wide range of products and use mostly high quality starch. For making cakes, cassava starch is mixed with other starches from soybean, green bean and rice as well as with wheat flour. About 25,000 t of cassava starch per year are used in this industry, currently the second largest starch user in the country.

For home consumption and the food industry high starch quality is required. Low price and acceptable quality are the two major factors making this starch competitive with others.

Monosodium glutamate

The total amount of monosodium glutamate (MSG) used in Vietnam is currently about 40,000 t/year. Most of it is imported from Japan, Taiwan and Singapore and only a small amount is produced nationally. In the 1980s, Vietnamese companies produced MSG using cassava starch (75%) and byproducts from the sugar industry (25%) as raw material. These companies used old technologies with very low conversion rates; 6 to 6.5 t of cassava starch were needed to produce one ton of MSG. To produce MSG, cassava starch was supplied from processing centers through wholesalers. Starch quality of 90-92% purity was required. At that time, using starch from starch processing centers had many problems, such as fluctuating starch quality due to processors using different technologies, and seasonal supplies, as root availability depended on harvest seasons. The MSG companies had to store starch for their production, but lack of good storage facilities, variable consistency and low quality of starch caused quality losses.

Low conversion rates, low MSG quality and very high production costs made locally produced MSG unable to compete with imported MSG. Thus, many companies have ceased production or have attempted to modernize their technology by investing their own capital or through joint ventures with foreign partners. The production of MSG decreased from 2,003 t in 1987 to 721 t in 1992 (Statistical Yearbook of Vietnam, 1993). In 1987, almost 12,000 t of cassava starch were used in this industry. But with modern technology MSG is produced mostly from imported glutamic acid and no cassava starch is currently being used.

Since 1990, several foreign multinationals have started businesses in the MSG sector. In the early years, they all imported MSG to sell in Vietnam. After conducting market research, they concluded that it was a viable option to produce MSG in Vietnam rather than import it. Currently most of them have projects to invest in MSG production using local raw materials. First, they produce MSG using glutamic acid imported from the mother company, and at the same time conduct research on market potential and on market reaction to their product. Most of them believe that there is a very good potential for MSG production in Vietnam. They are looking further into raw material availability, market environment, site selection and production organization, after which further construction will begin. The available raw materials could be cassava starch, byproducts from the sugar industry, and other starch sources. Foreign, joint-venture interest in the domestic production of MSG has currently led to the planned construction of four new MSG factories with a combined capacity of 35,000 to 40,000 t/year.

Textile industry

Cassava starch is also used in the textile industry for sizing of cotton fabrics of all kinds. Currently this industry is using about 1,550 t of cassava starch annually. Other substituting starches could be from maize, wheat, potato and rice. In the past, some textile factories in the north of Vietnam used maize starch, since this was available in the Red River Delta while the supply of cassava starch was limited. Later they changed to using cassava starch when there was a sufficient supply. The starch quality satisfied their requirements and the price of cassava starch was lower than that of maize. Also, the government encouraged the use of cassava starch to substitute for that of other food crops used in the industry. Currently, most textile factories use cassava starch in their production, since its price is lower than that of other starches and its supply is sufficient. In addition, cassava starch quality satisfies their technical requirements.

Starch supplies from the processing centers arrive at the factories through wholesalers. The average price of cassava starch is about 2,000 Vietnamese dong (VND) to 2,200 VND/kg for the best quality. The textile industry's technical requirements for starch quality are: homogeneity in quality, high adhesiveness, purity (92-95%), whiteness, no fermentation, no change in color and no other quality losses when stored for later use. The best quality cassava starch from some processing factories can satisfy these requirements.

At present, some textile factories have invested in modern weaving machinery with high production capacity and high weaving speed. This modern technology requires glue of a high quality, which is presently imported. This type of glue is made from starch and chemicals to obtain certain characteristics. Cassava starch could be used to produce chemically modified starch for this industry. It is expected that in the future, chemically modified starch will be used in the whole textile industry instead of using raw cassava starch. But cassava starch will still be used in small weaving factories and could be used for producing the new glue.

Glue for cardboard production and other purposes

Cassava starch is used as glue for the production of cardboard and other packing materials. In other countries, where cassava starch is unavailable, wheat flour and maize and rice starches are used in making cardboard. In Vietnam mostly cassava starch or flour is used, since it is available and has a relatively low price. Small cardboard producing units with simple technology use both cassava flour and starch, but in modern cardboard factories only starch is used, since cassava flour cannot satisfy their technical requirements. This industry needs cassava starch with a high degree of adhesiveness and a purity of 90-92%; whiteness is not so important. In general, the starch produced in different processing centers satisfies these criteria. About 200 kg of cassava starch is used to produce five tons of cardboard. Currently, about 15,000 tons of cardboard is produced annually in Vietnam using about 600 tons of cassava starch. The estimated consumption of cassava starch as glue material for other purposes, such as for use in offices, for packing etc., is about 50 t/year.

Maltose and glucose

The total quantity of cassava starch consumption in maltose production for Vietnam is estimated to be about 40 t and for glucose about 1,800 t. To produce one ton of maltose, about 1 to 1.5 tons of cassava starch are needed, while the production of one ton of glucose requires about 1,300 kg of starch. Starch needs to be at least 90% pure for these two products. Maltose and glucose produced in this industry have further use in the pharmaceutical and food processing industries on which depends their demand.

Plywood industry

Cassava starch is an ingredient used to produce industrial glue for plywood production, along with urea, formaldehyde and other chemicals. To produce one square meter of plywood, about 0.46 kg of industrial glue is used, of which about 30-35% is cassava starch. Cassava starch and wheat flour are the two substituting materials. Because of its relatively low price, cassava starch is preferred. For the plywood industry, cassava starch needs to be pure (less than 5% of substance remaining after burning), have a pH value of 5.5 to 7 (not fermented starch), and must have less than 10% cellulose. As in the case of the cardboard industry, whiteness is not so important. With the current plywood production of about 700,000 square meters, about 96 t of cassava starch is used annually. The inclusion rate of cassava starch in the glue material used for producing plywood is relatively high in Vietnam. In the 1980s, the cost of glue was about 30-35% of the total production cost. Since the cost of chemicals for glue is high, one way for producers to reduce production costs was to include a high rate of cassava starch (35%). But this also decreased the product's quality. As chemicals for glue material became cheaper, the inclusion rate of cassava starch decreased from 35% to 30%.

Pharmaceutical industry

At present, the pharmaceutical industry uses cassava starch in producing tablets and pills. Purity, whiteness and adhesiveness are the most important criteria in this industry and cassava starch produced using traditional technology generally does not satisfy these criteria. Starch is, therefore, bought from processing centers, after which it has to go through further processing to generate a starch that satisfies the requirements of the pharmaceutical industry. About 100 t of cassava starch has been used annually in this industry. The reason for it using cassava starch instead of other starches, such as rice or potato starch, is that cassava starch is lower priced and there is sufficient supply. Also, the technology is available for using cassava starch in producing tablets and pills.

One constraint is that the adhesiveness of dry cassava starch is not so good compared to that of other starches. Adhesiveness is good when cassava starch is hydrated, but in the production of certain medicines no water can be used in the process as it may interfere with the medicine's effectiveness. Therefore, there is a need to investigate technologies that could use dry cassava starch directly in producing tablets and pills without the need for hydration. At present, there is no cassava processing factory producing starch for pharmaceutical use and cassava starch in the market does not satisfy the industry's requirements. There exist an urgent need to improve the quality of cassava starch and to have starch for the production of high quality dextrine, malto-dextrine and glucose for pharmaceutical use.

Cassava starch export

Vietnamese cassava exports are mostly in the form of dry chips and only a small quantity of cassava starch is exported. About 30,000 t of cassava chips is exported annually to the European Union (EU), and 10,000 t to Asian countries; only about 1,000 t of cassava starch and tapioca pearl are exported to neighboring countries. The export price of cassava chips (120 to 130 US$/t) to the EU is much higher than to Asian countries (70 to 80 US$/t). Because of the high export price to the EU, the price of locally used dry chips has increased and the export to Asian countries cannot compete. So, companies exporting chips to Asian countries have changed to investing in starch processing and in the export of starch or tapioca pearl.

Major constraints to cassava starch export are: poor starch quality, inefficient processing and marketing systems, insufficient or poor storage facilities, relatively high transport costs and insufficient volume available for export when needed. The current conversion rate from fresh root to dry starch in processing is 5:1 in the wet season and 4:1 in the dry season. Dry matter content is high in the dry season but farmers adjust their cropping calendar so that they can harvest at the end of the wet season as less labor input is required. When the harvest is in the wet season, processors have problems with low starch content and thus low conversion rates, and they have problems drying the starch because of the high relative humidity. Many processors cannot produce export quality starch. Because of small-scale processing and low starch quality, it is difficult to collect enough starch for export. These constraints make cassava starch in Vietnam non-competitive with starch from China and Thailand.

Compared to Vietnam, Thailand has more advantages in cassava starch production in terms of the low price of fresh roots (farm gate price is about 20 US$/t), a highly efficient (large-scale) processing and marketing system with good storage facilities, high starch quality, large volume and low cost of transport. The cheap labor cost and the potentially lower farm gate price are the two major advantages for cassava starch production in Vietnam.

At present, some foreign companies have invested in cassava starch production in Vietnam with high production capacity, better technology and better export facilities. These investments may generate an increased opportunity for cassava starch exports in the future.

Cassava Starch Market Potential

Future domestic demand growth by each end product

It is clear that cassava starch consumption is currently quite important (corresponding to about 20% of total cassava production). It is essential to assess whether this status is changing or likely to do so over time. Results of this study reveal that there is great future potential for cassava starch. The major demand could come from the MSG industry, food processing and home consumption (**Table 2**). The demand for starch for MSG production is expected to grow to 90,000 t by the year 2000. Today, many companies are opening businesses in this industry. They have invested or plan to invest in MSG production for domestic consumption. It is difficult to increase production for export since the surrounding countries also produce MSG for their own consumption and satisfy these markets. Therefore, MSG production in Vietnam is mostly to satisfy domestic consumption.

At present, most companies begin producing MSG from imported glutamic acid. There is a great potential in the demand for cassava starch in this industry. Byproducts from the sugar industry can substitute as raw material, but cassava starch could still become the major source for MSG production. Modern technology and the use of efficient types of bacteria in the MSG production process will increase the conversion rate from cassava starch to MSG and its cheap price will increase the inclusion of byproducts from the sugar industry. Even so, there is still a very high potential for cassava starch demand and it is expected to be about 90,000 t/year by the year 2000.

However, there are some constraints in the use of cassava starch in this industry. When a company decides to use cassava starch as raw material, a great volume of it will be used daily. For example, if a company produces 10,000 t of MSG/year, about 29 t of cassava starch of 90% purity will be used daily. If the company decides to produce starch itself, about 116 t of fresh roots are required per day. It is difficult to have a sufficient supply under current conditions. Collecting this large volume is also costly since in some areas cassava production is not concentrated. Transport costs are acceptable to a distance of less than 120 km around the factory, but organizing the collection is a problem. Another problem is the seasonality of cassava production with the harvest concentrated in about 5-6 months per year while good storage facilities are lacking. This means insufficient starch for year-round production. If these constraints could be solved, then there is a very high cassava starch demand for MSG production.

Cassava starch is an inferior food for home consumption so its demand declines with an increase in consumer income. However, demand increases with population increase. With an expected annual population growth of 2.1% and an expected gross national product (GNP) growth of 8%, the demand for cassava starch for home consumption, conservatively estimated, will increase slightly from 40,000 t to 45,000 t/year by the year 2000.

In the food processing industry cassava starch can be used in many different food products, so its use is likely to diversify greatly in the future. Cassava starch will be used in producing higher quality food products as well as many new ones such as different kinds of cakes and snacks. Better starch quality will be required in this industry.

The trend in the textile industry indicates that production will increase substantially. There will be a great demand for glue material and with the investment in modern technology, e.g. high speed weaving machinery, more high quality glue material (chemically modified starch) will be used instead of raw cassava starch. At present, some companies import this glue, but in the future it could be produced locally using cassava starch. Hence, the potential demand for cassava starch in the textile industry is expected to be about 2,000 t/year. Demand for cassava starch as glue material for cardboard production is expected to increase to about 1,200 t and for other purposes to 150 t/year. These demands account for only a small proportion of future total starch demand.

In the plywood industry, higher quality plywood will be needed. The inclusion rate of cassava starch in glue material will decline from 30% to 20-25% in the future. But with the increase in plywood production, about 120 t of cassava starch will be used annually.

The demand for cassava starch for maltose production and for the pharmaceutical industry will not greatly increase. The demand for glucose production could increase to about 3,000 t/year. **Table 2** summarizes the estimated future demand and growth rate by industry.

Export potential

By the year 2000 the export of cassava starch is expected to increase significantly. At present, foreign companies are investing in the cassava processing sector and in the export of their products. Once these large-scale processing plants with better technology (e.g. good drying facilities, higher conversion ratio, better starch quality, lower production cost) are operating at full capacity, and when new high-yielding and high-starch cassava varieties are widely grown in Vietnam, there is a good prospect for increased exports of cassava starch. By the year 2000 the export volume could be around 10,000 t/year. But when the comparative advantage of cheap labor declines, it is expected that more starch will be used for domestic industrial consumption.

Assessment of Competition From Other Starches

Cassava starch has a relatively lower price than rice starch and wheat flour (**Table 3**), a price relationship which will not change much in the future. The price of rice starch will not decline compared to that of cassava starch because of the production technology used, and because the government will not encourage the use of rice starch in industry. Wheat flour is less competitive with cassava starch in industrial usage because of its high price, as it has to be imported using scarce foreign exchange; and if used in industry, production costs will be very high. Other starches, such as canna and maize starch, are mostly used in the food processing sector. For industrial use, they have either too high a price or insufficient supply.

Table 3. Prices of some products in Ho Chi Minh city, November 1993.

Products	Wholesale price (VND/kg)[1]	Retail price (VND/kg)[1]
Cassava starch		
-Quality I	2,200	2,300
-Quality II	2,000	2,200
-Quality III	1,800	2,000
Rice starch	2,900	3,000
Wheat flour	3,000	3,200
Cassava flour	950	1,300
Cassava noodles	3,200	3,300
Monosodium glutamate	5,500	16,000

[1] 1 US$ = 1,080 VND.

Assessment of Government Policies Incluencing Market Potential

The Vietnamese government has emphasized the substituting role of cassava and other roots and tubers in order to use rice for domestic human consumption and export. Government policies also encourage the export of agricultural products, including cassava-based products such as dry chips and starch, through a zero export tax. The government also uses tax policies to limit the import of goods that can be produced in Vietnam in order to protect domestic production. For example, the import tax on MSG and wheat flour is 20% of C.I.F. (cost, insurance and freight) price. The investment policy has also encouraged investment in the cassava sector. These policies can have a great effect on cassava starch potential, especially in the MSG industry and for cassava processing for export. As a result, several foreign companies have invested in these two industries.

CONCLUSION

The analysis of current cassava starch use and its division by end products reveals that food processing, home consumption, textiles and glucose are currently major cassava starch consumers. Demand for cassava starch in the MSG industry is expected to become very high. There will be little change in the demand for cassava starch in food processing and home consumption, but it will remain very high in these two sectors. In the food processing industry, products made from cassava starch are very diversified. This industry requires better starch quality. Cassava starch exports are also expected to increase substantially. Demand for cassava starch by the year 2000 is expected to more than double current demand (**Table 3**).

The trend of cultivated areas in Vietnam (see Thang, this Proceedings) shows that the cassava area has been decreasing during the 1980s, while productivity increased only slightly. In the future, the cassava area is likely to decrease further since other industrial crops with higher profits will substitute for cassava. With the expected increase in future demand for cassava starch, there will be a gap between supply and demand. The gap will increase even further when we include the increasing demand for cassava chips for livestock and poultry. Therefore, if cassava productivity is not improved, a serious supply shortage can be expected in the future.

Since the cassava supply can not be increased through increasing the cultivated area, it can only be obtained by intensifying cassava production. Introducing high-yielding and high-starch varieties can be part of the solution to this problem. To increase cassava yields various research activities are needed, such as research on the adaptation of new high-yielding varieties to different agro-ecological regions, and the transfer of more efficient production technologies to farmers. It is also necessary to look into farmers' abilities to use new technologies. High yielding varieties give higher output but may also require more chemical fertilizers than local varieties, and not all farmers can afford this. Lack of knowledge about new technology and the lack of credit are the two major constraints for farmer adoption; both will require increased extension activities.

Developing the cassava sector should follow a harmonic development process involving production, processing and consumption. Only thus can the country progress without causing economic disequilibrium. Efforts to promote cassava production must be tied to the market's capacity to absorb the increased root supply. For example, in 1987 farmers were encouraged to produce more cassava at a time when market demand was actually decreasing. There was an oversupply situation resulting in a significant decrease in the price of cassava fresh roots. The price of roots was so low that farmers decided not to harvest their crops to cut their losses. For a harmonic development of the cassava sector, and of agriculture in general, cassava production, processing and marketing activities must be coordinated, and a favorable disposition toward cassava-based products must be created. Therefore, integrated research is needed with cooperation among agronomists, plant breeders, processing technologists and economists. To develop the cassava sector, the government should provide a good data base and adequate information on prices, demand and other market developments in order to help farmers, processors and other producers make correct decisions. The government should also provide clear signals on its own pricing policy and make market information widely available.

The technical requirements with respect to starch quality for different end-products using cassava starch could be used as criteria for cassava production and starch processing. To satisfy future demand in terms of cassava starch quantity and quality, many improvements in the production, processing and marketing system should be made. In processing, besides investing in modern processing factories, traditional processing units need to be improved to increase efficiency and obtain a higher conversion ratio and better starch quality.

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TECHNOLOGY TRANSFER STRATEGY IN VIETNAM

Tran Van Son[1]

INTRODUCTION

During the past five years (1986-1991), roots and tuber production in Vietnam has increased substantially, but is still unstable. The production of root and tuber crops in 1991 totaled 4,780,000 tons. The cassava growing area was 267,200 ha, while the production was 2,389,900 tons. The sweet potato growing area was 348,400 ha, with a production of 2,104,500 tons. The potato growing area was 31,700 ha with a production of 284,800 tons. Thus, root and tuber crops are making an important contribution to solving the food problem in the country.

To achieve this, a lot of attention has been paid to both research and technology transfer.

1. Institutional Arrangement for Agricultural Technology Transfer of Food Crops.

In Vietnam, agricultural technology transfer is considered an essential component of agricultural development and the Ministry of Agriculture and Food Industry is responsible for this activity.

Although technology transfer is one of the essential factors for development, it is greatly dependent on the quality of agricultural research, the degree to which policy and prices support the adoption of new technologies and the effectiveness of a supporting infrastructure. In Vietnam technology transfer can be illustrated as the link between research and farmers (**Figure 1**).

This linkage between various activities focusing on the farm family is illustrated in the diagram of **Figure 2**, while the organizational chart for agricultural technology transfer in Vietnam from the national to the village level is illustrated in **Figure 3**.

At the Ministry of Agriculture and Food Industry, the Department of Plant Production and Protection is responsible for technology transfer. This department plays an important role in training and the dissemination of information about newly improved technologies; it sets up various demonstration models on farmers' fields, which are used for training and field visits. The department also organizes at the regional or national

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level field days for exchanging of experiences among extensionists and farmers on the applicability of the technologies. Together with provincial extensionists, our department's extensionists establish optimum cropping maps for various provinces.

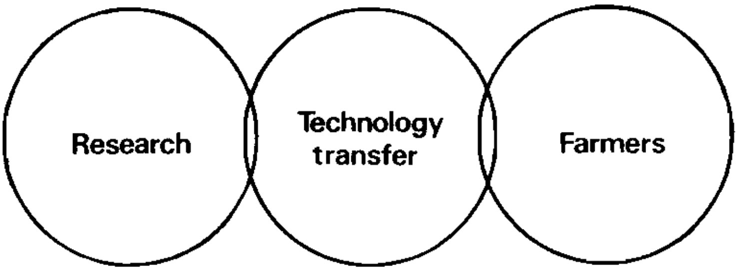

Figure 1. Technology transfer linkage with research and farmers.

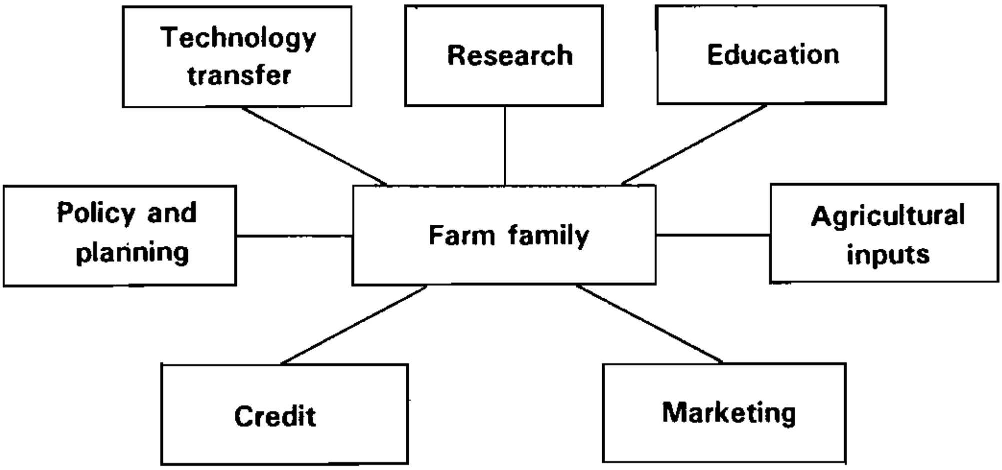

Figure 2. Linkages in support of the farm family.

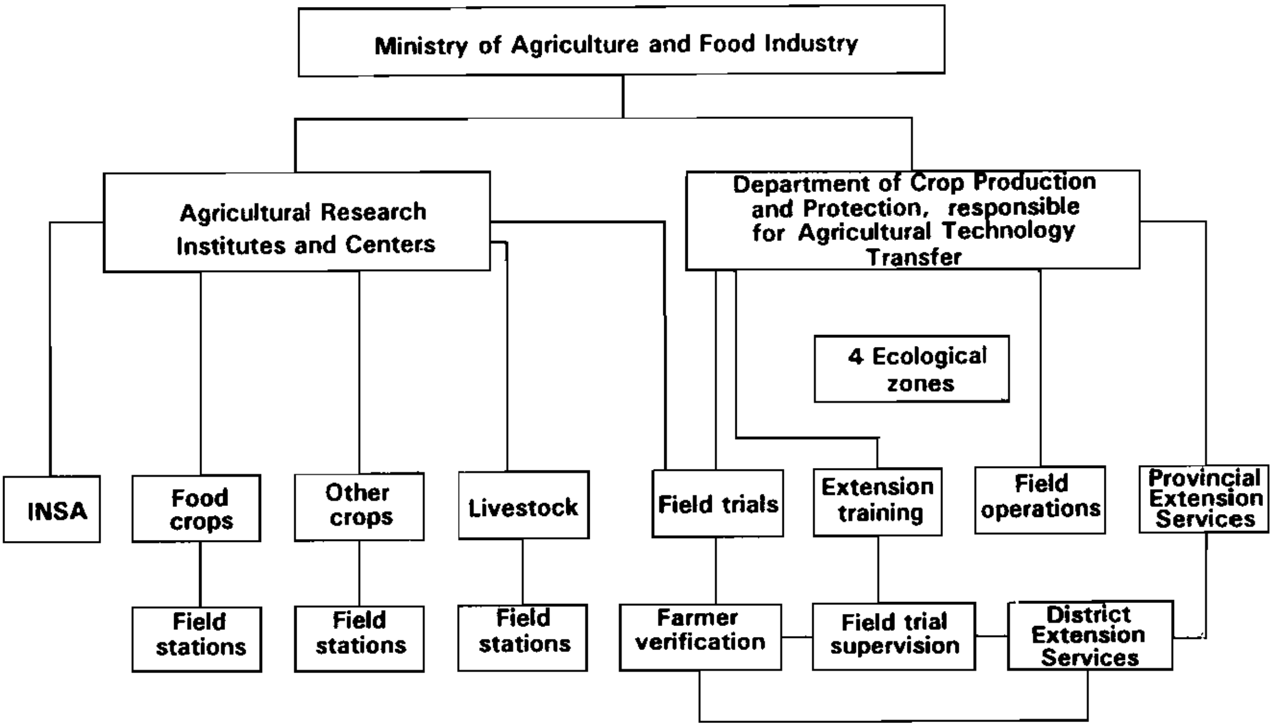

Figure 3. Organizational chart for agricultural technology work in Vietnam with emphasis on food crops.

The Provincial Departments of Agricultural Extension also play an important role in transfering technological packages to farmers. These provincial extensionists directly introduce detailed technologies to farmers through provincial training courses for farmers, they disseminate technical notes and leaflets to farmers, and organize field days and demonstrations on farmers' fields. They also organize extension review meetings with various district extensionists and farmers. They help farmers find the necessary inputs for intensive farming as well as markets to sell their products.

2. The Mechanism of Technology Transfer.

The technology transfer process is accomplished within the framework of various programs, such as on-farm verification programs, farmers' training programs and mass communication support programs:

a. **On-farm verification programs** involve on-farm tests, on-farm demonstration fields and on-farm models. These programs aim at verifying suitable cropping patterns and other component technologies under actual farm conditions. Farmers are willing to apply new technologies only after they have seen the results of on-farm tests, demonstrations and models.

b. **Farmers' training programs** involve local farmers and extension workers at the village, district or provincial levels, the dissemination of information on new technologies and the exchange of experiences on how to apply these to production.

c. **Mass communication programs** help extension workers to communicate necessary information concerning technology transfer to farmers.

All these activities are directed towards the improvement of the living standards in rural areas by the use of improved farming technologies and the development of skills. This is done through various projects designed to increase family incomes and to promote self reliance and a healthful and correct family and community life.

3. Constraints to Technology Transfer

Two of the major constraints to technology transfer in Vietnam are:

a. Lack of necessary funds and facilities from the government to support the technology transfer work. Although the Ministry gives some financial support and tries to create favorable conditions for the extensionists to transfer new technologies, this support is still inadequate.

b. The farmers are very poor, especially those living in the midlands and mountainous regions where root and tuber crops are important food crops. Few farm inputs are available for the application of new technologies for intensive farming of root and tuber crops. The farmers are willing to participate in extension programs, but the achievements of these programs depend greatly upon the applicability of the new technology to the conditions of poor farmers.

We suggest, therefore, that the technology transfer programs on root and tuber crops should pay more attention to the study of low input technologies, appropriate to resource-poor farmers. Priorities should be given to the transfer of technologies that require low inputs but give high economic efficiency.

4. Action Programs for Technology Transfer in Vietnam

At present we concentrate our efforts on the following action programs for technology transfer:

a. The transfer of new technologies for promoting rice and other food crops, among which are root and tuber crops, such as cassava, sweet potato and potato. New technologies include improved crop varieties, cropping systems, management techniques, as well as post-harvest and marketing issues.

b. The transfer of new technologies for integrated plant protection and soil fertility improvement programs.

ON-FARM RESEARCH AND TRANSFER OF TECHNOLOGY FOR CASSAVA PRODUCTION IN SOUTH VIETNAM

Hoang Kim, Tran Ngoc Quyen, Nguyen Dang Mai and Vo Van Tuan[1]

INTRODUCTION

Cassava (*Manihot esculenta*) planting area in South Vietnam in the period of 1980-1990 ranged from about 116 to 170 thousand hectares, and presently accounts for about 46% of the total cassava area of the country. The South Central Coast and the Southeastern Region are the two major cassava producing regions of South Vietnam with presently a total of about 90 thousand hectares of cassava every year.

On-farm research and transfer of technology for cassava production are key factors for cassava development. They are an important bridge linking science with production.

During the past few years, Hung Loc Agricultural Research Center has collected local cassava germplasm, and from this has selected and recommended three cassava cultivars: HL-20, HL-23 and HL-24. At the same time, the Center has studied mungbean, peanut and winged bean as intercrops with cassava to increase the farmers' income and to contribute to the maintenance of soil fertility in cassava fields. Since 1991, we have cooperated with CIAT to carry out preliminary on-farm trials of promising new cassava varieties and more intensive cultivation techniques for the major cassava producing areas of the Southeastern Region.

METHODOLOGY

The strategy for on-farm research and transfer of technology for cassava production used by the Hung Loc Center is depicted in **Figure 1**. The cassava research and development program in cropping systems is following the methodology for on-farm cropping systems research proposed by IRRI (Zandstra *et al.*, 1981; Carangal, 1990) and the Agro-ecological Systems Analysis method of Conway (1986).

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RESULTS

1. Collection and Analysis of Basic Data of the Southeastern Region on Cassava Production and Marketing.

The basic characteristics of climate and soils of the region are shown in **Figures 2** and **3**. The 12 leading districts for cassava production of the Southeastern Region are: Thong Nhat, Long Thanh and Xuan Loc districts of Dong Nai province; Thuan An, Ben Cat and Dong Phu districts of Song Be province; Hoa Thanh, Duong Minh Chau and Tan Bien districts of Tay Ninh province; and Chau Thanh, Xuyen Moc and Long Dat districts of Ba Ria-Vung Tau province (**Figure 4**). Among them Thong Nhat is the most important cassava producing district in terms of concentration of cassava production areas. In 1991, the area planted to cassava was 4,650 hectares.

The analysis results of 219 surveys on cassava production, conducted in 1990 in the Southeastern region (in a total of 592 surveys conducted in South Vietnam) (Pham Van Bien *et al.*, 1996), and 180 surveys on general root crop cultivation techniques and economy (in a total of 420 surveys in South Vietnam) (Hoang Kim *et al.*, unpublished) shows that cassava soils in South Vietnam in general, and in the Southeastern Region in particular, are poor in nutrients, subject to severe erosion and they are poorly fertilized. In about 48% of the cassava growing area in the South Central Coast and the Southeastern Region cassava is intercropped with maize, grain legumes and others crops. Of the cassava farmers who intercrop, about 16% grow cassava in association with grain legumes and 51% with maize in these regions (**Table 1**), but this could be further expanded. The most common cassava cultivars used are H-34 and Gon (**Table 2**) (Hoang Kim, 1992).

An economic analysis of 60 cassava producing households in the Southeastern Region (**Figure 5**) shows the difference in average costs and profits of cassava production in various locations. The average cost effectiveness (net profit x 100/total costs) in growing cassava was 119%, with the period from planting to harvest being 12 months (Tran The Thong *et al.*, 1992). The economic efficiency of cassava starch, cassava strips (*bot khoai*), tapioca and noodle processing methods are shown in **Table 3**. The cost effectiveness of cassava starch processing is 26.9% with a processing shift of three days (Hoang Kim *et al.*, 1992). The fluctuations in price of cassava fresh roots, dry chips and starch are shown in **Figure 6**, while the various market channels and the costs of cassava raw material and transport are shown in **Figures 7 and 8** and in **Table 4** (Tran The Thong *et al.*, 1992).

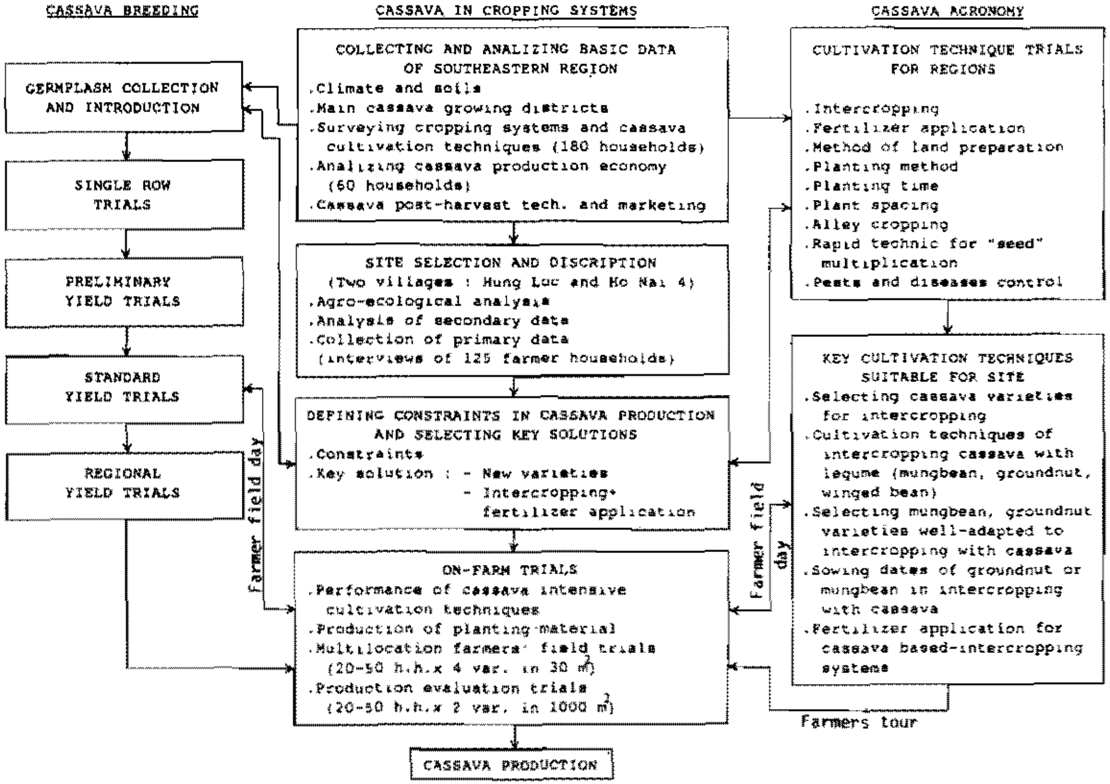


Figure 1. Strategy for on-farm research and transfer of technology for cassava production in the Southeastern Region: A case study conducted by Hung Loc Agricultural Research Center.

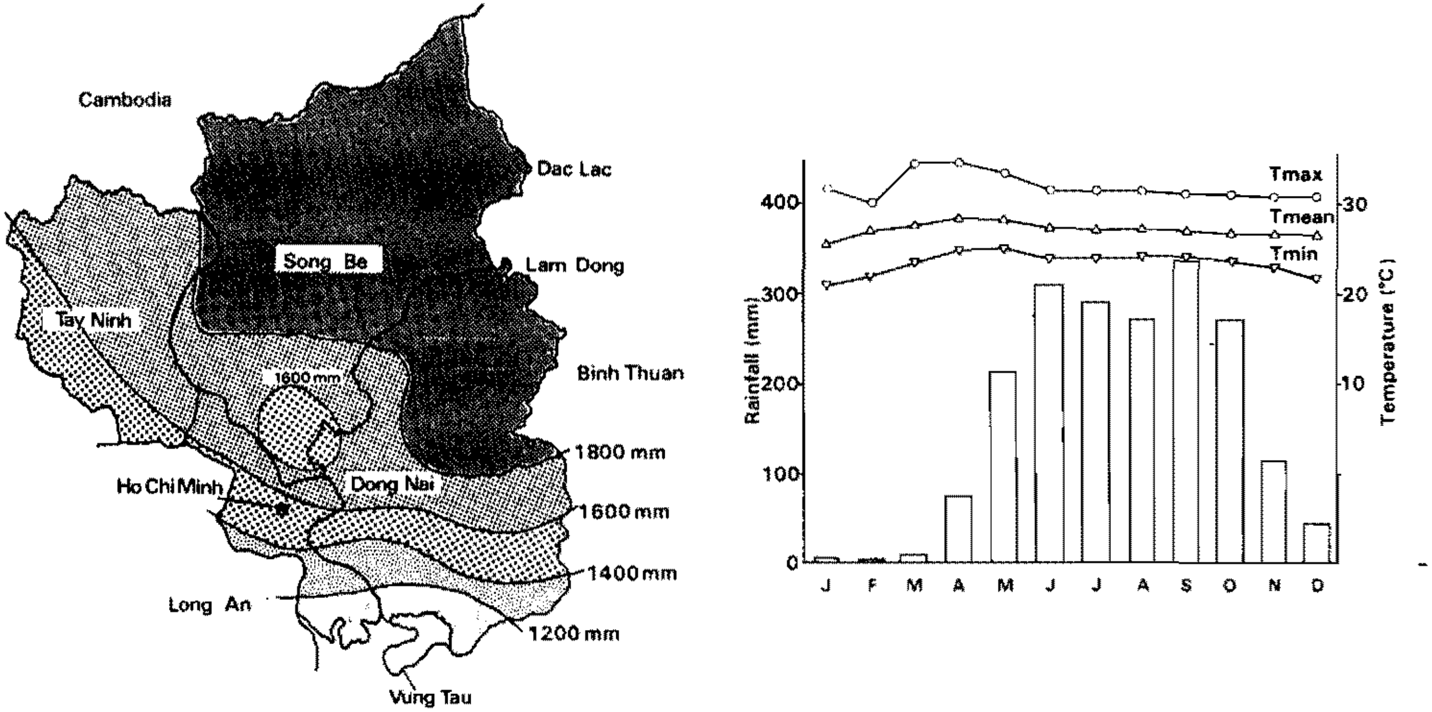


Figure 2. Isohytes for the mean annual rainfall in Song Be, Tay Ninh, Dong Nai and Baria - Vung Tau provinces and Ho Chi Minh city of the Southeastern region of Vietnam. At right are the average rainfall distribution and temperature for Ho Chi Minh city.

Source: *Hoang Kim, 1992.*

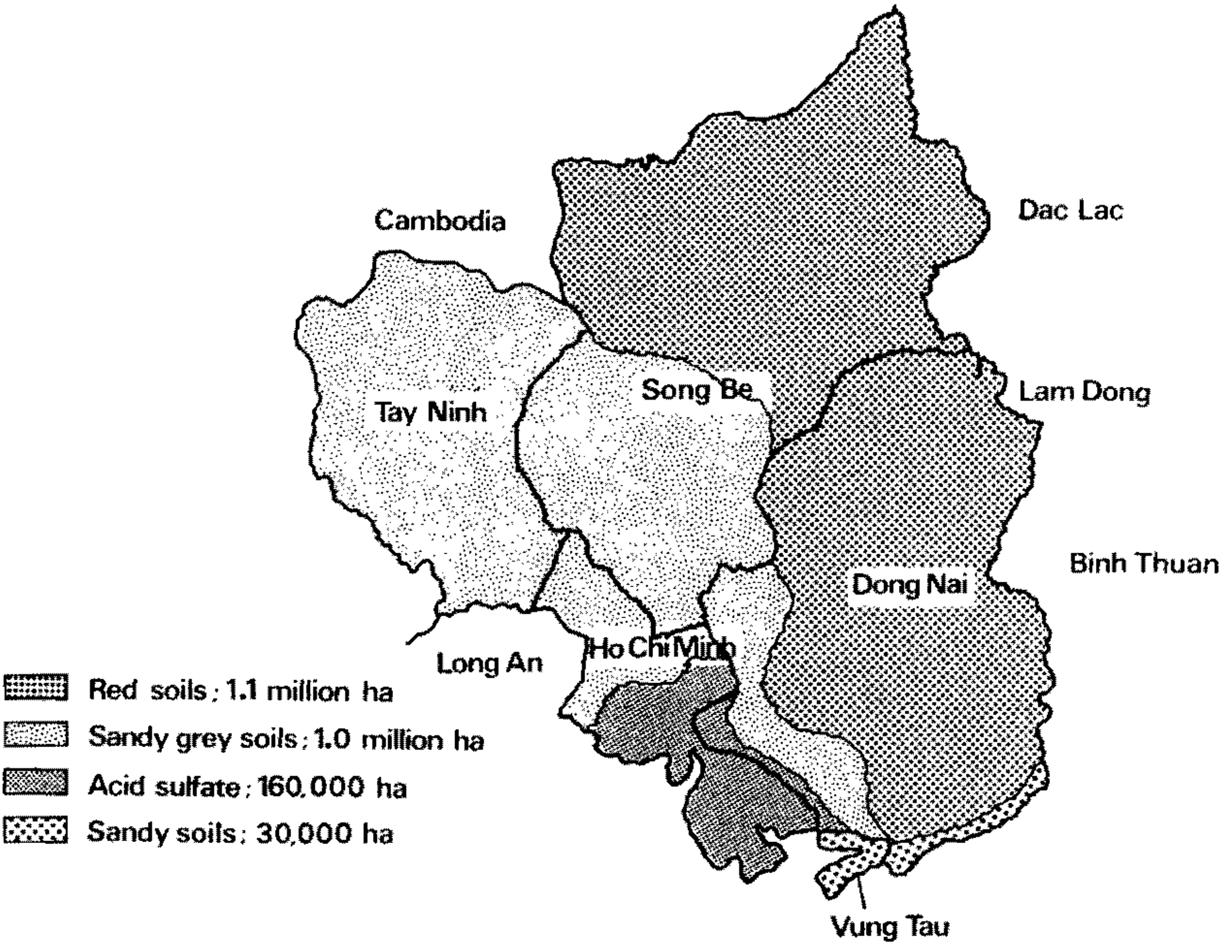


Figure 3. Distribution of soils in Song Be, Tay Ninh, Dong Nai, Baria - Vung Tau provinces and Ho Chi Minh city of the Southeastern region of Vietnam.

***Source:** Phan Lieu et al., 1992.*

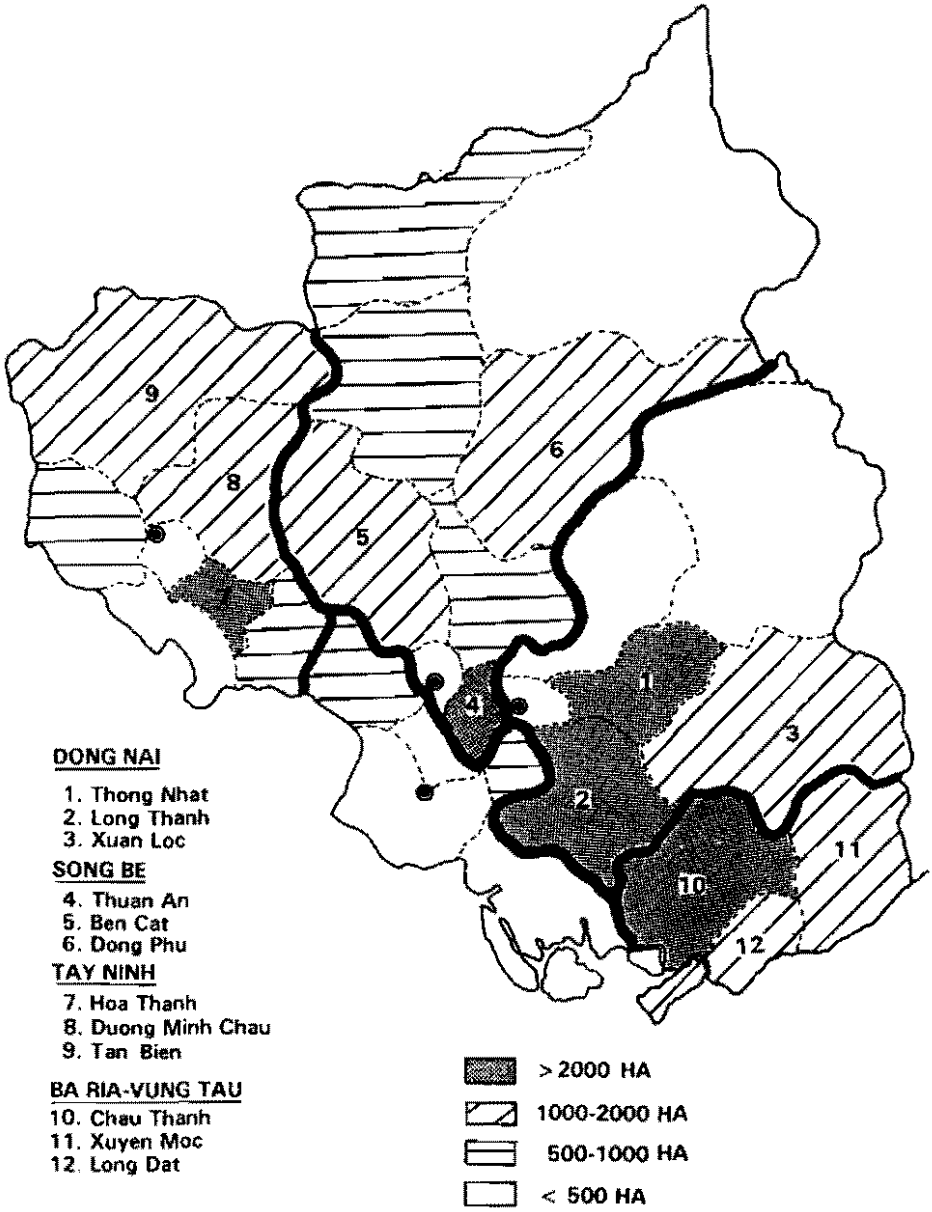
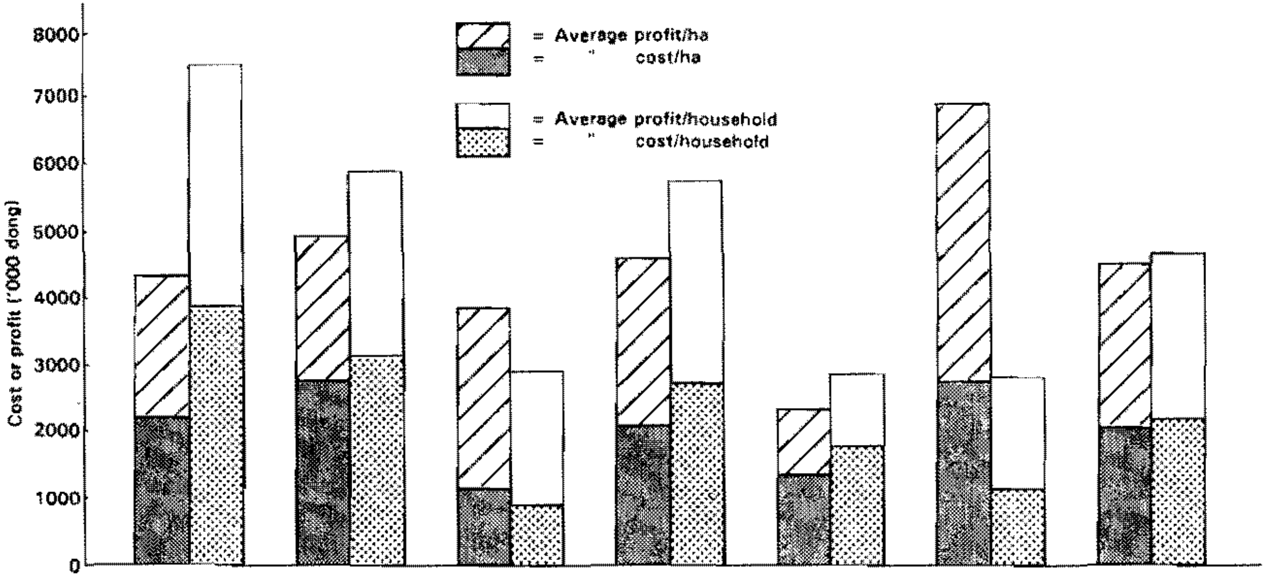


Figure 4. Cassava growing districts of the Southeastern region of Vietnam according to their production area in 1991.



Province	DONG NAI	DONG NAI	DONG NAI	SONG BE	TAY NINH	HO CHI MINH	Average of
Village	XUAN LAP	HUNG LOC	TRA CO	AN PHU	NINH SON	LINH TRUNG	6 Zones
Kind of soils	Red yellow	Red yellow	Sandy grey	Sandy grey	Sandy grey	Sandy grey	
No.of respondents	10	10	10	10	10	10	
Average area (ha)	1.73	1.17	0.78	1.25	1.23	0.40	1.09
Cost effectiveness (%)	96	80	268	110	64	156	119

Figure 5. Economic efficiency of 60 households in growing cassava in the Southeastern region in 1991.

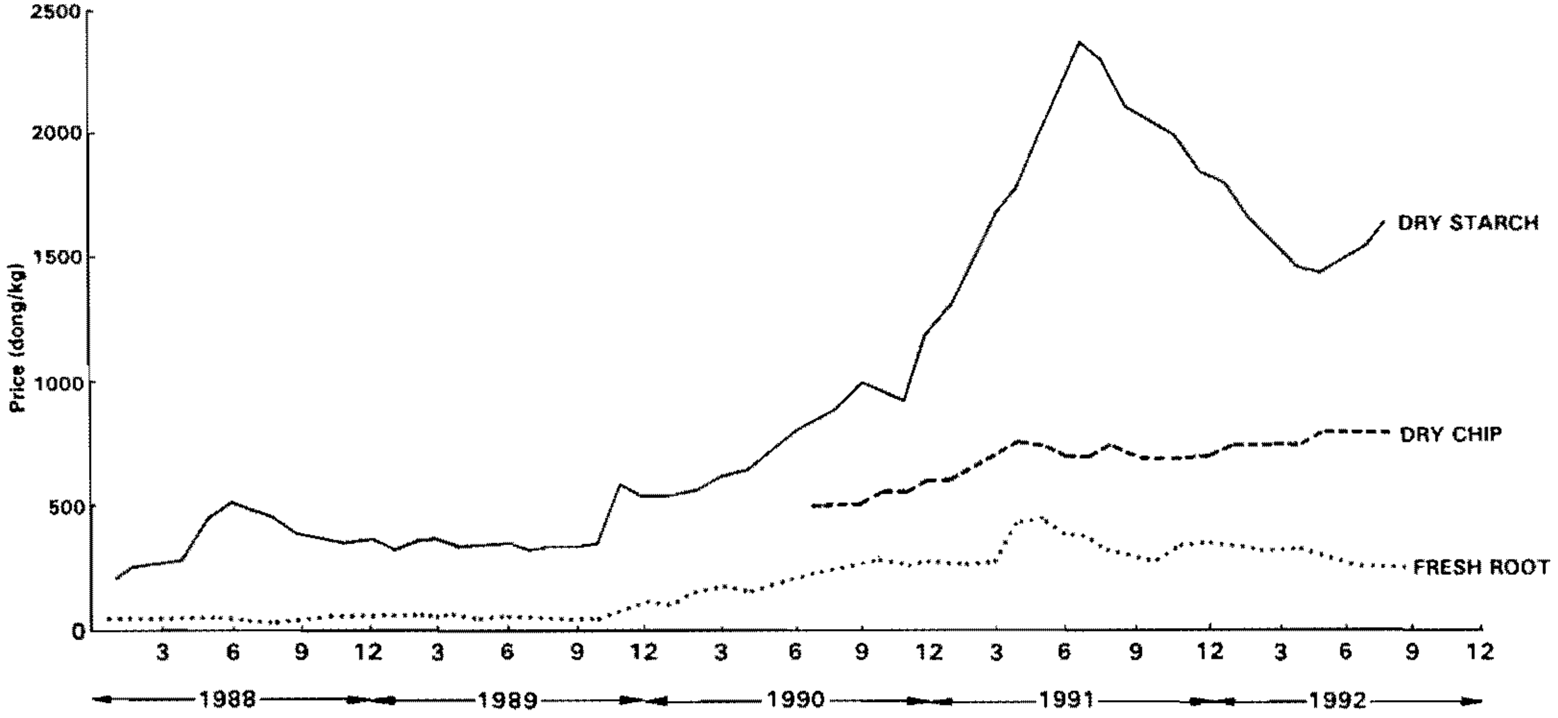


Figure 6. Price flutuation of cassava dry starch, dry chips and fresh roots at Tra Co village (Dong Nai province) from 1988 to 1992.

***Source:** Tran The Thong et al., 1992.*

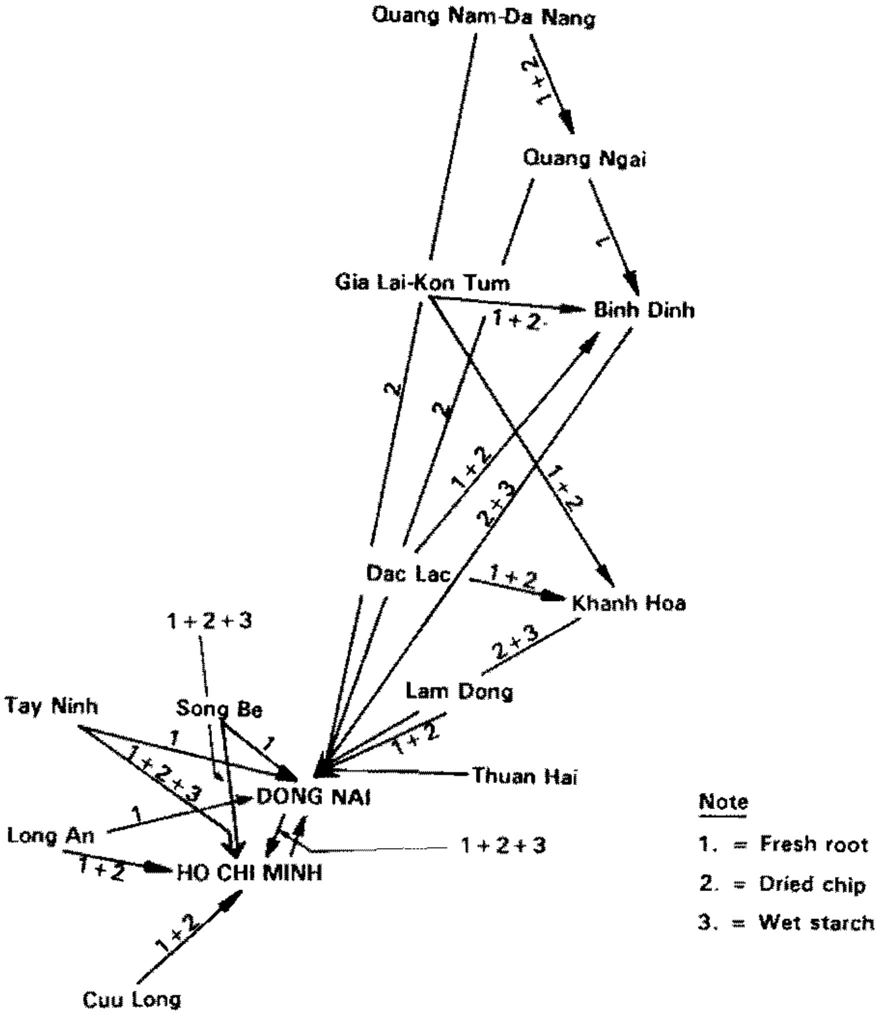


Figure 7. Distribution of various cassava raw materials in South Vietnam.

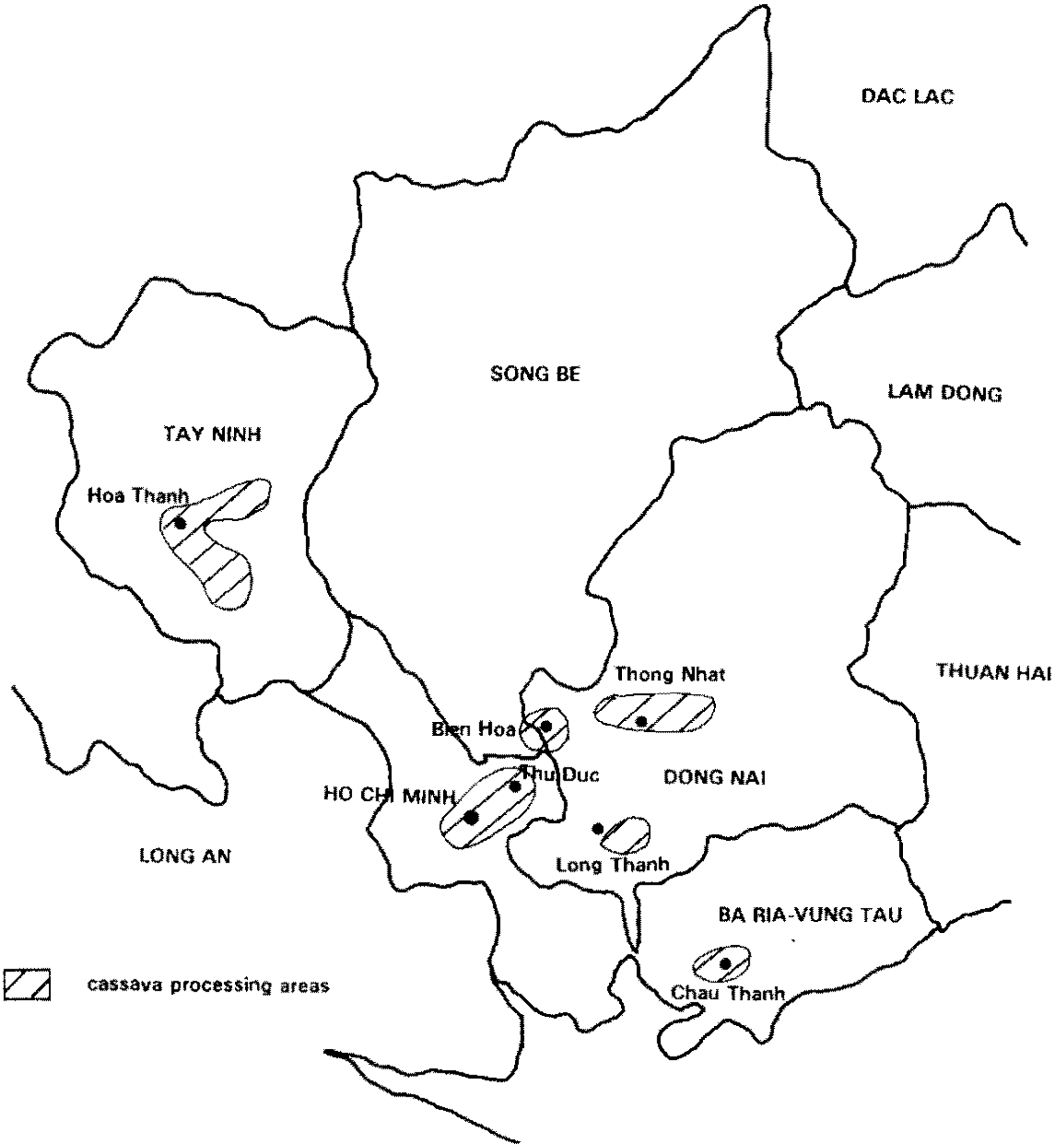


Figure 8. Cassava processing zones in the Southeastern region of Vietnam.

Table 1. Survey results about cassava cropping systems used in various districts of the Southeastern and South Central Coastal Region.

Province	District	No.of respondents	Cassava monoculture		Caşsava intercropped		No.of respondents growing-casasava in association with			
			Area (ha)	%	Area (ha)	%	Maize	Grain	Other legume	Total
Quang Nam-Da Nang	Thang Binh	21	0.81	100	0.00	0	0	0	0	0
	Hoa Vang	24	2.35	94	0.15	6	0	1	0	1
	Que Son	24	0.46	100	0.00	0	0	0	0	0
Quang Ngai-Binh Dinh	Son Tinh	22	2.07	100	0.00	0	0	0	0	0
	Phu My	24	4.84	100	0.00	0	0	0	0	0
	Phu Cat	24	4.30	98	0.10	2	0	1	0	1
Khanh Hoa	Van Ninh	17	5.17	96	0.23	4	0	0	1	1
	Dien Khanh	23	14.91	99	0.15	1	2	0	0	2
	Cam Ranh	23	14.20	97	0.40	3	0	0	4	4
Binh Thuan	Ham Tan	24	2.95	63	1.70	37	5	0	2	7
	Ham Thuan Nam	24	1.30	54	0.90	46	4	4	4	12
	Duc Linh	24	2.47	39	3.80	61	2	4	10	16
Dong Nai	Thong Nhat	22	4.70	42	6.40	58	11	0	4	15
	Long Thanh	24	0.50	13	5.10	99	10	6	5	21
Ba Ria-Vung Tau	Xuyen Moc	24	1.00	0	8.50	90	17	0	4	21
Total		344	61.75	52	56.43	48	51	16	34	101

***Source**: Hoang Kim, 1992.*

Table 2. Survey results about cassava cultivars and planting methods used in various districts of the Southeastern and South Central Coastal Regions.

Province	District	No.of respondents	No.of respondents growing cassava-cultivar					No.of respondents using planting method		
			H-34	Gon	HL-23	HL-24	Other	Ridge	No ridge	Other
Quang Nam - Da Nang	Thang Binh	21	9	6	0	5	1	21	0	0
	Hoa Vang	24	8	2	0	0	14	24	0	0
	Que Son	24	9	7	0	6	2	23	1	0
Quang Ngai - Binh Dinh	Son Tinh	22	12	4	0	6	0	7	15	0
	Phu My	24	24	0	0	0	0	3	21	0
	Phu Cat	24	24	0	0	0	0	6	18	0
Khanh Hoa	Van Ninh	17	10	3	0	0	4	1	16	0
	Dien Khanh	23	23	0	0	0	0	9	14	0
	Cam Ranh	23	23	0	0	0	0	10	12	1
Binh Thuan	Ham Tan	24	7	5	2	3	7	21	3	0
	Ham Thuan Nam	24	4	12	0	6	2	24	0	0
	Duc Linh	24	3	11	5	3	2	16	8	0
Dong Nai	Thong Nhat	22	0	2	8	10	2	0	22	0
	Long Thanh	24	0	4	5	3	12	15	9	0
Ba Ria - Vung Tau	Xuyen Moc	24	3	7	4	3	7	0	24	0
Total		344	159	63	24	45	53	180	163	1

Source: *Hoang Kim, 1992.*

Table 3. Economic efficiency of cassava starch, cassava strips (bot khoai), cassava pearls and noodle processing in the Southeastern Region of Vietnam in July 1991.

Processed product Item	Starch	Cassava strips (bot khoai)	Cassava pearls	Noodles[2] of cassava (1)	Noodles[2] of canna (2)	Noodles[2] No.8 (3)
-Amount of raw material/shift (kg)	3,000	1,000	1,000	500	500	500
-Average buying price/kg raw material (VND)[1]	350	1,400	1,400	1,400	1,400	750
-Product recuperation ratio (%)	26	65	65	80	80	80
-Products/shift (kg)	780	650	650	400	400	400
-Total cost/kg of product (VND)	1,570	2,394	2,441	2,765	7,707	1,156
-Raw material	1,346	2,154	2,154	2,333	7,375	937
-Fuel	22	23	27	116	22	62
-Package	29	14	14	20	25	5
-Labor	100	100	100	200	200	200
-Amortization	44	64	107	46	35	10
-Other costs	34	39	39	50	50	10
-Selling price of 1 kg of product (VND)	2,000	2,700	2,700	3,000	9,000	1,400
-Profit/1 kg product (VND)	424	306	259	235	393	244
-Profit for 1 processing shift (1,000 VND)	330.7	198.9	168.3	98.7	146.6	102.5
-Cost effectiveness (%)[3]	26.9	12.8	10.6	8.5	6.3	21.1

[1] In Vietnamese dong; 1 US$ = 9,000 VND.

[2] (1) Noodles of cassava: 100 % cassava (high quality wet starch)
(2) Noodles of edible canna: 70 % edible canna + 30 % cassava
(3) Noodles No.8: 100 % cassava (lower quality wet or dry starch)

[3] Cost effectiveness = net profit x 100/total costs.

Source: *Tran The Thong et al., 1992.*

Table 4. Marketing costs[1] of wet cassava starch from farm level in Hoai Nhon (Binh Dinh), Hoa Thanh (Tay Ninh), Ho Nai 4 (Dong Nai) and Thu Duc (Ho Chi Minh) to retailer level in Tan Binh (Ho Chi Minh city).

Price level and costs items	VND/kg	%
<u>I. From Hoai Nhon to Ho Nai 4 to Tan Binh</u>		
- Buying price (wet starch)	780	65.0
- Loading cost	10	0.8
- Transport cost (from Hoai Nhon to Ho Nai 4, about 639 km)	140	11.0
- Business taxes, daily kiosk ticket, sanitation and other fees	30	2.5
- Unloading cost	10	0.8
- Decantation	40	3.3
- Gross profit I	40	3.3
- Loading cost	10	0.8
- Transport cost (from Ho Nai 4 to Tan Binh, about 49 km)	32	2.6
- Business taxes, daily kiosk ticket, sanitation and other fees	20	1.6
- Gross profit II	88	7.3
- Buying price by consumers in Tan Binh	1,200	100.0
<u>II. From Hoai Nhon directly to Tan Binh</u>		
- Buying price (wet starch)	780	71.0
- Loading cost	10	0.9
- Transport cost (from Hoai Nhon to Tan Binh, about 688 km)	172	15.6
- Business taxes, daily kiosk ticket, sanitation and other fees	30	2.7
- Gross profit	108	9.8
- Buying price by consumers in Tan Binh	1,100	100.0
<u>III. From Hoa Thanh to Tan Binh</u>		
- Buying price (wet starch)	1,030	85.8
- Loading cost	10	0.8
- Transport cost (from Hoa Thanh to Tan Binh, about 100 km)	65	5.4
- Business taxes, daily kiosk ticket, sanitation and other fees	22	1.8
- Gross profit	73	6.1
- Buying price by consumers in Tan Binh	1,200	100.0
<u>IV. From Thu Duc to Tan Binh</u>		
- Buying price (wet starch)	1,070	89.1
- Loading cost	10	0.8
- Transport cost (from Thu Duc to Tan Binh, about 100 km)	32	2.6
- Business taxes, daily kiosk ticket, sanitation and other fees	10	0.8
- Gross profit	78	6.5
- Buying price by consumers in Tan Binh	1,200	100.0

[1] Date: July 31, 1992; 1 US$ = 11,300 VND.

Source: *Tran The Thong et al., 1992.*

2. Site Selection and Cropping Systems Analysis of Two Villages: Hung Loc and Ho Nai 4.

Hung Loc village (representative of areas with reddish brown latosols) and Ho Nai 4 village (representative of areas with grey podzolic soils) were selected for more intensive research. Data was collected on soils, climate, number of people and workers in a family, and the present status of agricultural production was analyzed. Further interviews were conducted in 125 households. The analysis of these surveys (**Table 5**) indicate that among 90 households surveyed in Hung Loc village, 47.8% are only-crop growing households, 40% crop-livestock integrated farming households, while 12% are crop-trading-secondary occupation households. The average cassava planting areas occupy 20.1% of the whole cultivated area. Among 30 households surveyed in the Ho Nai 4 commune, 17.7% are only-crop growing households, 17.1% only-processing households and the remaining 65.8% crop-livestock-trading or processing integrated households. The average cassava planting area occupies 81.0% of the whole cultivated area

3. Defining Constraints in Cassava Production and Selecting Key Solutions.

Three major constraints to cassava production at Hung Loc and Ho Nai 4 communes were identified:

-Low price of cassava and unstability of the market
-Varietal degradation and mixture
-Lack of fertilizer supply

The following three key solutions are proposed:

-Using high-yielding, high-starch content new cassava varieties with a 7-12 months growth cycle and a good plant type for intercropping (medium leafiness, late branching and no lodging)
-Growing cassava intercropped with mungbean, peanut and winged bean in order to increase farmers' incomes and improve soil fertility
-Promoting increased cassava household processing and on-farm animal feeding.

Table 5. Cassava intercropping systems used in Hung Loc and Ho Nai 4 villages of Thong Nhat district of Dong Nai province in 1991/1992. Data from 90 respondents in Hung Loc and 35 in Ho Nai 4 villages.

Cropping systems	Hung Loc		Ho Nai	
	No.of respondents[1]	Area (ha)	No.of respondents[1]	Area (ha)
Cassava-based cropping systems	30	28.08	17	18.10
-Cassava monoculture	2	3.95	14	16.90
-Cassava + maize + mungbean	7	7.13	0	0.00
-Cassava + mungbean	7	6.00	0	0.00
-Cassava + maize	6	4.40	0	0.00
-Cassava + cashew	5	3.70	3	1.20
-Cassava + cashew + maize + mungbean	3	2.90	0	0.00
Other cropping systems	**165**	**111.88**	**13**	**4.25**
Total	**195**	**139.96**	**30**	**22.35**
% of cassava-based cropping systems	15.4	20.1	56.7	81.00

[1] Number of respondents using particular cropping system; a number of respondents used 2-3 different cropping systems.

4. Evaluation Trials of New Cassava Varieties and Cassava Intercropping Systems.

From data of nine trials conducted during three years we can conclude that:

a. The best cassava variety for growing both in monoculture or in association with grain legumes is Rayong 60 (the others good varieties are HL-24, CM6125-125 and HL-23) (**Table 6**).

b. The most suitable cultural practices for cassava grown in association with mungbean is: cassava planted at 1.20x0.80 m intercropped with winged bean in the cassava rows and with two mungbean rows between cassava rows; this produced an increase in profit from 25-90% compared to cassava monoculture, and the amounts of mungbean green matter that could be incorporated in the soil was 7.2 to 8.3 t/ha (**Table 7**) (Hoang Kim, 1992).

c. The cropping pattern of two peanut rows grown between cassava/winged bean rows resulted in an increase in profit from 35-85% compared to cassava monoculture, and the amounts of peanut green matter to be incorporated in the soil was 6.6 to 12.5 t/ha (Hoang Kim, 1992).

Table 6. Yield and economic efficiency of various cassava cropping systems with mungbean (M) and winged bean (W) on reddish brown latosols of Hung Loc (Dong Nai province) in 1991.

Treatment[2]	Yield (t/ha)			Total cost ('000 d)	Gross income[1] ('000 d)	Net profit ('000 d)	% of sole crop	Cost effectiveness (%)[3]
	Cassava	Winged bean	Mungbean					
Cassava (Rayong 60)/W+M	31.1	0.43	0.86	3,544	14,841	11,297		319
Cassava (HL-24)/W+M	27.7	0.23	0.85	3,504	13,176	9,672		276
Cassava (CM6125-125)/W+M	31.9	0.34	0.71	3,544	14,398	10,854		306
Cassava (HL-23)/W+M	26.7	0.39	0.71	3,504	12,688	9,184		262
Cassava (Gon)/W+M	24.5	0.31	0.79	3,484	12,020	8,536	143.2	245
Cassava (Gon)+mungbean	24.3	-	0.82	3,260	11,375	8,115	136.1	249
Cassava (Gon) monoculture	24.7	-	-	3,684	8,645	5,961	100.0	222
CV (%)	13.2	8.7	3.2					
LSD (0.05)	1.6	0.1	0.05					

[1] Price at Hung Loc; November 1991: cassava (fresh root) 350 d/kg; winged bean (dry seed) 2,200 d/kg; mungbean (dry seed) 3,500 d/kg. 1 US$ = 9,700 dong.

[2] Cropping pattern: cassava (spacing 1.20x0.80 m)
intercropped with winged bean (spacing 1.20x0.80 mx2 seeds) in the row and
intercropped with 2 mungbean rows (spacing 0.40x0.20 mx2 seeds) between rows.

[3] Cost effectiveness = Net profit x 100/total cost.

Source: *Hoang Kim, 1992.*

Table 7. Biological efficiency and biomass production in various cassava intercropping systems with mungbean (M) and winged bean (W) on a reddish brown latosol in Hung Loc (Dong Nai province) in 1991.

Treatment	LER[1]	ATER[2]	Mungbean biomass yield (t FW/ha)	Amount of nutrients in mungbean biomass incorporated into the soil (kg/ha)[3]		
				N	P_2O_5	K_2O
Cassava (Rayong 60)/W+M			7.8 ab	29.7	7.0	31.5
Cassava (HL-24)/W+M			8.3 a	31.7	7.6	33.5
Cassava (CM6125-125)/W+M			7.2 c	27.5	6.6	29.1
Cassava (HL-23)/W+M			7.2 c	27.5	6.6	29.1
Cassava (Gon)/W+M	1.86	1.32	7.7 bc	29.4	7.0	31.1
Cassava (Gon)+M	1.76	1.20	7.9 ab	30.1	7.2	31.1
Cassava (Gon) monoculture	1.00	1.00				
CV (%)			7.6			
LSD (0.05)			0.5			

[1] LER = Land Equivalent Ratio; Mung bean yield (HL89-E3) monoculture: 1.05 t/ha; winged bean yield (Binh Minh) monoculture: 2.44 t/ha; Mungbean is harvested 2 months after sowing; cassava and winged bean are harvested 7 months after planting.

[2] ATER = Area-Time Equivalent Ratio.

[3] Percent dry matter of mungbean biomass: 20.4 %; concentrations of N, P and K are 1.91, 0.20 and 1.68 %, respectively.

Source: *Hoang Kim, 1992.*

d. The best early, high-yielding mungbean variety, moderately resistant to Yellow Mosaic virus, with green glossy seeds and suitable for growing in both monoculture or in association with cassava is HL-89-E3 (IPBM79-9-82) (the other good varieties are VC3178A, VC2768A, K12230, K12228 and Mo Long Khanh).

e. The best early, high-yielding, big seeded peanut varieties, suitable for monoculture or intercropping with cassava are HL-25 (ICGS-E56) and HL-28 (Lompong) (the other good varieties are Li and Giay).

5. Farmers' Field Trials

In 1991, a field day was organized for farmers and extension workers to harvest and evaluate cassava trials at Hung Loc Center. Farmers and extension workers discussed and then selected cassava varieties for further testing. The results of these farmers' field trials indicate that Rayong 60 was the most promising variety, which should be promoted for general production (**Table 8**).

In 1992, there were 41 on-farm trials on cassava varieties in grey and red soils of the Southeastern region, using the farmers' cultural practices. The results again show that Rayong 60 has a higher fresh root yield than the best local cultivars, HL-23 and HL-20 (**Table 9**).

Table 8. Cassava yields (t/ha) in regional and on-farm trials coordinated by Hung Loc Agricultural Research Center, 1991/1992.

Treatment	Regional trials[1]				On-farm trials[2]						
	a	b	c	d	A	B	C	D	E	F	Av.
Rayong 1	15.0	18.6	19.0	36.5							22.3
Rayong 3					12.3	12.5	13.8	14.2		13.2	13.2
Rayong 60	17.2	18.6	29.5	37.4		16.8			17.4		22.8
CM5257-33				23.5	10.5	12.1	12.1		15.8		14.8
CM6125-117				28.3	14.7	13.7	16.7	16.4	16.7	17.8	17.8
CM6125-125				37.2	17.1	16.2	19.6	18.6	20.0	14.6	20.5
CM6125-129				37.3	15.6	13.4	18.4	15.8	15.4	16.4	18.9
MKUC28-71-66				28.3	16.4	14.6					19.7
HL-23*	18.0	15.3	17.7				12.6	13.7	12.3		14.9
HL-24	13.8	12.2	21.2	26.1	10.5		11.8	14.8	14.5	10.4	15.0
Gon	8.9		14.3	31.3		11.0				8.4	14.8
H-34		13.9									13.9

[1] Extension Centers in
- a. Ho Chi Minh city (Mrs. Nguyen Thi Sam)
- b. Khanh Hoa (Mr. To Van Minh)
- c. Song Be (Mrs. Nguyen Dieu Hong)
- d. Tay Ninh (Ms. Pham Thi La)

[2] A. Mr. Tran Van Lai
- B. Mr. Tran Dan
- C. Mr. Tran Van Tai
- D. Mr. Nguyen Van Thang
- E. Mr. Nguyen Dinh Van
- F. Mr. Truong Van Nguon

Table 9. Results of on-farm trials conducted on grey and red soils of the Southeastern region of Vietnam in 1992.

Varieties	Grey soil[1]		Red soil[2]	
	No.of farmers	Fresh root yield (t/ha)	No.of farmers	Fresh root yield (t/ha)
Rayong 60	21	24.37	10	25.21
CM6125-125	8	25.15	3	24.10
CM4785-29	13	23.98		
CM6125-119	13	23.15		
CM4131-32	7	19.47		
CM6125-117			3	20.96
HL-23	2	23.10	10	19.50
HL-20	19	17.07		

[1] Grey soil: Data from cassava multi-location farmers' field trials (21 hh.x4-5var.x 30 m^2/var.) at Ho Nai 4 village, Thong Nhat district, Dong Nai province.

[2] Red soil: Data from cassava production evaluation trials (10 hh.x2-4var.x 1000 m^2/var.) at Xuan Thanh village, Long Khanh district, Dong Nai province.

CONCLUSIONS

On-farm research and transfer of technology for cassava production in South Vietnam obtained very encouraging preliminary results. The cassava varieties HL-24, HL-23 and HL-20 are now widely used in production. The cropping pattern of cassava intercropped with mungbean, peanut and winged bean obtained satisfactory preliminary results. New cassava varieties introduced from CIAT, particularly the variety Rayong 60, is being tested in multi-location farmers' field trials, and planting material is being multiplied for distribution to farmers. We hope that with the cooperation of the National Root and Tuber Crops Program, as well as the help of CIAT, IDRC, etc. new cassava varieties and better cultivation techniques can be recommended to cassava farmers. This will assist farmers in increasing their income and in improving the fertility of cassava soils.

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THE ROLE OF CASSAVA IN FARMING SYSTEMS OF HILLY AND MOUNTAINOUS AREAS

Dao The Tuan[1]

For the whole country the contribution of cassava to total food crop production is not so high (about 4%), but for the hilly and mountainous areas the role of cassava is very important (25% in hilly area of Vinh Phu and 28% in Son La).

Cassava is a buffer crop in the food crop production system. Rice production and cassava production are inversely related with a coefficient of correlation of -0.405; but, rice production of the previous year and cassava production of the following year are more highly correlated with a coefficient of correlation of -0.852 (P=0.99).

The Agrarian Systems Department of INSA in recent years has conducted research in a number of sites in hilly and mountainous areas of North Vietnam. In Thanh Hoa district of Vinh Phu province cassava occupies 24% and in Cho Don district of Bac Thai province 35% of total food crop production. In these sites we found that cassava plays a very important role in the capital accumulation of farmers households. The following remarks were drawn from the results of a systems analysis of these sites:

1. There is a close relationship between the total income of farm households and the income from pig husbandry and from cassava production.
   - In Cho Don, the correlation coefficient between total income with income from pigs was 0.744 and from cassava 0.652, while between pigs and cassava it was 0.692 (P=0.99).
   - The result of principal component analysis shows that the first component, which explains 38.5% of the variability, is closely correlated with income from pigs and cassava, and only the third component, which explains 13.1% of the variability, is correlated with income from rice.
   - In Thanh Hoa, 55% of the cassava production is utilized for feed, 35% for human consumption and only 14% is commercialized. Farmers consider that it is more efficient to realize income from cassava through pig husbandry. In Cho Don there

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is no trade in cassava.

2. Cassava is a source of capital accumulation of farm households in the hilly area. A study conducted at Thanh Hoa district shows that households could be classified into three groups:
   - Poor households (33%): use cassava as food or sell it in order to buy rice. So the cassava trade in this area plays a small role.
   - Middle income households (24%): use cassava entirely to feed pigs, which is a main source of their income.
   - Rich households (43%) grow cassava more intensively and develop pig husbandry more intensively. They also generate income from coffee and tea plantations.

   The study conducted at Cho Don also shows that:
   - Poor households (5%) produce cassava for human consumption. This group has less access to land, capital and labor.
   - Middle income households (32%) produce cassava for feeding pigs. This group has more land and labor but not much capital.
   - A subgroup of rich households (14%) produce more cassava together with rice and pigs. This group has access to more land and labor as well as capital.

   Both studies show that:

   a - Cassava is the food of the poor.

   b - Cassava is a source of capital accumulation for development of the household economy, mainly through pig husbandry.

3. A field survey showed that there are different types of cassava cultivation:
   - Intensive cultivation in old plantations entirely owned by farmers. These farmers use more inputs and obtain high yields. There is no erosion or yield decrease in this area (15%).
   - Extensive cultivation in new plantations, where land is not yet owned by farmers (rented from the cooperative or newly distributed). Here cassava is grown with few inputs (28%).
   - Shifting cultivation of cassava on fields (common land) borrowed by farmers. There cassava is grown without commercial inputs and after five years the land must be

returned to fallow (28%).

- Temporary cultivation on young tea plantations, with very few inputs (8%). Major constraints in cassava cultivation are lack of farmyard manure and inadequate planting density.

4. The main economic constraint in cassava commercialization is the low price of cassava. The production cost of cassava is about 35-50% of that of paddy. But the price of fresh cassava in the market is only about 40% of that of paddy (in Vietnam we consider that 3 kg of fresh cassava is equivalent to 1 kg of paddy).

Recently, INSA has been trying to introduce cassava processing into the mountainous area in order to increase the income of cassava farmers. But the following constraints were identified:

- lack of labor
- lack of markets

In Cho Don where we introduced cassava processing for human consumption, farmers used the product as feed instead. So, we must reconsider the problem of cassava processing in mountainous areas.

VIETNAMESE CASSAVA CONSTRAINTS AND OPPORTUNITIES: THE BOTTOM LINE

Guy Henry[1], *Le Cong Tru*[2] *and Veronica Gottret*[1]

INTRODUCTION

The Vietnamese cassava benchmark study has had a two-fold objective. First, to characterize all aspects of cassava production, processing, marketing and utilization in the most relevant areas of Vietnam. During the first day of this workshop all the relevant papers on these aspects have been presented to you. Secondly, based on the collected data and complemented by secondary data, to distill the most important constraints and opportunities, for specific regions, at different levels and *vis-a-vis* other crops.

When reviewing other National Program strategies for cassava research (for example, Indonesia) the bulk of the arguments underlying the selection and priorization of the proposed future research topics is based on cassava production constraints analyses. Although very thorough and with much detail, the constraints analyses is not (*per-se*) integrated with an assessment of opportunities for cassava research activities. Opportunities may be found, in growing of the crop in different areas *vis-a-vis* traditional production zones; the development of cassava based products that can well compete with (expensive imported) other raw materials; or the development of rural small-scale *vis-a-vis* semi-urban large-scale processing units. Opportunity analysis is not only limited to research topics, it also includes research collaboration and integration. For example, there may be a significant opportunity of linking cassava processing research with the private sector.

As such, this paper has been divided as follows. First, cassava production constraints are analyzed through production function and factor efficiency analysis. This is followed by a discussion on processing and marketing constraints. Then, all three aspects are compared in an analysis to assess the relative importance of different opportunities in the cassava sector. The paper is concluded by drawing the major bottom lines and a discussion on further issues needed for the strategic cassava research planning

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exercise.

CASSAVA PRODUCTION

In earlier papers in this workshop ample information has been presented on cassava yields and inputs. It has become clear already that there is a wide variation throughout Vietnam. Stratifications by zones, farm size and importance of rice, generated general indications that larger farms and more cassava oriented farmers (with a smaller percentage rice area) obtained relatively higher cassava yields. In this section the earlier qualitative assessment of cassava productivity will be complemented with an in-depth quantitative assessment through a cassava production function analysis.

A common and widely used methodology for the estimation of a production function is the Cobb-Douglas function[3] (Gujarat, 1978; Maddala, 1985). As such, this function has been applied to the Vietnamese survey data. The double logarithmic functional form has proved to be a good fit. However, initial runs demonstrated a significant level of heteroscedasticity. In order to decrease this, a Generalized Least Squares (GLS) procedure was applied by transforming all variables into a "per-hectare" base. As such, the intercept term was deleted. This procedure reduced the level of heteroscedasticity, but the elimination of the intercept artificially increased the R^2 (degree of explanatory power). As such, one must be cautious about the interpretation of these estimates.

The first production function for total Vietnam includes "dummy" variables to investigate the significance of different farm sizes, varieties, color and texture of soils, growing cycle and type of cropping (monoculture vs. intercrop) system. In addition, a "dummy" was introduced for each of the agro-ecological zones. The significance of the results for the latter "dummy" provided an indication for the need to further analyze production functions for each zone. As such, **Tables 1** and **2** show the results for

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[3] In general form the Cobb-Douglas production function may be expressed as:

$Q = \beta o X1i^{\beta 1} . X2i^{\beta 2} . e^{\mu}$

where:

Q = output
βo = intercept, which is a constant representing the average production level
X1i = amount of labor
X2i = amount of other inputs
μ = stochastic disturbance term
e = base of the natural logarithm
$\beta 1$ $\beta 2$ = (partial) elasticities of output with respect to labor and other inputs

Vietnam and for six agro-ecological zones. Since the functional form is a double logarithmic, mathematically the parameter estimates can be interpreted as "partial elasticities".

Table 1 shows that the total Vietnam estimates for land, labor, inorganic nitrogen, tractor use, planting density, growing cycle and farm size, are highly significant. For example, in the case of (total) labor, if one increases labor by 10% this would increase cassava production by 3.67%. The estimate for nitrogen input shows to be significant, but negative. This implies that a further increase in the amount of nitrogen by 10% will decrease cassava production by 0.18%. Although this effect is not large, this shows diminishing marginal returns from additional N-application. This effect will also be demonstrated through the input efficiency analysis in a further section. When comparing the relative importance of the inputs (that are statistically significant), it can be seen that, given that total area remains unchanged, planting density, total labor, growing cycle and tractor use, have the largest effects in order of importance.

While a Vietnam-wide analysis shows the overall general aggregates only, a regional analysis can show much more detail, and from a practical point of view, is more relevant. **Table 1** shows that certain variables, like land, labor and planting density, have a significant and very important effect on cassava production on a regional basis, which is consistent with the Vietnam- wide analysis.

Land

From the relative size of the land parameter estimate we can deduct that land is a major constraining factor to increased production in especially the South Central Coast and the Red River Delta, and to a lesser extent in the Southeastern Region.

Labor

From **Table 1** we can get an impression about the relative significance and importance of total labor. It can be seen that especially in the southern zones, labor has been limiting cassava production. In the North Central Coast and in the Red River Delta the labor parameter estimate is insignificant. As such, it does not seem to have an effect on production, or, in other words, it is not a limiting factor.

However, it is of much more interest to desagregate total labor into different activities. **Table 2** shows this separation. It must be noted that the planting labor activity includes stake selection and preparation. Although on a total labor basis the Red

Table 1. Cassava production function estimates (double-log, Cobb-Douglas) for different regions in Vietnam, 1991.

Variable	Unit	Parameter estimate						
		Total Vietnam	North Mountainous Region	Red River Delta	North Central Coast	South Central Coast	Central Highlands	South-eastern Region
Land	ha	**0.654*****	0.846***	1.366***	0.961*	2.106***	0.632***	0.320**
		(6.58)[1]	(3.18)	(2.80)	(1.35)	(6.67)	(2.11)	(2.55)
Total labor	mdays	**0.367*****	0.224***	0.119	-0.001	0.550***	0.580***	0.547**
		(12.30)	(4.28)	(1.17)	(-0.01)	(6.73)	(7.87)	(8.67)
Inorganic N	kg	**-0.018*****	0.060***	-0.011	0.083**	-0.011	0.166***	0.000
		(-2.03)	(2.49)	(-0.30)	(1.77)	(-0.76)	(2.43)	(0.00)
Inorganic P	kg	**-0.011**	0.040**	0.043**	-0.124***	-0.004		-0.021
		(-1.25)	(1.72)	(1.66)	(-2.86)	(-0.03)		(-1.03)
Inorganic K	kg	**0.016***	-0.079***	0.069***	0.067	0.014		0.005
		(1.37)	(-2.74)	(2.01)	(1.25)	(0.72)		(0.21)
Organic fertilizer	kg	**0.005**	-0.019***	0.015	0.024*	0.014***	-0.001	0.033**
		(1.22)	(-2.23)	(0.56)	(1.41)	(2.00)	(-0.03)	(2.81)
Tractor	days	**0.096*****					-0.015	0.012
		(2.53)					(-0.47)	(0.16)
Animal power	days	**0.014****	0.017*	0.070***	0.010	0.059**	-0.006	-0.066**
		(1.76)	(1.31)	(2.64)	(0.52)	(3.24)	(-0.17)	(-2.39)
Credit	US$	**0.140***						0.135**
		(1.38)						(1.67)
Plant density	#/ha	**0.727*****	0.876***	0.804***	0.889***	0.536***	-0.564***	0.622**
		(39.08)	(28.58)	(11.86)	(9.86)	(11.27)	(14.05)	(17.89)
Growing cycle[2]	dummy	**0.243*****	0.992***		-0.265		-0.456***	
		(2.43)	(7.02)		(-0.65)		(-2.31)	
Monoculture[3]	dummy	**0.030**	-0.158**	0.158	0.080	0.124	-0.141***	-0.059
		(0.69)	(-1.87)	(0.89)	(0.49)	(1.19)	(-1.92)	(-0.77)
Medium farm[4]	dummy	**0.119*****	-0.010	-0.371***	0.131	0.091	0.371***	0.296***
		(3.00)	(-0.16)	(-2.56)	(0.83)	(1.22)	(3.72)	(2.75)
Large farm[4]	dummy	**0.128*****	-0.081	-0.473**	0.151	0.017	0.213***	0.264***
		(2.57)	(-0.85)	(-1.84)	(0.81)	(0.17)	(1.97)	(2.43)
R^2 Adjusted		0.997	0.998	0.997	0.998	0.997	0.999	0.998
F-value		10,106.73	7,181.33	1,736.78	1,671.94	4,256.30	5,989.60	5,170.95

[1] t-values in parethesis;
[2] dummy; base is less than 12 months
[3] dummy; base is cassava intercrop;
[4] dummy; base is small farm (<0.6 ha)
* Significance level between 0.10-0.20;
** Significance level between 0.05-0.10;
*** Significance level less than 0.05.

Table 2. Cassava production function estimates (double-log, Cobb-Douglas) with labor differentiation for different regions in Vietnam, 1991.

	Parameter estimate						
Variable	**Total Vietnam**	North Mountainous Region	Red River Delta	North Central coast	South Central coast	Central Highlands	South-eastern Region
Land preparation	**0.017** **(0.89)**[1]	-0.011 (-0.22)	-0.019 (-0.46)	0.093 (1.14)	0.059 (0.97)	0.099** (2.02)	-0.012 (-0.33)
Planting	**0.102***** **(2.65)**	-0.095* (-1.47)	0.052 (0.41)	-0.095 (-0.72)	0.190** (1.77)	0.042 (0.41)	0.241** (3.26)
Weeding	**0.112***** **(3.97)**	0.131*** (3.09)	0.235** (1.82)	0.031 (0.48)	0.055 (0.65)	0.402*** (2.92)	0.182*** (2.78)
Fertilizer application	**-0.051***** **(-2.82)**	-0.040* (-1.45)	-0.049 (-0.68)	0.069 (1.24)	-0.050 (-0.27)	0.524*** 2.96	-0.042 (-0.98)
Harvesting	**0.096***** **(3.04)**	0.151*** (3.27)	-0.124 (-1.11)	-0.117 (-0.94)	0.177*** (2.34)	0.005 (0.04)	0.094 (0.22)
R^2 Adjusted	**0.997**	0.998	0.997	0.0997	0.997	0.999	0.998
F-value	**8,737.2**	6,194.5	1,413.3	1,437.9	3,356.7	4,437.7	4,141.2

[1] t-values in parentheses.

* Significance level between 0.10-0.20

** Significance level between 0.05-0.10

*** Significance level less than 0.05

River Delta did not show any significance, once labor is desagregated, it shows that weeding has a significant postitive effect on cassava production. A similar effect is shown for the majority of zones. Especially in the Central Highlands, cassava production can be increased by 4% through the increase of weeding labor by 10%.

Labor for land preparation does not seem to be a constraint, except in the case of the Central Highlands where it shows to be significant. This may be explained by the different topographical situation of cassava plots on steep slopes.

Planting labor seems to be a significant and important constraining factor in the Southeastern Region, and to a lesser extent in the South Central Coast (and North Mountainous Region). The highly productive and multiple cropping systems in the Southeast present conflicting labor activity peaks for the different cultivated crops.

Although the results show that harvesting labor in several zones is a limiting factor, some caution needs to be exercised with the interpretation. Although harvesting labor is highly dependent on topography, soil and season (and variety), it is also directly (and linearly) dependent on the amount harvested. As such, it is only logic that harvesting labor increases with increasing yield. Therefore, the direction of causality may not be very obvious here and hence, the interpretation may be not that clear.

Labor for fertilizer application is an important and significant parameter in the case of the Central Highlands. It seems that this follows a similar argument as for land preparation. The application of organic fertilizer (produced at the farm) includes the (difficult) transport to the cassava plots, especially when situated at a higher elevation.

Fertilizer Application

Inorganic (or chemical) fertilizer application has been divided into N (nitrogen), P (phosphorus) and K (potassium) and calculated in terms of amount of the active elements. For the whole of Vietnam, nitrogen has a low but positive and significant effect on production. On a regional basis this also applies for the North Mountainous Region, the North Central Coast and the Central Highlands. The estimate of nitrogen for the latter region proves to be significantly larger than for the other regions.

Although P on a country basis does not prove to have a significant effect, for the North Central Coast it shows to be negative and significant. This can be explained in two ways. Either, cassava farmers apply too much P, or the majority of soils have a high level of P. At any rate, additional phosphorus application in the North Central Coast has a negative effect on cassava production. A similar negative effect is caused by potassium application in the North Mountainous Region, which again may be due to soil characteristics. In addition, in the same region organic fertilizer has a negative effect on production. As such, the analysis indicates that too much organic material is currently being used by cassava farmers in the North Mountainous Region.

Tractor and Animal Power

Tractor use on a country basis has a strong positive and significant effect on cassava production. However, when analyzed by zone this could not be shown. This may be caused by the apparently low tractor use frequency (of observations) by zone.

Animal power is still the most common source for cassava land preparation in Vietnam. It seems to be a constraining factor in the Red River Delta and the South Central Coast.

Cassava Production Credit

The low frequency of credit usage in Vietnamese cassava production has as a result that in this analysis it only enters the Southeastern Region production function and with a low level of significance. It must be deducted from this that in the other zones very little credit is available, which is in line with earlier findings. In addition, farmers' general complaint is that the terms of borrowing money in Vietnam incorporates a lot of risk, given that cassava farm-gate prices fluctuate significantly.

Cassava Cropping System, Plant Density and Growing Cycle

In previous presentations we have been informed that the majority of cassava in Vietnam is cropped in monoculture systems. When this variable was introduced in the production function (as a "dummy"), the results show that in both the North Mountainous Region and the Central Highlands, monoculture had a negative effect on cassava production, when compared with intercropping. Although this ought to be further investigated, it seems that this relates to problems of cultivation on slopy and steep terrain, which may cause soil erosion and other negative (sustainability) effects.

As mentioned earlier, increased plant density has a large and very significant effect throughout Vietnam on cassava production and productivity. Earlier data suggested that the majority (61.6%) of farms plant less than 15,000 plants/ha. A further 20.8% of farmers plant 15,000-20,000 plants/ha. Our current analysis indicates strongly that planting density can be further increased to obtain a higher productivity. Especially in

North Vietnam this will have a significant and large effect.

Another significant explanatory variable in cassava production is "growing cycle". Although the majority of farmers harvest cassava less than 12 months after planting, several provinces have a tradition for a longer cycle. It seems only logic that this will increase production. However, this may not be the most efficient utilization of the land resource *vis-a-vis* other crops and the opportunity cost of the land itself.

Other explanatory variables

As mentioned before, a range of dummy variables where introduced in the production function to test for relative differences. The dummy variables that have not been discussed are for cassava variety, texture and soil color. Regarding varieties, the results show that (compared to the most frequently used variety in each zone) several varieties have a significantly different, and both positive and negative, effect on cassava production. A more in-depth further analysis will be of much use to show cassava breeders the potential that certain varieties have to increase productivity in specific zones. However, caution must be exercised with this type of information, since farmers may not (always) consider "high yield" as the most important factor in their decision-making process regarding their cassava varieties' port-folio.

Cassava Production Factor Efficiency Analysis

In the proceeding production function analysis the focus was on productivity in terms of yield and therefore the output per unit of land and the explanatory power of different parameters. In this section an analysis will be discussed that focuses on the economically efficient use of factors of cassava production. As such, prices and costs are introduced into the analysis.

The methodology is straightforward. From the production function analysis, the parameter estimates are used as production input elasticities, that, together with average input quantities and prices, generate values for marginal product, marginal revenue, marginal cost and marginal benefit for a 10% (arbitrarily chosen) increase in each input usage. In addition, for production factors other than labor and land, observations were stratified by current "users" and "non-users" (of the input). The analysis was conducted at the country and at the regional level.

Table 3 shows the summarized results. For easy interpretation, all negative values imply that an additional 10% input usage result in a net beneficial loss. *Vice versa*, all positive values indicate a net gain in benefits (expressed in US$/ha). As with the production function analysis, the results vary significantly across regions. Except for the South Central Coast and the North Central Coast all regions show significant economic gains from additional weeding.

As was already alluded to in the previous section, the Central Highlands have a major labor constraint for fertilizer application. Here, the results show that with a 10% additional labor input, benefits can be increased by US$13.23/ha. In addition, most labor activities, such as planting, weeding and harvesting, will have a significant economic potential to be increased in the Southeastern Region.

When looking at the marginal benefits from land, it can be noted that additional land in most zones has a big potential to increase cassava farmers' income. On the average, this is the input with the highest pay-off. However, it is very obvious that in Vietnam, land, and especially prime agricultural land, is a highly scarce good. **Table 3** shows clearly that additional land for cassava production in the southern provinces has a relatively lesser economic pay-off than in the northern regions. The most important reason here is the relative higher price of land and its relative higher scarcity in the South. Especially in the Southeast, land prices (rent) are high.

As explained earlier, other factors of cassava production, like fertilizer and animal/tractor power have been stratified by user vs. non-user. If we compare these two groups, it becomes apparent that, in general and for most zones, non-users will benefit much more from additional (from zero) input usage than those farmers that already are using the inputs. Also, the results imply that the current users, for several inputs and for most zones, are using the inputs in an inefficient manner. Additional usage will often result in significant economic losses.

With the results of this efficiency analysis it must be noted that regarding additional inputs, such as fertilizer or hired labor, which require capital, credit becomes a major issue. Also, the opportunity cost of capital to be invested in other crops, cassava processing or other activities, becomes important. In addition, as was discussed before, the availability and the terms for credit are a major constraint for the, in general, risk-averse small cassava farmers.

Table 3. Efficiency analysis of additional factor usage for cassava production in Vietnam, 1991.

	Marginal benefits (US$/ha) from 10% increase in factor indicated						
		North	Red North	South			South-
	Total	Mountainous	River	Central	Central	Central	eastern
Factors	Vietnam	Region	Delta Coast	Coast	Highlands	Region	
1. Labor							
-Land preparation	-1.16	-2.33	-2.18	1.80	-0.75	-0.05	-1.18
-Planting	1.25	-7.01	-0.31	-7.41	0.83	-0.38	4.34
-Weeding	0.47	3.76	5.56	-0.46	-2.58	6.32	1.63
-Fertilizing	-1.97	-2.39	-2.86	2.92	-1.08	13.23	-1.08
-Harvesting	0.22	4.47	-7.47	-9.63	-0.35	-2.55	0.54
2. Land	17.01	40.95	42.97	45.79	21.41	14.42	6.64
3a. Other Production Factors - in case of non-users							
-Inorg N	-0.53	3.01	-0.37	4.21	-0.12	4.20	-0.002
-Inorg P	-0.33	2.00	1.51	-6.34	-0.01		-0.51
-Inorg K	0.48	-3.94	2.03	3.41	0.15		0.13
-Organic	0.16	-0.95	0.54	1.25	0.15	-0.07	0.77
-Tractor	2.81					-0.43	0.25
-Animal power	0.40	0.85	2.43	0.53	0.62	-0.16	-1.57
3b. Other Production Factors - in case of users							
-Inorg N	-9.98	0.65	-5.24	2.43	-23.20	0.23	-2.98
-Inorg P	-6.21	0.60	-5.55	-7.80	-13.12		-1.94
-Inorg K	-4.61	-5.47	-2.60	0.25	-10.41		-2.73
-Organic	-2.56	-1.23	-0.52	1.08	-1.18	-0.45	-3.20
-Tractor	1.05					-4.15	-1.24
-Animal power	-1.45	-0.86	0.77	-1.14	-1.82	-5.24	-2.87

Efficiency Sensitivity Analysis

Both prices and yields of cassava fluctuate in time and across regions and provinces. However, both the production function and factor efficiency analysis were conducted based on 1991 survey data. As such, this is only a "snap-shot" in time, which does not incorporate any price or quantity changes. Also, in Vietnam in general, 1991 cassava yields were (relative to previous years) high, and farm-gate prices were subsequently low. In order to investigate the sensitivity of our efficiency analysis results to price fluctuations, a simple two-scenario sensitivity analysis was conducted on the effect of higher cassava farm-gate prices.

As such, the same efficiency model was run with scenario (1) 50% increase in average cassava farm-gate price; and (2) 100% increase in price. Although the results will not be shown here, it can be concluded that:

- In general, the sign of the marginal benefits do not change. This is, what before was a beneficial loss did not change into a beneficial gain, for both scenarios.
- However, the magnitude of the marginal benefits do change. Positive marginal benefits become higher and marginal losses become lower (but still losses in general).

Hence, it may be concluded that although a substantial increase in the cassava farm-gate price does have an effect on additional cassava production factor utilization regarding marginal benefits, it does not change the relative outcomes on losses vs. gains, but it does have an effect on the absolute magnitudes of losses and gains.

CASSAVA PROCESSING

Depending on the type of cassava product and the specific region, cassava (rural) processors see a range of constraining factors to cassava processing. These include: raw material supply, product quality, market organization, market demand and labor and capital availability. Although the importance of the different constraints vary significantly, some constraints are clearly common denominators across regions and products. These are in order of relative importance (1) supply of raw material (which includes price); (2) product quality; and (3) market organization.

The most important constraint, supply of raw materials, is a common denominator for cassava processors in many different countries, including Indonesia, Thailand, Brazil, Colombia and Ecuador. The causes for raw material (roots) supply fluctuations are various, but seasonal production, short harvesting period, root perishability, and the range of cassava processed products and their respective demand are in most countries the major factors causing root supply fluctuations. Also for Vietnam do these factors apply to the cause of root supplies' instability. In a later section on marketing constraints this will be discussed again.

The second most important constraint, product quality, is also an important constraint in many other cassava processing countries. Much of this has to do with the usage of old traditional processing technologies and small-scale operation. Sub-optimal product quality is of importance in two different ways. First, poor quality is oftentimes both technically and economically inefficient. Besides low conversion rates which increase production costs, poor quality products demand a lower price in the market. As such, poor technology levels punishes the processor twice, and lowers his benefits substantially.

Secondly, sub-optimal product quality limits the potential for the product's utilization in alternative markets. The potential of a cassava processed product to a large extent depends on two factors: intrinsic product characteristics and relative cost price. As such, low quality lowers the potential for alternative markets on two accounts. Hence, low product quality indirectly has a negative effect on cassava processed products demand, which in various regions is also experienced as a limiting factor.

The third most important constraint is market organization. To a major extent this incorporates two causal factors. First of all, the distance to final markets and the organization of the marketing channel are both of prime importance. On-farm or village level processing in isolated mountain areas implies that products will be either consumed (or further processed) locally or in the region, or products will enter the market channels to other provinces or even countries. Inefficient marketing systems and underdeveloped distribution networks will cause relatively large marketing margins, unstable demand, and fluctuating prices. Secondly, the volume of the processed product and its relative share of the market throughout the year has important implications of market efficiency and effective distribution systems. Relatively large volumes of more important products will, in theory, enjoy scale economics, lower marketing margins, and more efficient and effective distribution systems.

Cassava Product Opportunities

So far, we have discussed several constraints that were expressed by cassava processors to be most limiting to their activity. Now, we will turn to discuss several opportunities for the cassava processing sector. As was discussed earlier in the socio-economics paper(Binh *et al.*, this Proceedings), there exist a large (absolute) difference and variance between costs and benefits of different cassava processed products. The data suggest that as cassava is being further processed and subsequently more value is added, larger benefits are being made. However, this does not imply that the suggestion would be that since, for example, maltose production generates the highest benefits, all processors should turn to maltose production. What first need to be assessed is the current and potential demand for different cassava-based products. Although an in-depth analysis of market potential goes beyond the (resources and) objectives of this paper, the assembled data would suggest the following:

The potential of cassava-based products to a large extent is based on the ability to (partially) substitute other products as a result of price or quality/characteristics advantages. Market potential may be regional, domestic or even international. In addition, a time perspective can be introduced since a cassava product may have a seasonal advantage. As such, the potential of cassava products needs to be assessed *vis-a-vis* the products that it can partially substitute.

1. Coarse (feed) grains: Currently, cassava chips, lower quality flour, wet starch and starch processing by-products are commercially utilized in animal feed rations. To a large extent these products partially substitute for rice (by-products) and maize (to a lesser extent) in poultry and pig rations. As was shown in an earlier paper, cassava flour (at 1991 prices) in several southern provinces enjoyed a 25-60% cost price advantage for the partial substitution of rice bran in pig feed rations, including 15% cassava flour. As such it seems that cassava products have a significant potential for utilization in animal feed rations. Given the fact that with an increasing Vietnamese economic development, *per capita* consumption of meat products (especially poultry and pork) and eggs will increase over time, future demand for cassava products for this usage seems promising. However, this depends to a large extent on price developments of the substituting products like rice (bran).

Although Vietnam has been exporting cassava chips to the EC, China, Cambodia, etc. this may not be a vary stable or sustainable demand. Especially the EC-export quota, at a preferred price rate, may erode in the future. Although cassava production costs in several Vietnamese provinces may be competitive with Thailand (at times), Thai processing and export infrastructures generate large-scale economies, implying h efficiency and effectiveness. In addition, Thai product quality (steam pressed pellets) is much superior to the Vietnamese (native chip) product.

2. <u>Food grains (rice, wheat)</u>: Since rice has traditionally been the most important crop grown in Vietnam, it has been utilized in several processed forms as alcohol, flour, starch etc. Given the very favorable rice/cassava ratio, depending on its intrinsic characteristic, cassava can substitute many of the product uses for rice. Currently, we see cassava partial substitution in many rice flour and starch based products, such as noodles and bakery products. Product development activities and market studies can further develop the potential demand for increased and additional cassava substitution, based on its cost-price advantage.

French colonial traditions have left a significant importance of "French bread" as a common ingredient in the Vietnamese diet, especially in the (semi) urban areas. However, the wheat for this product is imported at a high cost. Already, INSA has started experiments on cassava flour utilization in "French bread" (Nghiem, 1992). Further investigation on cassava/wheat substitution and product testing may offer a significant opportunity to strengthen cassava demand, lower consumer prices of bread, and at the same time lower the significant social costs of wheat imports.

3. <u>Other substitutes</u>: Cassava flour and starch are currently being utilized for several industrial purposes, such as alcohol, glue, textiles, paper and paint. However, little information exists at this point on the potential demand from these industries (for more information on this topic see Ha *et al.*, this Proceedings).

Besides domestic substitution with cassava-based products, cassava starch has a current demand from foreign (Asian) markets, as mentioned in the marketing analysis of the socio-economics paper. This only includes the highest quality (Type I) starch. Although little data exists on volumes and prices of cassava starch exports, there is scratchy evidence that (at 1991 prices) Vietnam can compete with other Asian cassava starch producers in foreign (mostly other Asian) markets. However, prices, quality, and volumes vary greatly, which effects the sustainability of this demand potential. In addition, infrastructure and organization of export agencies are still poorly developed, which decreases considerably the efficiency and effectiveness to export. However, there seem to be opportunities for improvement here and subsequent improved export potential of Vietnamese cassava starch.

CASSAVA (PRODUCTS) MARKETING

Constraints to cassava product marketing have been discussed already in a previous paper (Binh *et al.*, this Proceedings). As such, it suffices to summarize these here:

- It is relatively easy to conclude that cassava, in comparison with sugarcane, rice, potato or sweet potato, has a extremely complicated marketing system, due to its large variety of intermediate and final (processed) products. In addition, production and consumption areas differ significantly by product and process.
- In the majority of marketing channels the number of pricing points (middlemen) is rather high, although the marketing margins do not seem to be too high. This points to some inefficiency. Typically, marketing margins in urban areas are significantly higher than in rural areas.
- An obvious lack of local and regional (frequent) public price information offers intermediaries opportunities to make sizeable profits. In addition, product supplies and demands are not in equilibrium. This has a negative effect in large price fluctuations and market inefficiencies, which is a cost for producers, processors and consumers.
- Official (vs. smuggled) exports loose a relative cost edge due to lack of updated (world) price information, various taxes, and trading inefficiencies. If all cassava product exports would be traded under a "free market" system, inefficiencies should be reduced.
- Theoretically, the large portfolio of cassava products for different end products and markets should make the overall cassava market relatively stable. However, the lack of price (and volume) information results in market inefficiencies. The alleviation of this constraint could make several cassava-based products more competitive, which subsequently will strengthen demand.

THE BOTTOM LINE: OPPORTUNITIES FOR CASSAVA RESEARCH

In the previous sections we have presented the major current constraining factors of the Vietnamese cassava sector, which were distilled from the various analyses of cassava production, productivity, processing and marketing aspects. The majority of the data was generated within the Vietnamese Cassava Benchmark Study. This study has produced much more data and in more detail than was presented so far. However, the general identification of constraints and opportunities will suffice for the purpose of this Workshop, that is, to present sufficient information to identify and discuss the future cassava research agenda and the prioritization of different research areas. At a later stage, the available data can be further analyzed to generate more detailed information for specific regional research recommendations that are needed for research project implementations.

For each of the different levels of the cassava sector the most important constraints and opportunities have been identified. One of the main issues that now needs to be discussed is which research activities will have a higher probability for technology adoption and impact, in order to assign relative priorities for research resources allocation. As such, in this final section we will analyze research opportunities in cassava production, processing and marketing, regarding relative pay-offs.

In order to discuss relative impacts of cassava research, the national Vietnamese cassava R & D goal needs to be well-identified. For the sake of this discussion the (highly probable) assumption is made that the objective of Vietnamese cassava R & D is to increase both social and economic benefits to the cassava sector, while trying to minimize adverse effects on the natural resource base. More specifically, we assume that our target beneficiaries include cassava producers, processors and consumers (or utilizers).

Given this objective, we have to analyze different research activities for their relative expected impact potential on the target audience. One way to make this comparison is to look at the price-column of cassava (products) which include production, processing and marketing. In **Figure 1** two price columns for cassava flour and starch are shown. They include on-farm processing, semi-urban processing and the urban wholesale market. From this we can learn that raw material makes up some 42-50% of total wholesale price and processing and marketing margins represent 36-47% and 11-14%, respectively. Although this is a rather rough and simplistic analysis it shows the potential for technology impact. In addition it shows the importance of processing in relation to production. Also, marketing margins do not represent a large share of the basic price column for these products. However, the latter may increase depending on distance to markets, destination, etc.

From improved production technology, a 10% increase in yields and/or decrease in costs will be able to decrease (theoretically) raw material cost share to the final wholesale price by 5%. Improved processing technology, for example on dry chip and starch conversion rates from 33% to 40% and from 20 to 30%, respectively, can decrease the processing cost share to an equal amount. This indicates that cassava production and processing technologies both have a large potential in decreasing consumer prices.

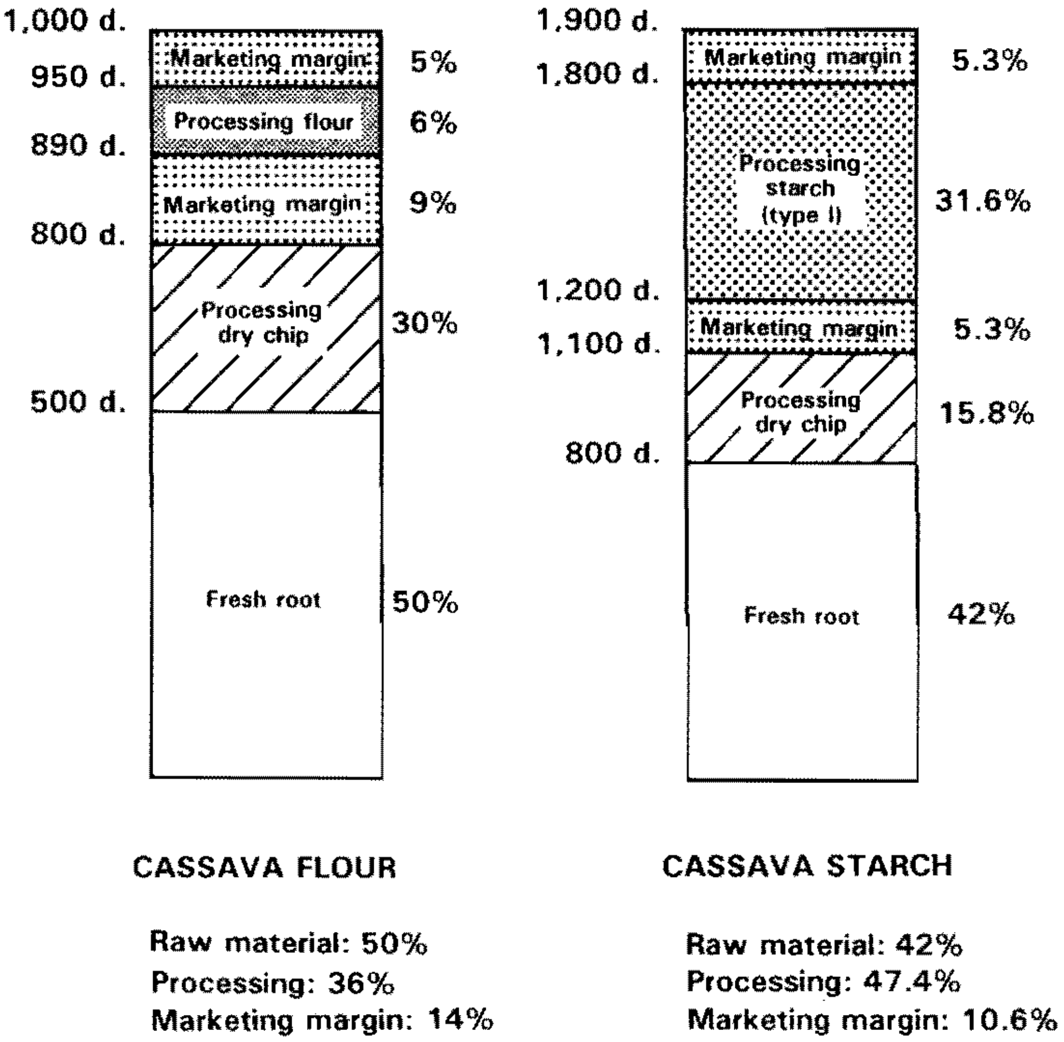

Figure 1. Cassava flour and starch price columns (farm to processor to city) in South Vietnam, 1992 (Vietnamese dong/kg of end product).

Another issue that arises is that processing scales and levels of technology differ. One can assume that larger-scale processing factories, using better technologies, have better conversion rates than household or village level processing. As such, the potential to improved processing technologies at the small-scale level is much larger. In addition, rural processing improvement has significantly more social benefits. Also, the further development of rural small-scale "agro-industries" will improve (urban employment and) rural incomes, which will increase demand for urban goods and services. As such, processing technologies targeted at the small-scale rural level have a strong effect on overall economic development.

Research on cassava production and processing technologies can not be individual activities. As discussed before, on-farm demand is strongly related to processing, marketing and market demand. Reduced processing costs, more efficient marketing and alternative product markets translate back to the farm as more stable prices, stronger demand and reduced marketing risk. This situation creates an incentive for the farmer to demand improved production technologies and results in increased cassava plantings.

In this paper we have identified constraints and opportunities. In addition, it was demonstrated that besides production, processing, product development, marketing shows a significant potential for research impact (to a lesser extent).

This information will serve research and political decision makers in defining the portfolio of future research activities and their relative priorities for resource allocation. Once this has been decided, decision makers have to analyze how current cassava research activities are prioritized *vis-a-vis* the newly identified agenda. This will probably lead to the re-organization of the research agenda in terms of different issues, different zones and different disciplines. This understanding will lead to identifying in-house resources and subsequent projects for additional (outside) funding.

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GENERAL CONCLUSIONS AND RECOMMENDATIONS

During the final discussion session the following conclusions were agreed upon:

1. Cassava plays an important socio-economic role as a secondary crop in Vietnam. In the North the crop is an important source of food and feed at the household level; in the South mainly as a source of cash income. In the South cassava is predominantly used as a raw material for processing into a wide range of products, both at the household and small-scale processor level, generating employment in the rural sector.
2. Over the last ten years total area of secondary food crops has decreased, especially for sweet potato and cassava, while the maize area increased.
3. Cassava area has declined in the last decade because of its relatively low profitability, low demand, price fluctuations and marketing problems.
4. From 1980 to 1990 cassava area decreased across all zones at an annual rate of 5.65%; however, the decrease was relatively less in mountainous areas than in the more fertile lowlands. In 1991, however, total area increased again slightly. Across zones, cassava yields increased, especially in the Red River Delta and the Southeastern Region.
5. Cassava farmers responded that market related aspects (profitability, demand and price fluctuations) are the major production constraints. Soil fertility problems are also important.
6. Cassava yield has potential to increase through the introduction of improved varieties, appropriate fertilizer use, and improved management (especially labor).
7. There exists a potential demand for cassava in the following areas of utilization: (1) animal feed at the household level, especially for the poorer sector of the rural population; (2) animal feed (dry) in the form of feed concentrates; and (3) starch and starch-derived products. The size of the demand in these areas of utilization need to be quantified.
8. Processing is constrained, especially by raw material supply fluctuations and quality. Potential for processing technology is significant.
9. Cassava product marketing efficiency can be significantly improved by better information (price) systems and the management of marketing systems.

The following recommendations were presented:

1. The present emphasis on research in the areas of varietal improvement and crop

management should be maintained given the significant contribution that the adoption of appropriate production technologies will have on productivity and costs.

2. Research on cassava processing and marketing needs significantly more attention and this research should be integrated with production research.
3. In order to better understand the future demand potential of cassava processed products and thus better target the research focus, additional demand studies need to be conducted.
4. Aforementioned studies should be first conducted before the long-term research program planning can be finalized.
5. The role and influence of government policies need to be analyzed in light of the future role of cassava (products).
6. Several questions on organizational structure and research comparitive advantages of collaborating institutions need to be addressed.
7. Similarities of demand for other roots and tubers need to be assessed, so as to include those in future demand studies.
8. The survey results need to be critically evaluated by local experts (validation) and must be further analyzed for district levels. On some aspects, questionable results need to be verified and if necessary corrected.
9. More information is needed on the role of cassava in animal production to increase farmers' income potential.
10. The link between cassava research and extension need to be further strengthened.
12. In the future, more emphasis needs to be placed (besides on yield increase) on the preservation of the natural resource base in cassava production systems.

APPENDIX

THE CIAT CASSAVA PROGRAM IN THE 1990s

Rupert Best[1]

Cassava research strategies must be formulated in the light of changes in the various environments, which, to a greater or lesser extent, influence the role that the crop may play in contributing to meet specific economic and social development goals. Government policies, trade balances and foreign debt pressures influence the market potential of the crop. The changing scope of international agricultural research--which has been broadened to encompass not only food supply but also income generation and a greater concern for the environment--also has to be taken into account. Finally,the relative strengths and weaknesses of national program partners and the level of interest shown by advanced research laboratories are key factors in determining an appropriate research strategy for the coming decade.

In the following sections, a short assessment will be made of cassava's socio-economic and political environment by reevaluating cassava's demand potential, as analyzed in 1987, in the light of current conditions. This will be followed by a brief statement on cassava in the context of the evolution of the CGIAR[2] and on the perceived institutional environment within which international cassava research will take place.

I. Cassava's Socio-economic and Political Environment

1. Latin America

In the Americas the trend of decreasing cassava production during the 1970s and early 1980s has gradually changed into one of slow growth in the late 80s. FAO data show that during the period 1985-90 cassava production increased by 9.6%, from 29.6 million t to 33.7 million t (**Table 1**). Brazil, Paraguay and Colombia--which together represent 92% of total cassava production on the continent--have all experienced production growth.

In Brazil the removal of government wheat subsidies in 1988 has increased wheat flour prices to above those of farinha, and this has likely influenced the stabilization of

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[1] CIAT Cassava Program, Cali, Colombia.

[2] Consultative Group on International Agric. Research.

Table 1. World cassava production (million t).

	1985	1986	1987	1988	1989	1990	Annual growth rate (%)
World	**136.6**	**133.6**	**136.8**	**141.3**	**148.6**	**150.0**	**2.34**
Africa	**58.2**	**58.6**	**58.4**	**59.6**	**62.9**	**64.1**	**2.04**
Ghana	3.1	2.9	2.7	2.8	3.3	3.0	0.95
Madagascar	2.1	2.4	2.2	2.2	2.3	2.3	0.93
Mozambique	3.2	3.3	3.4	3.2	3.5	3.6	2.01
Nigeria	13.5	14.7	14.0	15.0	16.5	17.6	4.97
Tanzania	6.8	6.2	6.0	6.1	6.2	5.5	-2.98
Uganda	2.7	1.9	2.8	2.5	3.1	3.2	6.30
Zaire	15.5	16.2	16.2	16.3	16.4	17.0	1.44
Asia	**48.5**	**42.7**	**47.6**	**52.3**	**54.1**	**52.0**	**3.29**
China	3.6	3.5	3.3	3.3	3.2	3.2	-2.45
India	5.7	4.9	4.8	5.4	4.5	4.6	-3.46
Indonesia	14.0	13.3	14.3	15.5	17.1	16.3	4.56
Philippines	1.7	1.7	1.8	1.8	1.8	1.9	2.08
Thailand	19.3	15.2	19.5	22.3	23.5	21.9	5.92
Vietnam	2.9	2.8	2.7	2.8	2.9	3.0	0.89
Latin America	**29.6**	**32.1**	**30.6**	**29.2**	**31.4**	**33.7**	**1.53**
Brazil	23.1	25.6	23.5	21.7	23.4	25.4	0.35
Colombia	1.4	1.3	1.3	1.3	1.5	1.7	4.00
Paraguay	2.9	2.9	3.5	3.9	4.0	4.0	7.60

Source: *FAO Production Yearbooks.*

cassava production. The increased cassava production in Paraguay is based on traditional usage, i.e. human consumption and on-farm animal feeding. Besides population growth, reasons for production increases in Colombia include increased consumption resulting from improved incomes (off-setting to a certain degree the negative effect that urbanization has on cassava consumption). In addition, the increasing importance of dried cassava for the animal feed industry has provided a new market outlet and stabilized prices. The demand for and adoption of improved cassava production technologies has been an important factor in increasing yields. Relative to several competing starchy products such as maize and potatoes, cassava retail prices have been relatively lower, which has led to increased consumption, especially among the urban poor. This phenomenon has occurred exclusively in those areas where there has been a strong adoption of cassava drying technology. In other regions of Colombia, cassava prices have increased relative to its substitutes in the diet.

The demand for meats, which remained strong in Latin America during the last decade, is expected to remain buoyant for the coming decade, especially for poultry. Consequently, the derived demand for feed grains will follow similar trends, although course grain production has shown a downward trend. Animal feed stuffs are generally supplied through increasingly costly imports, which will have an even greater effect on diminishing trade surpluses. Hence, the demand for feed grain substitutes such as cassava will continue to have great potential.

Government policies indirectly affecting cassava's comparative advantage to substitute food and feed grains have been under strong pressure within the import liberation philosophy that many countries are currently following. Transportation subsidies, support prices and input price subsidies for the major grains are being lowered in several countries. This will indirectly favor the potential demand for cassava in alternative markets, thereby strengthening traditional demand. Thus the premise formulated in 1987, that alternative cassava markets, such as the animal feed industry, showed great potential in strengthening traditional demand, remains valid.

Besides the animal feed market, cassava continues to be a strong price competitor for imported starches, principally maize. From the late 1980s onward, cassava starch has started to penetrate markets for industrial usage in Colombia and Ecuador. A similar trend can be envisaged for cassava flour as a substitute for wheat flours in bakery products, soups, processed meats, etc.

2. Asia

In Asia strong industrial growth has been the major factor behind overall economic growth and development. The agricultural sector has not remained behind during the last decade. The self-sufficiency philosophy has continued to boost production of primary crops.

Cassava production in Asia rose from 48.5 million t in 1985 to 52.0 million t in 1990--almost 1.5% above the annual population growth rate. The largest increases have taken place in Thailand and Indonesia, the two major Asian cassava-growing countries (**Table 1**). The Thai cassava industry used to be largely based on the export of cassava pellets to the EC. During the mid 1980s, it was predicted that the imposition of quotas by the EC would put a ceiling on this growth market. Nevertheless, Thailand's comparative cost price advantage has made it possible to make heavy inroads into other export markets in Asia, Eastern Europe and the USSR. Thai cassava exports have experienced a continued annual growth rate of 7% from 1985-90 (**Table 2**). The last five years have also seen an increase in cassava starch manufacture, with the Japanese investing in plants for producing modified starches and other starch-derived products.

Table 2. World trade in cassava[1] ('000 t).

	1985	1986	1987	1988	1989	1990	Annual growth rate 1985-90 (%)
World exports	8,130	7,600	7,900	10,050	11,930	10,200	7.79
Thailand	7,410	6,760	6,572	8,580	10,340	8,945	7.09
Indonesia	600	425	783	1,086	1,200	1,000	17.13
China	100	280	340	320	200	180	5.34
Vietnam	-	50	40	20	150	30	3.00
Others	20	85	165	44	40	45	1.35
World imports	9,000	7,840	7,900	10,440	11,950	10,200	6.20
EC	6,730	6,225	6,990	7,025	6,982	6,000	-0.60
China (Taiwan)	470	265	192	500	960	900	23.05
Japan	650	370	215	600	650	500	4.00
Korea Rep. of	240	260	138	40	930	900	32.80
USA	70	70	72	75	260	245	29.26
USSR	-	-	-	988	861	750	-13.87
Others	840	650	293	852	1,307	905	10.10

[1] Includes pellets, "native" pellets and dry cassava chips.
Source: *FAO.*

Although export volumes from Indonesia are only one tenth of those from Thailand, the former has experienced an even stronger growth (17.1%) during this period. The reported decline in cassava production in China is not substantiated by local figures, which report a significant increase. In fact, China and Vietnam together are seen as having a high potential for cassava development given the gradual liberalizing of their economies. The situation of cassava in India will depend largely upon government policies toward competing crops. The decline observed over the past five years is almost entirely due to the subsidized replacement of cassava by rubber in Kerala and very favorable policies that maintain rice prices low. Nevertheless, there are some indications that cassava production is expanding in non-traditional growing regions, where it will be used as a raw material for industrial purposes.

Government agricultural policies have always played an important role for cassava in Asia. Historically, policies have been oriented toward boosting primary commodity production (rice); however, during the last few years, several Asian governments have been lifting such policies. Fertilizer subsidies and support prices have been decreased in countries such as Indonesia and Vietnam, directly affecting production costs and market prices for high input-dependent crops such as rice. Consequently, low input-dependent crops such as cassava have become more price competitive. This is leading to an increased demand for cassava products to substitute for rice, maize and wheat in processed products for human consumption and in animal feeds.

3. Africa

Cassava production in Africa increased from 58.2 million t in 1985 to 64.1 million t in 1990, a growth rate of 2% yearly. The most significant increase in production was recorded by Uganda, with a growth rate of 6.3% yearly. In Nigeria the ban on wheat imports has been a stimulus to cassava production, which went from 13.5 million t in 1985 to 17.6 million t in 1990 (**Table 1**).

The results of the COSCA[3] study will provide a much clearer picture of the demand potential for cassava in Africa. It is, however, safe to predict that cassava will continue to play its role as a major food-security crop. The rapidly urbanizing environment will present new demands as cassava makes the transition from a food staple to a carbohydrate source with multiple end uses.

II. Cassava Within the Context of International Agricultural Research

The CGIAR is in the process of undertaking radical changes with respect to its objectives, scope and role. Since its founding in the early 1970s, priority setting has evolved from being based purely on food production potential to include income- and employment-generating opportunities and the long-term sustainability of agricultural production. What was essentially a system that provided improved genetic materials and associated management practices to national programs is now diversifying, both in terms of its mandated commodities and its research focus. New commodities, such as fisheries and forestry, have been included in the portfolio, and an increasingly greater proportion of activities will be oriented toward resource management research. This general trend

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[3] Collaborative Study of Cassava in Africa.

has been wholeheartedly embraced by CIAT, with plans for the 1990s to "...move assertively to combine commodity and resource management into an integrated systems approach in its efforts to increase food production and economic growth without jeopardizing the national resource base..."[4]

Within the changing context of international agricultural research, where does cassava stand? The above has demonstrated the importance of the crop in providing food for millions of people in developing countries and described some of the advances being made to overcome the principal production and utilization constraints. The integrated cassava projects established in Latin America have highlighted the tremendous potential that the crop has for income and employment generation in some of the most marginal areas of the tropics through the integration of small-scale agriculture with more comprehensive forms of productive rural development, including postharvest processing and other rural service activities. Cassava is therefore undoubtedly a crop that can significantly contribute to alleviating hunger and poverty--the goal of the CGIAR system. Both internal CIAT analysis (Janssen *et al.*, 1991) and recent TAC[5] priorities and strategies documents support this view, the latter ranking cassava among the top ten commodities in terms of priority, and indicating that roots and tubers have been underfunded with respect to other groups of commodities such as cereals and food legumes. This is in marked contrast to the situation eight years ago when a reduction in investment in cassava research at the international level was seriously considered.

In light of evident overall donor fatigue, the broadened scope of activities contemplated by the CGIAR system in general, and CIAT in particular, means that core resources available for cassava research at CIAT will decline slightly over the next ten years unless the CGIAR sees fit to make shifts in resource allocation among its mandated commodities in line with TAC's latest priority assessment.

III. The Institutional Environment

National Cassava Research and Development Systems

The strength of national cassava R&D systems is highly variable; at the present

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[4] in "CIAT in the 1990s and Beyond: A Strategic Plan".

[5] Technical Advisory Committee of the CGIAR.

time, with the exception of Thailand and India in Asia and Brazil in Latin America[6], none of the countries has the capacity to conduct R&D activities across the whole spectrum of basic, strategic, applied and adaptive research.

Latin America: With the exception of Brazil, the national cassava research programs in the Americas are relatively weak and poorly funded. Few non-government institutions are involved in cassava-related research activities. The importance of cassava as a vehicle for promoting rural welfare was first recognized by development agencies and associated extension services. During the 1980s these institutions became the principal counterparts of the Cassava Program in the endeavor to link resource-poor cassava farmers to expanding markets. The interinstitutional model that was subsequently developed to integrate cassava production, processing and marketing activities in specific cassava-growing regions has provided a framework for:

- financing research activities within a development context
- linking research and extension activities oriented toward resolving the most immediate problems of the cassava farmer
- identifying, through feedback, priorities for longer term research

The fact that there is an almost total absence of postharvest research within the national programs has led to the need for identifying nonconventional partners with whom to interact. Experiences in Colombia, Ecuador and more recently Brazil, suggest that second-order farmer organizations may have an important role to play in the future.

In the medium term, the Cassava Program's partners in Latin America will continue to be a range of institutions from both the public and private sectors. Public cassava research programs are likely to remain underfunded, although opportunities do exist for financing research activities through integrated cassava projects.

Asia: The major cassava-producing countries in Asia have competent cassava research programs that vary in size, depending upon the relative importance of cassava, and that include both official and private institutions (e.g. universities). Research does cover both production and post-harvest processing aspects, either within the same institute or among

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[6] This discussion excludes national programs in Africa, where IITA has responsibility.

various separate institutions. Interaction and complementarity among institutions and groups working in the same country are sometimes lacking. The Cassava Program has interacted principally with those institutions involved in production research; but, although links between research and extension obviously do exist, it would appear that they are not organized in such a way as to permit a flow of feedback information on the constraints to adoption of improved production components. This aspect requires attention so as to improve technology design criteria.

IITA

The overwhelming importance of cassava in Africa determines that a significant proportion of the resources allocated to international research on the crop must be dedicated to relieving constraints to improved cassava production and utilization on that continent. In the past, collaboration between IITA and CIAT scientists has clearly demonstrated the contribution that CIAT's Cassava Program, located in the center of origin of the crop, can make in this regard. With the inevitable tightening of core resources for commodity research, the need for the Centers to complement each other's work will become greater in order to make the most efficient and effective use of the available human and financial resources.

Advanced Research Institutions

Cassava's status as an "orphan" crop in terms of research interest in advanced laboratories in both developed and developing countries is slowly changing. It is expected that the formal organization of the Cassava Biotechnology Network (CBN) will greatly enhance that interest and attract additional donor funds for new initiatives. The Cassava Program has an important role to play within the CBN in ensuring that the efforts of advanced laboratories are directed toward those problems whose resolution will bring direct benefits to small-scale cassava farmers.

Cassava Program Strategies in the 1990s

The strategies of the Cassava Program formulated five years ago were based on the experience accumulated by the Program since its inception in 1973 and on the results of the demand studies. These strategies have produced tangible results, both in terms of technology generation and institutional cooperation. Since the cassava demand situation today is as least as favorable as it was five years ago, it is felt that these basic strategies will remain valid through the 90s. However, the afore-mentioned changes that have occurred in the external environment will require modifications in emphasis and reprioritization of activities. In the 1990s the Program will continue to promote the consolidation and integration of national cassava R&D systems in Latin America and Asia and to facilitate linkages between these systems and institutes undertaking advanced research on cassava through the CBN. Closer collaboration will be sought with IITA to help meet the needs of African programs. While maintaining a commodity-system perspective, the Program will emphasize germplasm resource development. Crop management, utilization and market research will concentrate on strategic issues of global importance. Applied research in these areas will be gradually devolved to national organizations, with horizontal cooperation encouraged among countries at the regional level. The Program will focus on crop management research for the subhumid, semiarid and subtropical ecosystems of the Americas and Asia, interacting closely with CIAT's new Resource Management Research Division on hillside, savanna and forest margin ecosystems, where an estimated 25-30% of cassava is produced in Latin America.

The goal, objectives and an overview of the Program's activities contemplated for the period 1992-2002 are described in "CIAT in the 1990s and Beyond: A Strategic Plan" **Table 3** summarizes the expected outputs and impact of the four specific objectives that will be pursued by the Program during this period. The key areas of activity can be grouped as follows:

- Building the knowledge base
- Development of component technologies
- Regional collaboration

These activities are briefly described below.

1. Building the knowledge base

This area of activity generates widely applicable basic knowledge about cassava that can be subsequently employed to develop component production and utilization technologies. Now that the most critical constraints to cassava production and utilization have been better defined, emphasis will be placed on expanding the knowledge of those crop characteristics that may be manipulated to relieve those constraints. Among the activities to be undertaken are:

- More precise characterization of cassava and wild *Manihot* spp. including agronomic, biochemical and molecular traits

Table 3. Outputs and impact of the Cassava Program.

Objective	Output	Impact	Assumptions
1. Improve productivity and yield stability of cassava genetically 2. Develop crop management practices for sustainable cassava production in selected ecosystems 3. Improve cassava quality for diverse end uses	- High-yielding parental materials tolerant of biotic and abiotic stresses and with desirable quality characteristics for specific end uses - Technology for the commercial production of cassava, using true seed - Principles and technology components for the design of cassava-based cropping systems, emphasizing: ● soil fertility maintenance ● soil conservation ● integrated pest and disease management - Consumer-acceptable cassava-based products	- Increased overall cassava production, stability and quality - Economically and environmentally sustainable cassava production, especially under adverse edapho-climatic conditions - Increased incomes for the rural population in cassava-growing regions - Increased market potential for cassava and cassava-based products - Cheaper cassava for direct and indirect human consumption in urban areas	- Continued and increasing interest in cassava research by advanced laboratories - Adequate funding for cassava research at the international level - Commitment of national governments to invest in the development of marginal areas where cassava is a principal crop - Government policies that are not biased in favor of competing carbohydrate sources
4. Strengthen national cassava R&D systems	- Trained national program personnel - Regional cassava R&D networks - Integrated cassava production, processing and marketing projects	- More effective and integrated national systems	- Minimum investment in cassava R&D at the national level

- Development of improved screening methods for root quality (HCN, starch and eating quality), drought tolerance and nutrient-use efficiency
- Manipulation of the unique cassava photosynthetic system
- Research into mechanisms of resistance/tolerance to drought and to pests and diseases

2. Development of component technologies

Sound knowledge of the crop and the environments in which it is grown is the basis for developing component technologies. Work will be carried out in three areas: genetic improvement, crop management, and utilization and marketing research.

Genetic improvement: The aim is to provide national programs in the Americas and Asia, as well as IITA in Africa, with basic and improved germplasm. Progressive incorporation of molecular tools and support methodologies resulting from activities developed by the CBN will be sought. Activities will include:

- Development of broadly based gene pools targeted to regional needs with subdivisions for high and low HCN and an additional gene pool for the semiarid tropics
- Basic genetic and breeding methodology research
- Exploratory research on true cassava seed production alternatives.

Crop management: Research and development of research methodologies in this area will be undertaken at specific, but representative sites in close collaboration with national programs in Latin America and Asia. Emphasis will be placed on subhumid, semiarid and subtropical ecosystems, while providing support to the Resource Management Research Division in hillside, savanna and forest margin ecosystems. Comparative studies across ecosystems will generate greater understanding of the interactions among plant growth, the physical and biological environment and the socio-economic factors that determine management practices, thereby providing a sounder basis on which to design improved technology components. Activities will cover:

- Development of soil fertility management and erosion control practices
- Integrated pest and disease management, emphasizing root-rot pathogens, the chinch bug and dry season pests such as mites, mealybugs and whiteflies
- Rotation and mixed cropping of cassava with other species
- Integration of soil fertility, crop protection and cropping systems research

Utilization and market research: The Program's core resources dedicated to this area will be reduced as research on quality-related activities is increased. Links already established with developed country institutions (e.g. NRI in London and CEEMAT in Montpelier) will be maintained through hosting of visiting scientists to work on process and product development issues of mutual interest. The principal activities will cover:

- Identification of appropriate national institutions with which to undertake and integrate market, processing and product research
- Continued development of appropriate cassava flour and starch-processing technology.

3. Regional collaboration

The consolidation and vertical integration of national cassava R&D systems remains a prime objective, which will be achieved through collaborative projects, regional networks and training. The aim will be to devolve applied research activities to national systems wherever possible, and through regional networks identify opportunities for horizontal collaboration among countries. With the support of the Institutional Development Support Program, activities will encompass:

- Better targeted and more relevant information exchange
- In-service, discipline-oriented training in conventional and advanced research techniques
- Development of appropriate cassava seed-supply systems to facilitate the adoption of improved varieties
- Support for *ex-ante* and *ex-post* analyses of adoption and impact of technology components to facilitate priority setting at national and Cassava Program levels
- Transitory intensification of efforts to improve skills of national personnel in technology transfer (training of trainers), problem and opportunity diagnosis, cassava research methods, and the conceptualization, formulation, execution and evaluation of integrated cassava projects.

Program Organization and Resource Allocation

The basic structure of the CIAT Cassava Program will remain the same, with a critical mass of headquarter-based scientists undertaking strategic and applied research of global significance, an Asian regional office in Bangkok, and a CIAT/IITA scientist stationed at IITA.

The annual core budget for the Cassava Program (excluding resources allocated to the research support units for cassava-related activities) are projected to decrease from their present level of US$2.504 million (1991) to US$2.446 million in 1996. This budget reduction will require a continuous process of assessing priorities and reorienting activities. The Program will progressively move towards a system of resource allocation by objectives as a means of facilitating priority setting and increasing flexibility.

Complementary Activities

Special project funds will be sought to finance a number of activities in support of the foregoing core activities (**Table 4**). The budget required to fund these initiatives varies between US$1.078 million and US$2.124 million/year.

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Janssen, W., L.R. Sanint, L. Rivas and G. Henry. 1991. CIAT's Commodity Portfolio Revisited: Indicators of Present and Future Importance. CIAT in the 1990s and Beyond: A Strategic Plan, Supplement. pp. 15-50.

Table 4. Complementary activities.

Genetic improvement	Collection, characterization and evaluation of germplasm for semiarid and subtropical ecosystems and the development of improved gene pools for these environments. Decentralized activities will be based at CNPMF (semiarid) EMPASC (subtropical), Brazil (5 years).
Soil fertility and conservation	Research on the basic mechanisms controlling nutrient-use efficiency in cassava and identification of plant characteristics related to nutrient use that may be employed as selection criteria for cassava improvement. Development of appropriate soil fertility maintenance and erosion control measures. Focus will be on hillside, subhumid and semiarid ecosystems (5 years).
Cassava integrated pest diseases management	Research with IITA on the implementation of integrated management of the IPDM, including diagnosis of farmers'pest control practices, augmentation and conservation of natural enemies, classical biological control, and effect of cropping systems on pest populations (5 years).
Cassava Biotechnology Network (CBN)	Joint coordination with the BRU and research institution members of the CBN to identify new initiatives in cassava-related biotechnology (5 years).
Cassava propagation from true seed	Overall coordination of interdisciplinary research, with emphasis on biotechnological techniques, to define an appropriate genetic structure for cassava propagation from true seed (5 years).
Africa - Germplasm	Joint project with IITA for the introduction and evaluation of germplasm, adapted to mid-altitude and seasonally dry environments, from homologous areas in the Americas (5 years).
Asia - Socioeconomic research	Establishment of a regional macroeconomic database for ongoing evaluation of the dynamics of cassava development in Asia and promotion of farm-level research to determine the effectiveness of new production technology (3 years).
Asia - Utilization and marketing	Joint activity with the Centro Internacional de la Papa (CIP) to establish a regional information exchange network and define regional research priorities and opportunities for horizontal cooperation (3 years).
Integrated cassava projects in tropical America	Transfer of knowledge to national programs on project conceptualization, design, execution and evaluation, together with preparation of training materials and guidelines for R&D personnel working on projects (3 years).

TWENTY YEARS OF CASSAVA VARIETAL IMPROVEMENT FOR YIELD AND ADAPTATION - PROCESS OF CIAT COLLABORATION WITH NATIONAL PROGRAMS

Kazuo Kawano[1]

ABSTRACT

The CIAT Cassava Breeding Program was established with the major objective of providing improved breeding materials based on world-wide germplasm variability for national breeding programs in the world. During the first ten years of activity, a highly significant improvement in the yielding capacity of breeding populations through upgraded harvest index was attained, as well as simultaneous improvement in resistances to major diseases and pests and tolerance to acid soils. While efforts to further improve the breeding materials to the specific needs of national programs continued at CIAT headquarters in Colombia, the Thai-CIAT breeding program, established in 1983 as a collaboration among the Department of Agriculture, Kasetsart University and CIAT, has further upgraded the yielding capacity of breeding populations through enhanced total bio-mass and dry matter content, without losing the adaptation of local germplasm to the semi-arid lowland tropical climate. The resulting materials proved to be highly promising in the semi-arid lowland tropics of Thailand and South Vietnam, as well as in the wet lowland tropics of Indonesia and Malaysia. Initial results suggest that these materials offer good selection opportunities also in the sub-tropics of South China and North Vietnam.

Through the systematic transfers of elite clones and selected hybrid seeds, both from CIAT headquarters and from the Thai-CIAT program, thousands of advanced genotypes have been transfered to Asian national programs. From this collaborative work, sixteen CIAT-related cultivars have been released by the national programs in Asia up to 1992 and several of them are now planted in tens of thousands of hectares generating economic effects in the order of millions of dollars.

CASSAVA IN THE DEVELOPING WORLD

Cassava is by far the most important root crop in the tropics in terms of fresh weight production (**Figure 1**). Since the dry matter content of cassava roots is generally higher than that of sweet potato and much higher than that of potato, the importance of cassava is more pronounced when the yields of major tropical root crops are measured

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in terms of calories produced. The production of cassava has increased steadily and substantially during the past two decades (**Figure 1**), suggesting that cassava is not only as important as it always has been, but is also playing an increasingly crucial role in the future of the developing world. For this reason, CIAT decided to take worldwide responsibility for collection, evaluation, conservation, improvement and distribution of cassava germplasm in the beginning of the 1970s.

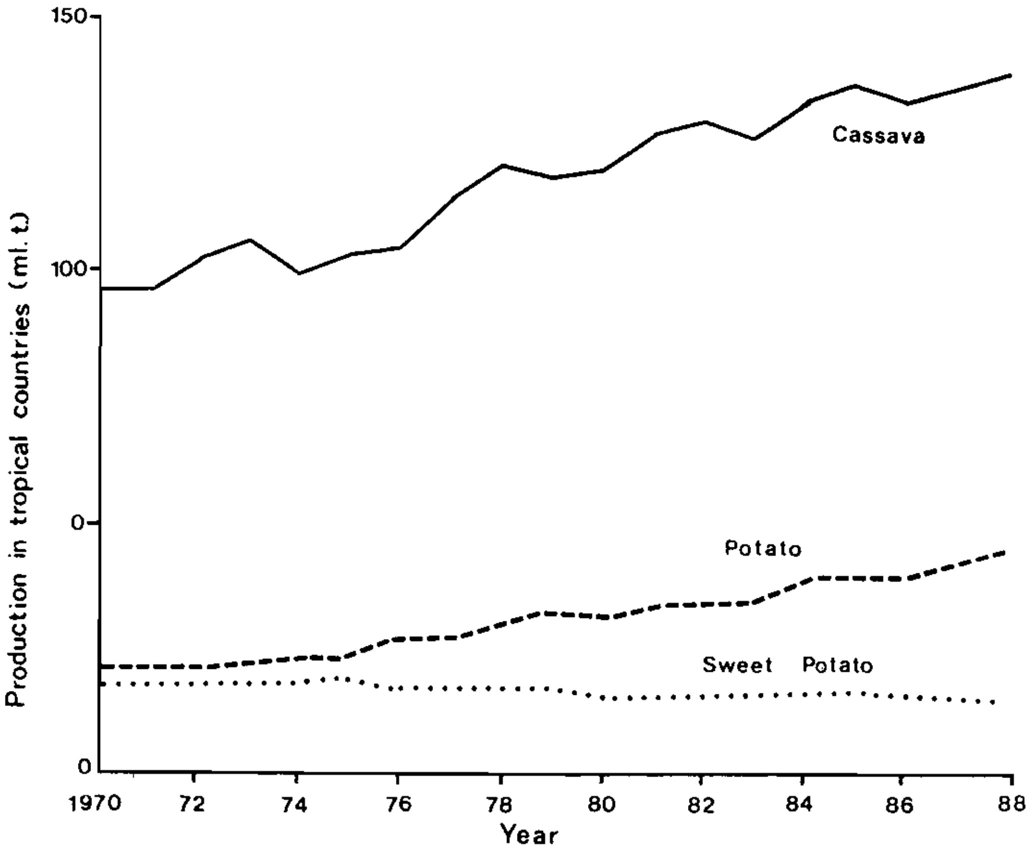


Figure 1. Change in production of major root crops in the tropics.

Cassava originated in tropical America and was transfered first to Africa during the Great Navigation era and then to Asia. Up until the end of the 1960s, Africa and Latin America were the major producers of cassava; however, during the past two decades the Asian cassava production share has increased remarkably and now claims a major share of the world production, together with Africa (**Figure 2**).

In Asia, cassava production for direct or semi-direct human consumption is decreasing. It is the cassava production for animal feed, starch and other industrial processing that has expanded very rapidly and has far offset the decrease in human consumption. Yet, in Asia, as well as in other parts of the world, the great majority of cassava production is managed by small farmers, who usually conduct their production on poor soils without irrigation. It is for this mass of small farmers, who are facing the changing role of cassava production from human consumption to industrial processing, that new, more efficient cassava production technology is most needed.

The productivity of cassava is currently low, especially compared with the experimental high yields of 70 t/ha/year, or the large-scale commercial high yields of 35 t/ha/year, which can be attained by planting improved genotypes under adequate cultural environments. Nevertheless, the average productivity in Asia has been steadily improving in the past decades, while it has been stagnant or decreasing in the other continents (**Figure 3**), suggesting that there are more positive factors for adopting new technology in the immediate future in Asia, while the gap between the present level and the ultimate potential is still very wide in every continent.

Cassava Breeding Research in the World

Cassava is the only major crop whose production does not take place in developed countries in the temperate region, and accordingly, cassava had been virtually unknown to the agricultural research community of the developed countries until recently. Mainly due to its image as a poor man's food produced by poor farmers, cassava had also been largely neglected by the research community of the tropical countries until the end of the 1960s. During that period, cassava varietal research in national programs was not much more than small-scale collections and the evaluation of local germplasm. There were a few exceptions, such as the cassava research program in Campinas, Brasil, or in Trivandrum, India.

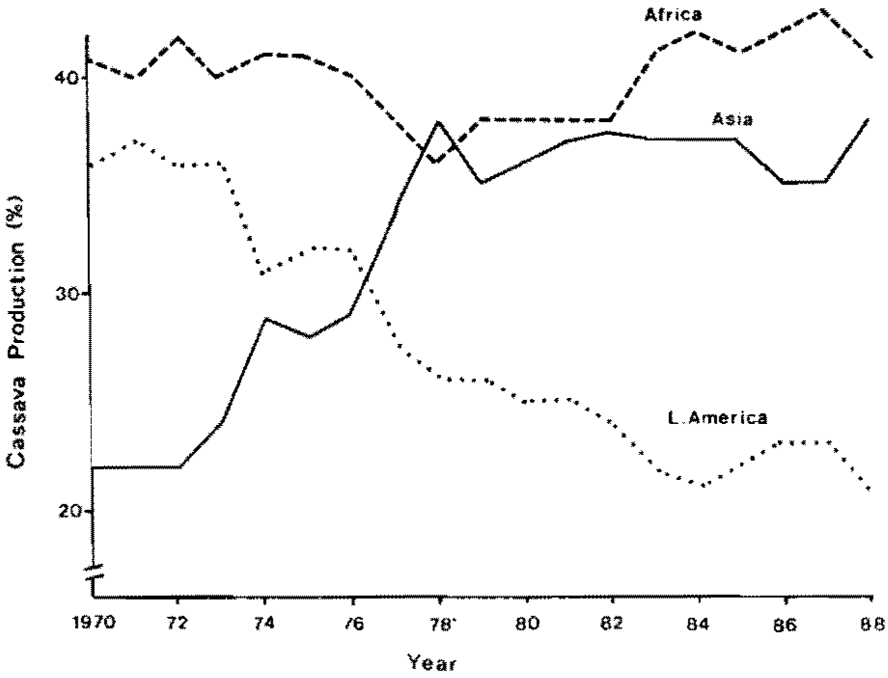


Figure 2. Change in share of cassava production by continents.

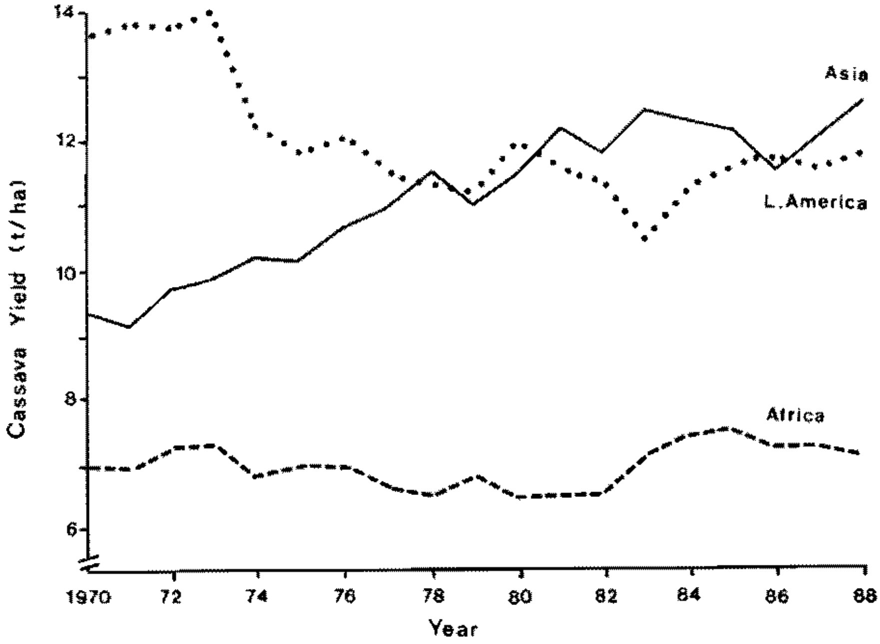


Figure 3. Change in yield of cassava in three continents.

With the establishment of cassava programs at CIAT in Colombia and at IITA (International Institute for Tropical Agriculture) in Nigeria in the early 1970s, national cassava research programs have been created or strengthened in many cassava growing countries. The CIAT cassava breeding program has the mandate to conserve the global germplasm and to generate breeding materials for Latin America and Asia, while the IITA program does the same for Africa. The final selection and release of recommendable cultivars are primarily the responsibility of national programs.

CIAT CASSAVA BREEDING PROGRAM

The collection of cassava germplasm started in 1969, mainly with materials from the American tropics, its center of origin and diversification. Since then, additional collections have been made in Africa and Asia and the germplasm bank at CIAT has now grown to include 5035 accessions at the end of 1991. This gene bank at CIAT, Colombia, is presently the backbone of global cassava breeding and will continue to be so in the future.

The CIAT cassava breeding activities can be described in the following three categories: basic research, generation of breeding materials and adaptive selection (**Figure 4**). What is commonly called bio-technology is the main component of the basic research. The generation of basic and advanced breeding materials and their distribution to national programs has been the most important responsibility of the CIAT cassava breeding program during the past 20 years and will continue to be so in the future as well. It is hoped that each national program produces its own breeding materials; yet, there are still many national programs which cannot effectively produce breeding materials on their own. Besides, the scale advantage of CIAT in producing broadly-based breeding materials will not decrease in the future either. Increasing numbers of national programs are now capable of conducting adaptive selection and varietal release. On the other hand, there are still many national programs where the breeding work cannot be effectively conducted without CIAT collaboration.

I joined CIAT to start the cassava breeding program in 1973; I have been engaged in the generation of breeding materials for ten years in Colombia and then moved to Thailand in 1983 to start the CIAT Asian Cassava Breeding Program in collaboration with the Field Crops Research Institute, Department of Agriculture, and with Kasetsart University to generate breeding materials suitable to Asian conditions, as well as to collaborate more directly with Asian national programs in varietal development.

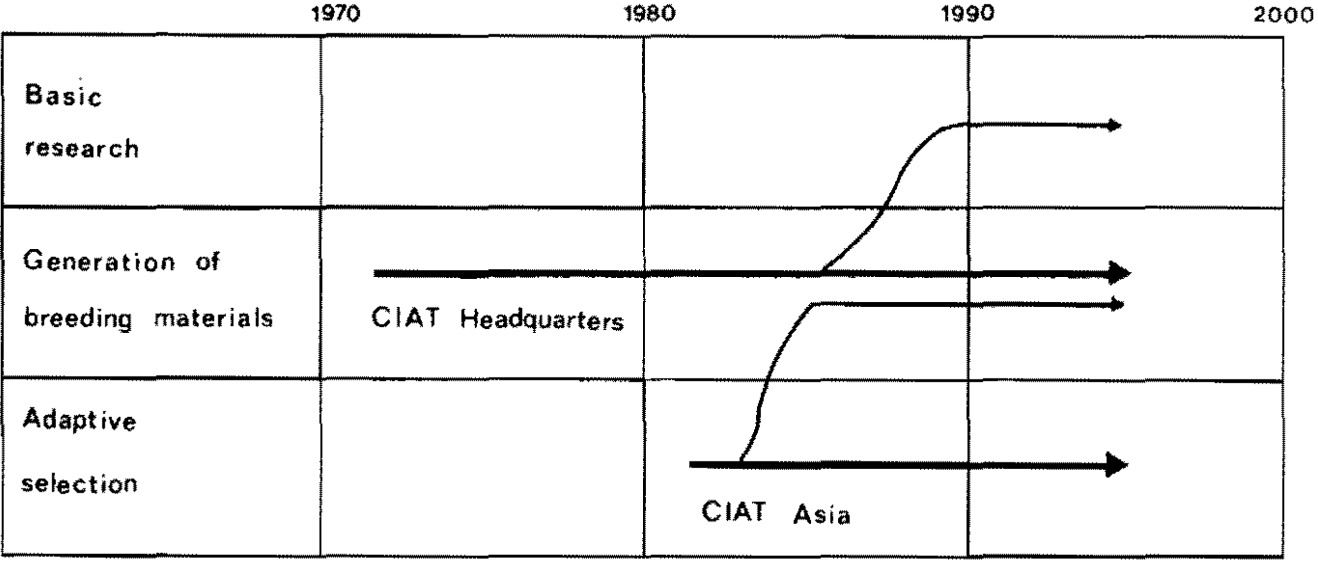


Figure 4. Evolution of CIAT cassava breeding research by three categories.

Generation of Basic Breeding Materials at CIAT, Colombia

1. Broad genetic base

The breeding work started at CIAT headquarters in 1973 with the evaluation of 2500 germplasm accessions collected from all over Latin America, and the formation of hybrid populations based on these accessions followed soon thereafter. To have started the breeding population with highly variable "untouched" germplasm accessions, without centering on "established" genotypes, guaranteed a broad genetic base, which in retrospect, was very significant in the success of the breeding generations to follow.

2. Improvement of yielding capacity under a high yielding environment

The Cauca Valley in Colombia, where CIAT headquarters is located, is characterized by fertile soils, moderate temperature fluctuations, and a well-distributed rainfall pattern. Cassava grew well and produced high yields, without being threatened by major diseases and pests, at least in the early years. While this environment was not very representative of major cassava growing areas and was not suitable for selecting practical cultivars, it offered the advantage of being able to deal with physiological yield capacity *per se* without being confounded with other yield reducing factors.

Observing the mean yields of the original population (planted in 1973), the first selected population (1974), and the hybrid populations thereafter (1975 onward), in which cycles of parental selection, hybridization and clonal selection were practiced, we can detect that a significant yield improvement had taken place (**Figure 5**). Relative to the yield of the control genotypes, the mean yield of the breeding population improved by nearly 100% in ten years compared with the mean yield of the original population in 1973.

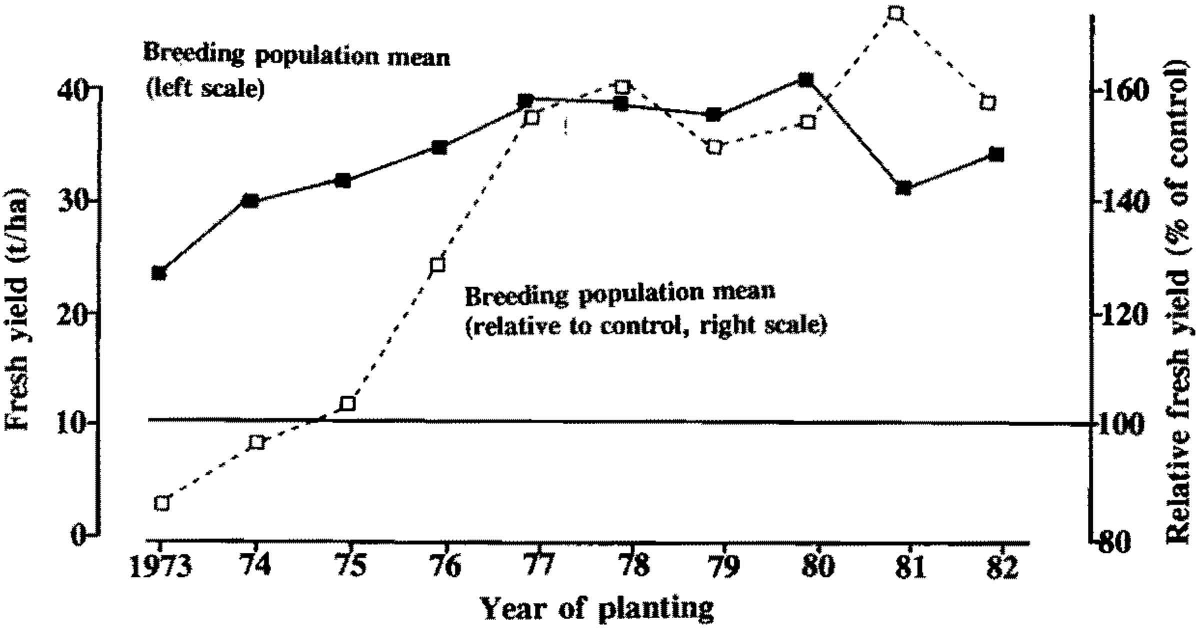


Figure 5. Change in mean yield of breeding population (all entry mean) at CIAT/Colombia HQ.

Viewing the yield improvement through its components, bio-mass (total plant weight) and harvest index (proportion of root weight to total plant weight, HI), the mean biomass of the breeding population increased by 15-20% and the mean harvest index improved by approximately 80% (**Figure 6**). Thus, the upgraded HI of the whole breeding population was the major component of yield improvement during the first ten years of the CIAT cassava breeding program. Virtually any breeder's population provided by CIAT these days is endowed with a significantly higher HI than unselected populations.

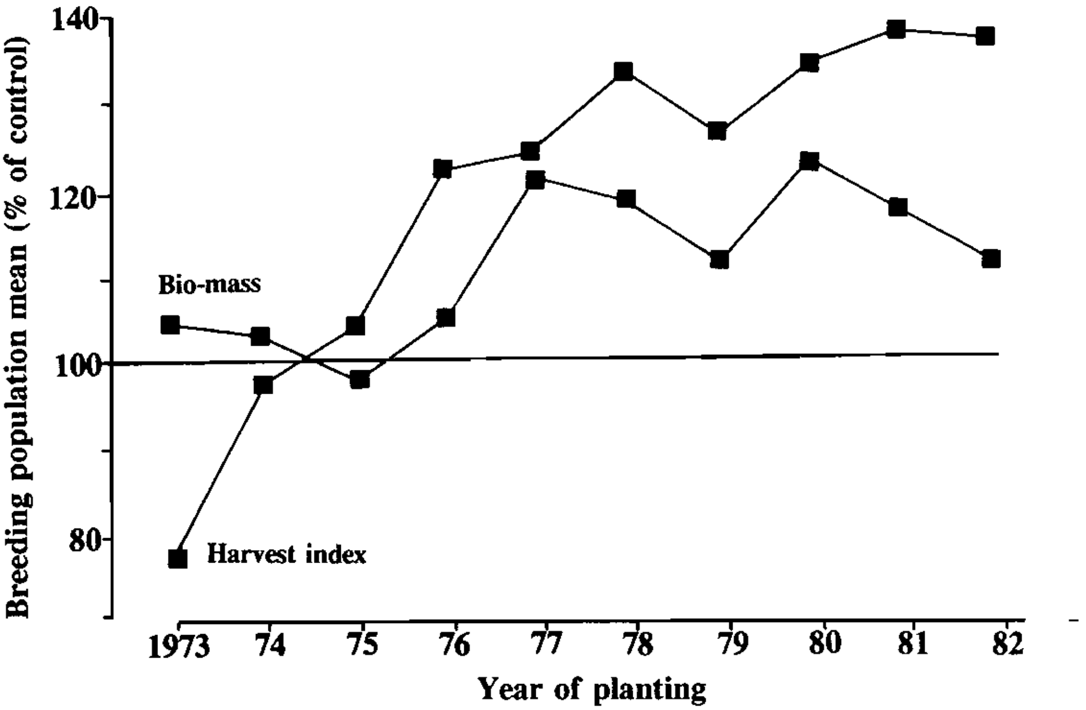


Figure 6. Change in mean harvest index and bio-mass of breeding population (all entry mean) at CIAT/Colombia HQ.

Adaptation to High Stress Environments

Since cassava is generally grown on poor soils without irrigation or application of fertilizers and pesticides, adaptability to high-stress and low-input environments is invariably required for recommendable cultivars. For its extremely high disease and pest incidence and its acid, poor soils, the Carimagua Research Station, located in the Llanos Orientales of Colombia, was chosen as the main evaluation/selection site for adaptation to-high stress environments and the evaluation of the same breeding population was started there in 1974. During the ten years thereafter, highly significant improvements of the breeding population took place in terms of resistance to numerous diseases and pests, as well as in terms of tolerance to poor, acid soils. The mean yield of the original population in 1974 was extremely low, but after several cycles of selection, the mean yield of the breeding population improved significantly (**Figure 7**).

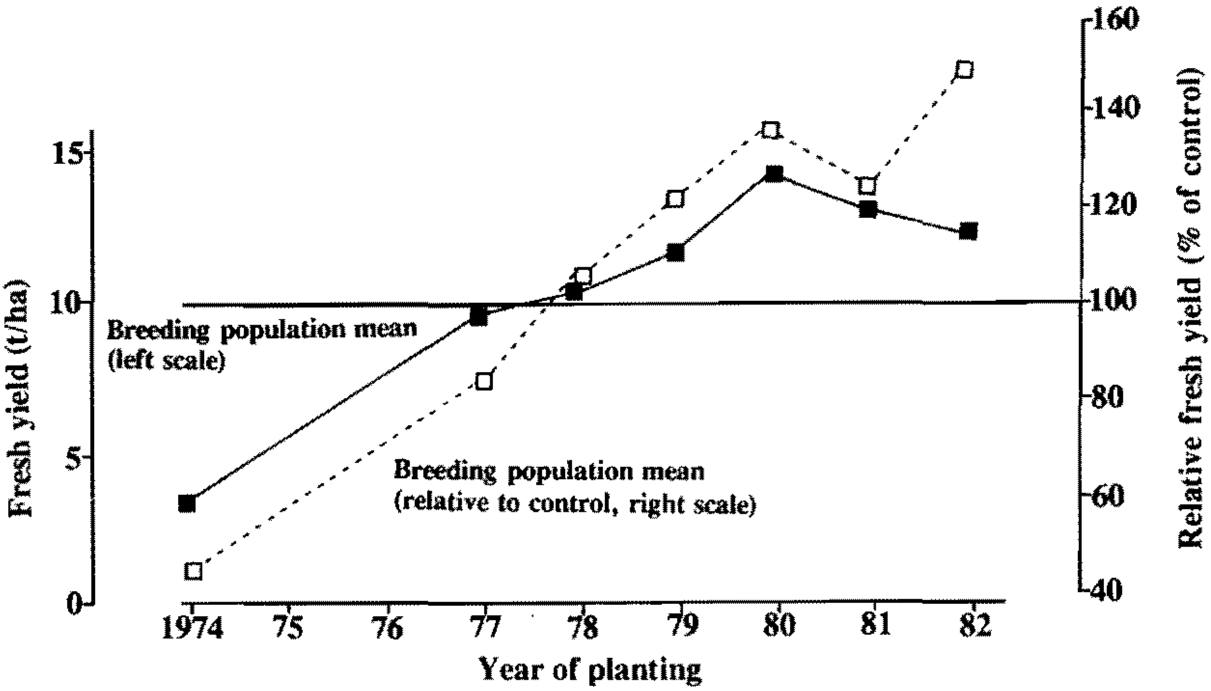


Figure 7. Change in mean fresh yield of breeding population (all entry mean) at Carimagua, CIAT/Colombia.

Especially noteworthy is the improved resistances to two major diseases, i.e. Cassava Bacterial Blight (CBB) and a fungus disease called Superelongation (SE). Research that was conducted simultaneously on these diseases revealed that accumulation of polygenic field resistance was the most effective measure for minimizing the damage caused by these diseases. The original unselected population of 1974 was predominantly susceptible to these two diseáses. But, the majority of the clonal entries in the advanced population of 1982 were resistant. Resistant genotypes thus identified continue to be resistant up to the present. Some of these were later released as commercial cultivars and many of these are still used as cross parents.

During the 1980s, the headquarters breeding program expanded its selection sites encompassing other representative cassava growing environments, so that the CIAT breeding materials could meet more specific requirements of each national program.

Generation of Advanced Breeding Materials for Asia at CIAT, Thailand

With the warm support from the Thai government we established the Thai - CIAT collaborative breeding program, by joining the existing cassava research program at the Rayong Field Crops Research Center, Field Crops Research Institute of the Department of Agriculture in 1983; the cassava research program at Sriracha Research Station of Kasetsart University also joined this scheme soon after. While varietal improvement for Thai cassava production is the primary task of this joint breeding program, generation of advanced breeding materials for other Asian countries is an important objective as well.

1. Utilization of indigenous and introduced germplasm

For most Asian cassava breeding programs, sexual seed materials provided by CIAT headquarters (HQ) in Colombia and by the Thai-CIAT program are the major sources for their adaptive selection. Comparisons between these two populations at Rayong, Thailand (semi-arid lowland tropics) and at Lampung, Indonesia (humid lowland tropics) revealed that at Rayong the Thai-CIAT population was far superior to the CIAT HQ population for all yield traits. But the difference was not conclusive at Lampung. The results at Rayong were predictable because the Thai-CIAT population came from cross parents selected at Rayong (local clones and clones of CIAT HQ origin). This suggests that the Thai-CIAT breeding population has acquired additional adaptation to drier climates, and that for immediate varietal selection for the semi-arid lowland tropics of Asia, Thai-CIAT materials may offer a better chance, while both are a good source for expanding the germplasm diversity. This shows once again the basics of germplasm variation, i.e. germplasm from the center of origin and diversification offers abundant genetic variation, but the germplasm of each location contains genes for local adaptation in a much higher frequency.

2. Yield improvement under semi-arid lowland tropical conditions

The cassava breeding program at Rayong Center started forming the breeding population using local germplasm during the 1970s, but it soon became clear that dealing only with the local germplasm did not produce new hybrid genotypes superior to the venerable local cultivar, Rayong 1, which occupied more than 1 million ha, or more than 99%, of the total cassava acreage in Thailand. The need to incorporate exotic germplasm was obvious and the program started incorporating an increasing number of locally-selected CIAT HQ clones as cross parents during the 1980s.

There was a significant improvement in yielding ability of the breeding population during the 1980s (**Figure 8**). A significant portion of the improvement in dry yield was attributable to the improved fresh yield, but there was also a steady improvement in root dry matter content (**Figure 9**). The HI of the population remained nearly unchanged, while total bio-mass increased significantly (**Figure 10**). This is in sharp contrast to the yield improvement during the first ten years at CIAT HQ, where the improvement in HI was the primary factor for the yield improvement (**Figure 5**). This may be because the yield improvement opportunity through improved HI had been largely consummated during the first ten years at CIAT HQ.

In our 20 years of cassava breeding, we have been recycling whatever clones looked good for whatever criterion in hybridization; thus, the whole scheme can be considered as a large-scale recurrent mass selection. Through this process, I believe, we are now providing national programs with breeding populations with upgraded yield components (bio-mass, HI, dry matter content), improved resistance to diseases and pests and considerable adaptation to poor soils and a semi-arid climate. On the other hand, we tend to have neglected fresh eating quality. In many parts of the world, cassava for fresh human consumption is still important. Incorporating good eating quality to the present breeding populations is a new challenge for us and national programs with the objective of selecting good dual-purpose cultivars.

Strengthening the Research Capacity of National Programs

In order to conduct breeding research a certain structure and facilities, such as space, equipment, field labor and budget are needed in addition to breeders and genetic materials. As far as I know, Thailand is the only country where all these are reasonably satisfied. In many other countries, some or all of these factors are deficient. It may seem in good order to first try to establish the research structure and facilities and then start the research activities; however, we have not heard many cases of success as such. As the distribution of IR rice lines developed by IRRI not only produced many successful cultivars, but also firmly established the rice breeding programs in many countries, the offering of sound technology can most frequently lead to the strengthening of the national program structure through their efforts to make the technology available to the users. We believe that offering truly useful basic technology and collaborating with national program counterparts in adaptive research is the most effective way to strengthen national programs.

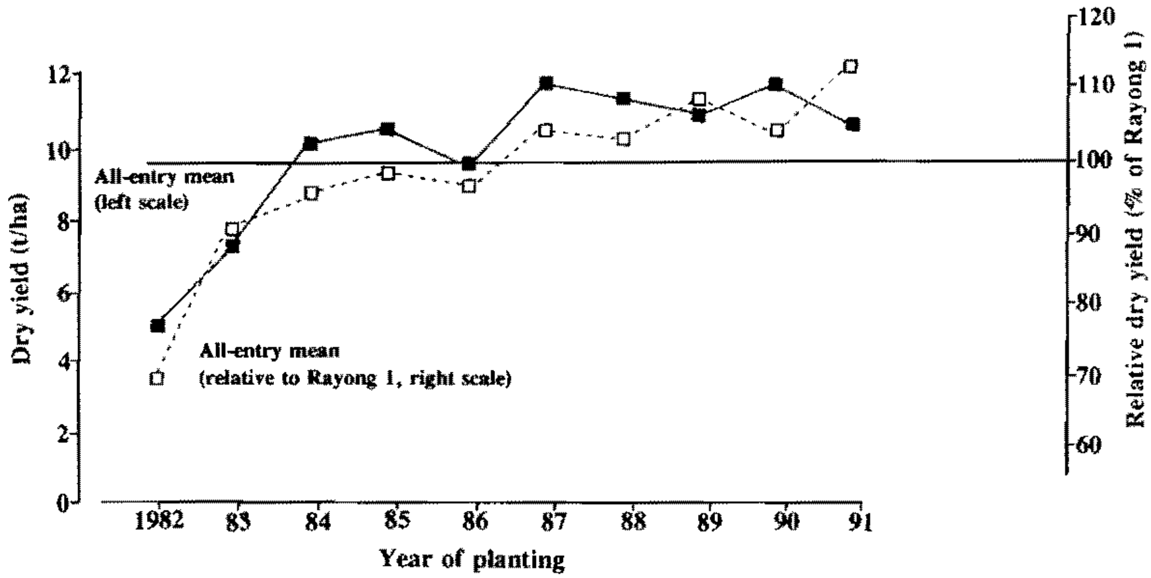


Figure 8. Change in mean dry yield of yield trial entries in Thailand; all-entry mean is the mean of all regional trial entries (8-10 clones) at all the regional trial sites (6-8 locations).

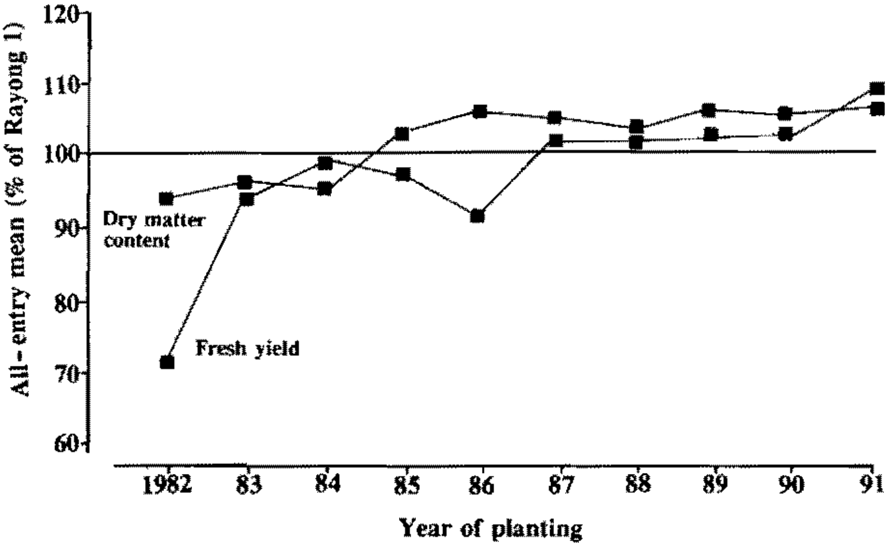


Figure 9. Change in mean fresh yield and dry matter content of yield trial entries (all-entry mean) in Thailand.

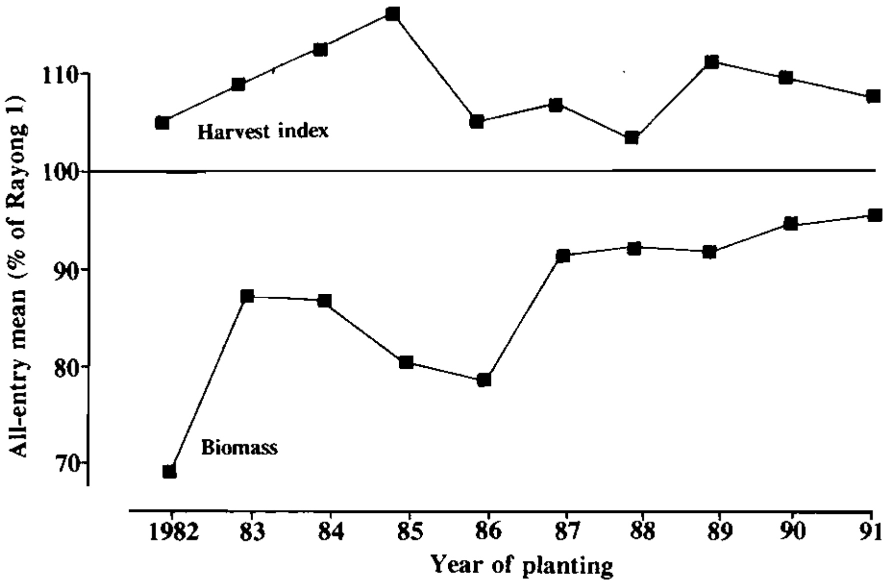


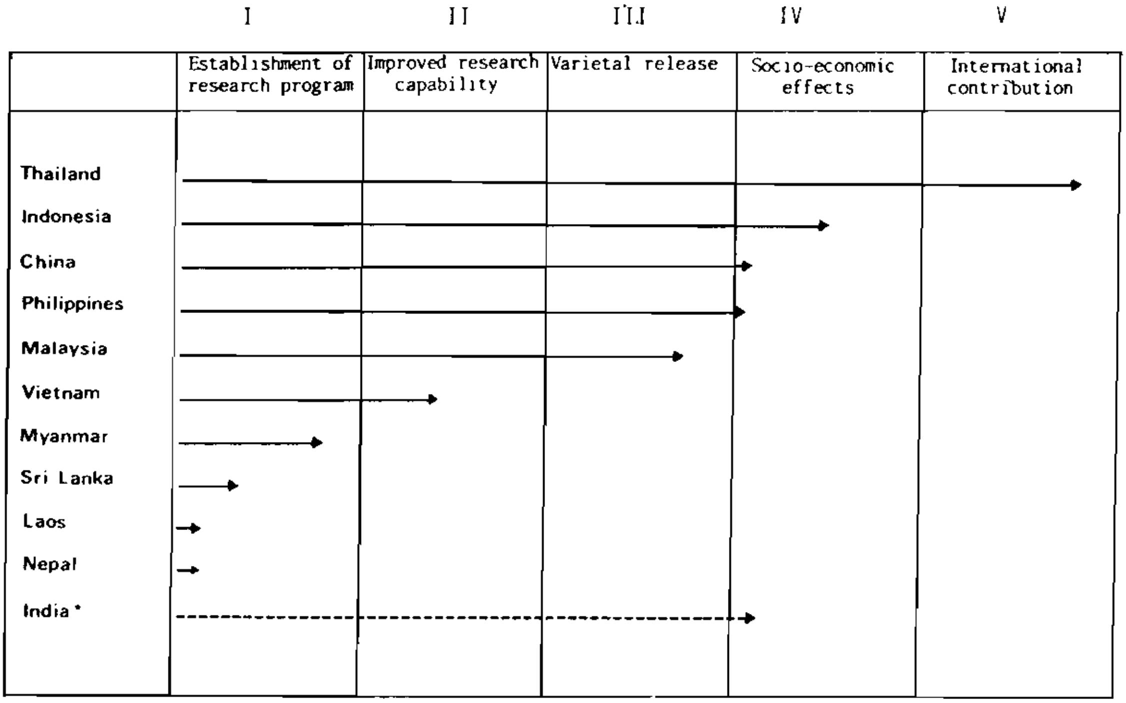
Figure 10. Change in mean harvest index and bio-mass of yield trial entries (all-entry mean) in Thailand.

There is a great difference in the development of cassava breeding programs among Asian countries, depending on the socio-economic situation and the importance of cassava in the national economy (**Figure 11**). I used to conduct field selections hand-in-hand with national program colleagues for several years after the establishment of the breeding program (development stage II in **Figure 11**). With this collaboration, the programs in Thailand, Indonesia, China and Malaysia are now fully capable of conducting the clonal selection by themselves. It is noteworthy that the Thai program is now contributing advanced breeding materials to other Asian programs.

Distribution of Breeding Materials to National Programs

The distribution of hybrid seeds from CIAT HQ to national programs started in 1975 and more than 300,000 hybrid seeds from about 4500 crosses have been distributed to nine countries in Asia up to the present. The distribution of hybrid seeds from the Thai-CIAT program (hybrids produced at Rayong Research Center) started in 1985, and more than 50,000 hybrid seeds have been distributed to ten countries in Asia. A smaller number of advanced clones have also been transfered to the Asian programs in the form of aseptic meristem culture. The clonal transfer from the Thai-CIAT program to other

Asian national programs is now becoming an important source for immediate varietal selection. As a consequence, the total germplasm variability thus transfered to Asia from Latin America through CIAT is now much greater than what had been spontaneously transfered previously.



* Development of Indian cassava research took place largely independent of CIAT collaboration.

Figure 11. Development of national cassava breeding programs in Asia in relation to CIAT collaboration.

Yield Performance of Advanced Clones in Asian National Programs

One of the most promising cultivars in Thailand is Kasetsart 50, of which the hybridization was made using the parents contributed by the Department of Agriculture and CIAT and the initial selection was conducted by Kasetsart University. This cultivar was released jointly by Kasetsart University, the Dept. of Agriculture and CIAT in 1992. The results of 60 regional and on-farm trials indicate that Kasetsart 50 had a dry yield about 35% higher than the local cultivar Rayong 1, the most widely grown cassava cultivar in the world (**Table 1**). Kasetsart 50 is superior to Rayong 1 in all yield components, i.e. total bio-mass, HI and root dry matter content.

Table 1. Comparison between Rayong 1 and Kasetsart 50[1].

Character	Rayong 1	Kasetsart 50	Kasetsart 50 as % of Rayong 1
Dry root yield (t/ha)	7.2	9.7	135
Fresh root yield (t/ha)	23.1	28.3	123
Root dry matter content (%)	31.0	34.3	111
Total plant weight (t/ha)	42.3	45.8	108
Harvest index	0.55	0.63	114
Germination and survival (%)	88.7	94.4	106

[1] Mean of 60 On-farm and Regional Yield Trials.

In a comparatively high-input production environment in Sumatra (humid lowland tropics), Indonesia, selected CIAT clones are giving some 100% higher yields than a traditional cultivar (**Table 2**). The much higher HI of CIAT clones is the primary cause of the high yield, but the total bio-mass and root dry matter content of CIAT clones are also higher than those of the local control.

In South Vietnam (humid to semi-arid lowland tropics), cassava is in transition from production for fresh human consumption to production for factory processing. Traditional cultivars are of good eating quality but have low yielding capacity. Under this situation, clonal introductions from the Thai-CIAT program are giving up to 100% yield superiority over the local control (see **Table 5** in Ngoan *et al.*, this Proceedings). Kasetsart 50 and Rayong 60, another promising Thai cultivar released by the Dept. of Agriculture in Thailand, were prereleased for intensive on-farm evaluation in South Vietnam in 1992.

Table 2. Results of varietal trials in Sumatra, Indonesia[1]

Clone	Origin		Dry root yield (t/ha)	Fresh root yield (t/ha)	RDMC[2] (%)	Total plant weight (t/ha)	Harvest index
	Hybridization	Initial selection					
CM4049-2UJ	CIAT HQ	Indonesia	20.4	53.4	38.2	82.2	0.65
CM4031-10UJ	CIAT HQ	Indonesia	19.5	50.0	39.0	80.6	0.62
Rayong 60	Thailand	Thai-CIAT	17.5	46.7	37.5	70.6	0.66
B6-3	Indonesia	Indonesia	17.3	46.6	37.1	74.0	0.63
Adira 4	Indonesia	Indonesia	16.9	46.2	36.6	81.1	0.57
B16-3	Indonesia	Indonesia	16.2	44.3	36.6	73.8	0.60
Rayong 3	CIAT HQ	Thailand	15.5	41.1	37.7	56.3	0.73
OMR28-19-3UJ	Thai-CIAT	Indonesia	15.2	41.4	36.7	64.7	0.64
OMR28-65-7UJ	Thai-CIAT	Indonesia	15.0	42.0	35.7	73.7	0.57
OMR28-82-4UJ	Thai-CIAT	Indonesia	13.5	38.2	35.3	62.6	0.61
B18-1	Indonesia	Indonesia	10.9	27.6	39.5	44.5	0.62
Kretek	Indonesia	traditional	9.3	27.9	33.3	62.0	0.45

[1] Means of three Replicated Yield Trials at Umas Jaya Farm, Lampung, Sumatra, 1990/91.

[2] Root dry matter content.

In Hainan, China (lowland sub-tropics), some CIAT clones and local clones selected from local crosses using CIAT parents gave considerably better yields than the local control (**Table 3**). However, the yield advantage of CIAT-originated clones was not as great as in the hot lowland tropics.

Table 3. Result of varietal trials in Hainan, China[1].

	Origin				
Clone	Hybridization	Intial selection	Dry root yield (t/ha)	Fresh root yield (t/ha)	RDMC[2] (%)
ZM8729	China	China	12.5	32.4	38.6
SM965-3	CIAT HQ	China	11.3	28.9	39.1
SM769-2	CIAT HQ	China	10.8	29.3	36.9
SM582-5	CIAT HQ	China	10.5	27.7	37.9
SM481-1	CIAT HQ	China	9.9	23.9	41.4
ZM8741	China	China	9.9	28.5	34.7
ZM8803	China	China	9.4	27.3	34.4
SM205	(Local control)		9.3	25.4	36.6
ZM8775	China	China	9.2	26.3	35.0
ZM8816	China	China	9.1	24.3	37.4
SM965-2	CIAT HQ	China	9.1	26.4	34.5
SM8758	China	China	9.1	26.2	34.7
ZM8774	China	China	9.0	23.8	37.8
SM980-1	CIAT HQ	China	9.0	24.9	36.1
SM987-2	CIAT HQ	China	9.0	24.1	37.3
ZM8752	China	China	8.7	25.0	34.8
SM979-2	CIAT HQ	China	8.7	25.2	34.5
SM758-4	CIAT HQ	China	8.4	24.1	34.9
ZM8769	China	China	8.4	23.9	35.1
SM965-5	CIAT HQ	China	8.1	22.0	36.8
ZM8701	China	China	7.3	26.4	27.7
ZM8702	China	China	6.5	22.9	28.4

[1] Mean of two Advanced Yield Trials conducted at South China Academy of Tropical Crops in 1990 and 1991.

[2] Root dry matter content.

Varietal Release

The first CIAT-related cassava cultivar released by Asian national programs was Rayong 3 in Thailand in 1983. Since then the number has increased to sixteen in 1992 (**Table 4**) and it is expected to increase every year. Local hybrids between selected local and CIAT cross parents are expected to be more important in the future.

Table 4. Number of CIAT-related cassava cultivars released by national programs in Asia.

Category	No.of cultivars	Country
Selected CIAT clones	4	China, Philippines
Selection from local cross of local germplasm	3	Indonesia, China
Selection from CIAT cross	5	Thailand, Malaysia, Philippines
Selection from local cross between CIAT and local parents	4	Thailand

Socio-economic Effects

Rayong 3 in Thailand and Adira 4 in Indonesia are reportedly planted on more than 50,000 ha, each generating an economic effect of millions of US dollars. VC2 and MCol 1684 in the Philippines and Nanzhi 188 and SC124 in China are planted on smaller hectareages. The initial adopters of these cultivars were primarily advanced farmers (Thailand) and commercial plantations (Indonesia and Philippines). Efforts are being made to spread these cultivars to smaller farmers. Adaptability to the conditions of poor farmers is being added to new cultivars.

CASSAVA AGRONOMY RESEARCH IN ASIA, 1987-1992

Reinhardt Howeler[1]

INTRODUCTION

During the past 17 years cassava production in Asia increased from 27.0 million tons in 1973 to 51.2 million tons in 1992 (**Figure 1**). In Asia cassava production increased at an annual rate of 3.9%, compared with 3.5% in Africa and only 0.2% in South America. Most of this increase in production was due to an increase in area (2.3% annual growth), but yields also increased substantially at an annual rate of 1.5% (FAO Year Books).

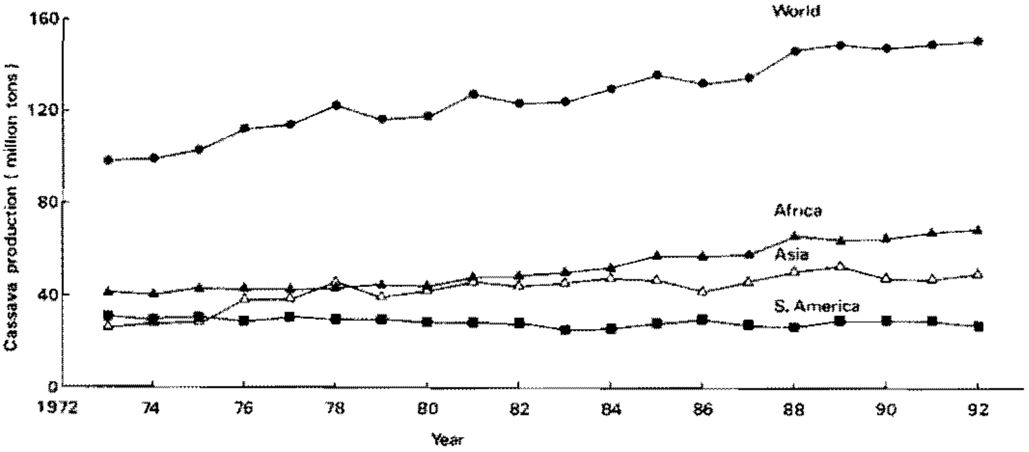


Figure 1. Production trends of cassava in the world and in the three major producing continents from 1973 to 1992.
***Source:** FAO Production Yearbooks.*

In Asia, Thailand has the highest cassava production, followed by Indonesia, while India has by far the highest yield (**Figure 2**). **Figure 3** shows that cassava production in Asia is concentrated mainly in the northeast of Thailand, on Java island of Indonesia, and in southwest India, while it is also extensively grown throughout Vietnam and southern China.

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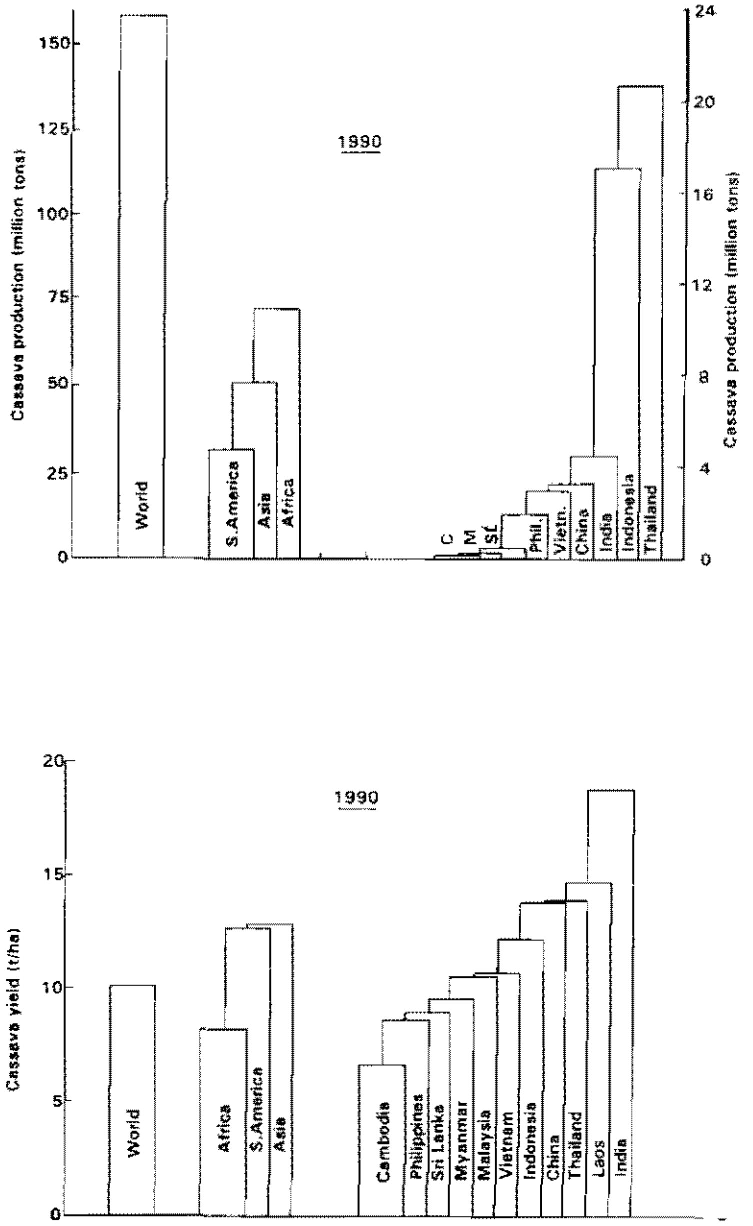


Figure 2. Cassava production (top) and yield (bottom) in the world, in the continents, and in several countries in Asia in 1990.
Source: *FAO Production Yearbook for 1990.*

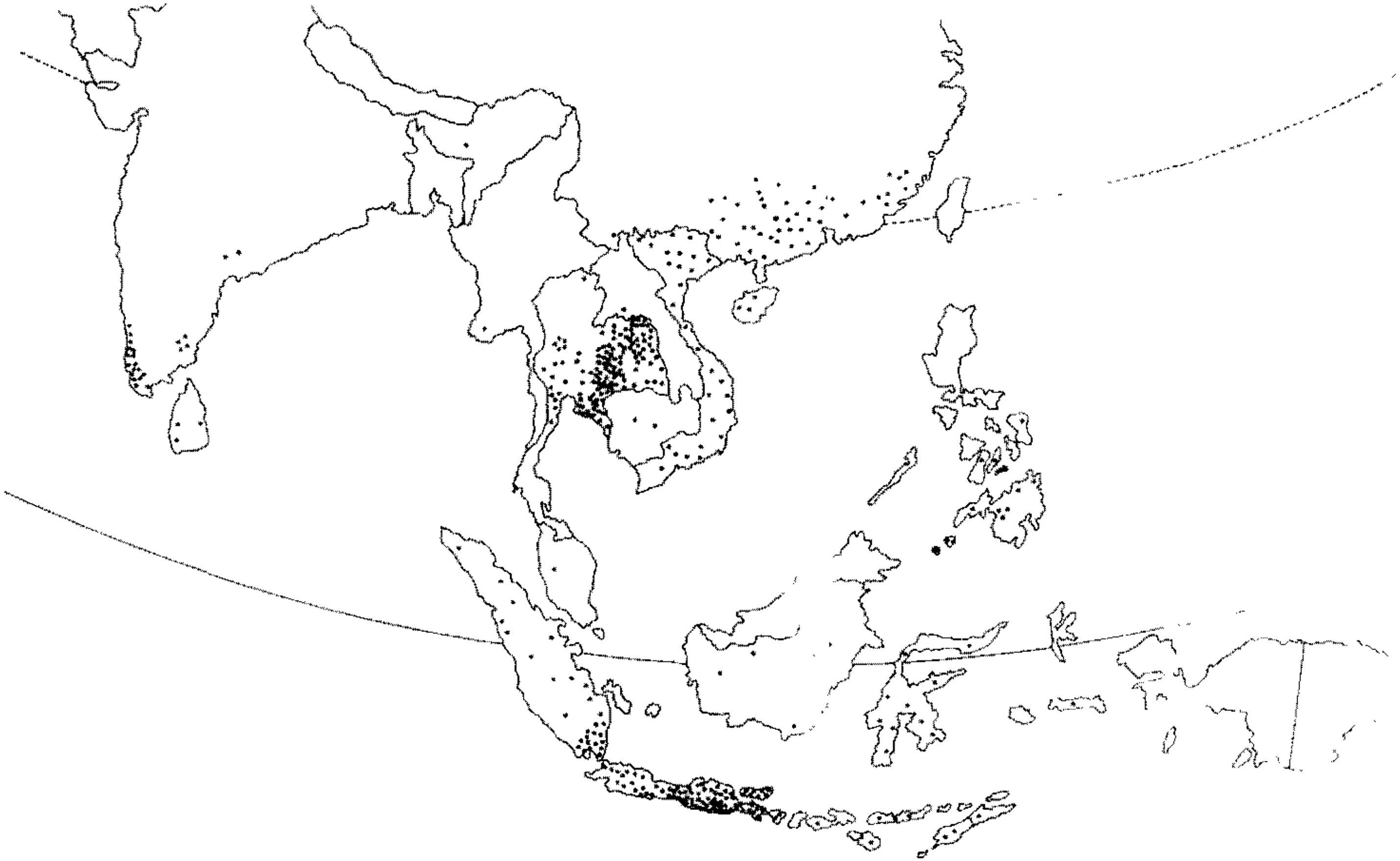


Figure 3. Cassava production zones in Asia in 1989, each dot represents 10,000 ha of cassava.

By overlaying the cassava production map on the FAO World Soil Map for Asia, it is possible to estimate the hectareage of cassava grown on each soil type (Howeler, 1992). In Asia about 55% of cassava is grown on Ultisols, 18% on Inceptisols, 11% on Alfisols, 9% on Entisols and the remaining 7% is grown on Vertisols, Mollisols, Oxisols, and Histosols. Thus, cassava in Asia is predominantly grown on Ultisols, which are characterized by low levels of organic matter (MO) and very low reserves of P, K, Ca and Mg. Also, most of the Ultisols are associated with an undulating or hilly topography, which makes them quite susceptible to erosion, especially those soils having a sandy or sandy-loam texture. Thus, continued cassava production on these soils may result in soil degradation due to excessive erosion as well as soil exhaustion by nutrient off-take in the root harvest. Particular emphasis should therefore be placed on the development of cultural practices that reduce erosion and that maintain the soil nutrient reserves.

LONG-TERM EFFECT OF CASSAVA ON SOIL PRODUCTIVITY

Thai researchers (Sittibusaya *et al.*, 1988) have shown that when cassava was grown on the same soil without fertilizer application, yields declined from about 27 t/ha to 15-18 t/ha in the course of 20-30 years. This yield decline is partially caused by nutrient depletion through plant uptake and removal in the harvest and partially by excessive erosion.

Many people consider cassava a crop that exhausts the nutrients in the soil, but data reported in the literature (Amarasiri and Perera, 1975) indicate that per ton dry matter (DM) produced, cassava extracts in the harvested product much less N and P and similar amounts of K as many other crops. Thus, nutrient removal is only high when yields are high.

In a recent trial in Thailand the nutrient absorption as well as the erosion caused by cassava was compared with that of other crops (Puttacharoen *et al.*, 1992). **Table 1** shows the nutrients absorbed by seven crops grown during nearly two years, corresponding to two crops of cassava for root production, four cuts of cassava tops for forage production, two crops of maize, sorghum and peanut, three crops of mungbean and one crop of pineapple. Nutrient removal in the harvested products was extremely high for cassava grown for forage production, since in this case plant tops were regularly cut off and removed, while roots were

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

Crop	Nutrients removed (kg/ha)			Nutrients returned (kg/ha)		
	N	P	K	N	P	K
Cassava for roots	102	19	104	182	20	87
Cassava for forage	329	39	193	-	-	-
Maize	118	44	87	101	13	271
Sorghum	79	25	51	147	27	305
Peanut	213	19	52	133	25	184
Mungbean	114	14	59	51	6	64
Pineapple	82	15	188	161	31	279

harvested only after two years. Comparing the other six crops, it is clear that cassava for root production extracted less N and P than most other crops; it extracted considerably more K, but still less than pineapple. Although cassava takes up relatively large amounts of N, most of this (about 65%) ends up in the leaves and stems, and as long as these are returned to the soil, N removal by cassava is not excessively high. In contrast, most of the absorbed K (about 65%) ends up in the roots and is thus removed in the root harvest.

In case of cassava, many farmers do not apply fertilizers or do not apply nutrients in the right proportions. If a cassava farmer produces an average root yield of 15 t/ha, he is removing about 50 kg N, 20 kg P_2O_5 and 70 kg K_2O/ha. Most cassava farmers apply between zero and 200 kg/ha of a compound fertilizer like 15-15-15. At the rate of 200 kg/ha this would correspond to 30 kg each of N, P_2O_5 and K_2O, i.e. about 60% of the removed N, 150% of P and only 40% of the removed K. Continuous cassava production without adequate return of the removed K may lead to K exhaustion.

With respect to erosion, **Figure 4** shows that when various crops were grown for 22 months on 7% slope, total soil loss due to erosion was about 140 t/ha for cassava for root production, 70 t/ha for mungbean and cassava for forage production, and only 30-40 t/ha for sorghum, peanut, pineapple and maize. Cassava for forage production caused much less erosion than cassava for root production, because the former crop was planted at closer plant spacing (0.5x0.5 m for forage compared with 1.0x1.0 m for root production) and did not have to be replanted in the second year. In areas like Thailand, where a long dry season allows the production of only one short-cycle crop like maize,

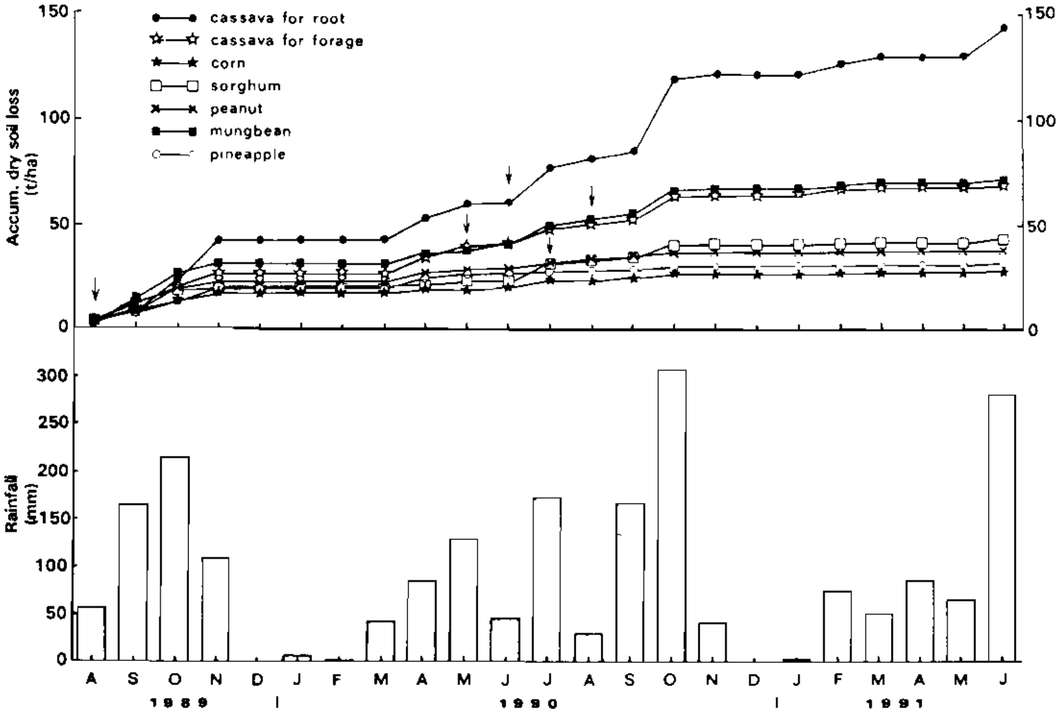


Figure 4. Accumulative dry soil losses due to erosion in various crops grown during a 22 month period on 7% slope in Sri Racha, Thailand in 1989/91. Arrows indicate time of planting. Rainfall distribution is shown below.

sorghum, peanut, and maximum two crops of mungbean per year, cassava is likely to cause much more erosion than these short-cycle crops. This is because cassava is planted at a wide spacing and is initially very slow to establish a canopy to protect the soil from rainfall impact. Thus, erosion losses in cassava can be high during the first 3-4 months after planting (see **Figure 4**), while in case of maize, sorghum, peanut and mungbean erosion is severe only during the first 1-2 months after planting; after harvest of these crops the soil is protected by the growth of weeds and by crop residues left on the soil surface.

If we assume that the erosion data in **Figure 4** are representative for many cassava growing areas in Thailand, then we could be losing about 5 ton of soil for each ton of fresh cassava roots produced, or about 75 ton for each hectare of cassava. Even higher levels of erosion of 100-200 t/ha have been observed in trials conducted in Vietnam, East Java, Sumatra and Thailand, while an extremely high level of 250 t/ha was measured on a 25% slope in Hainan island of China. These erosion losses are much higher than those observed in similar trials in Colombia, even those conducted on much steeper slopes (**Table 2**). Thus, there is no doubt that both nutrient extraction and soil erosion are serious problems in cassava, particularly in Asia where soil and climatic conditions tend to enhance erosion and where high population pressure has pushed cassava production onto ever steeper and less fertile soils.

RESEARCH RESULTS 1987-1992

Since 1987 many national cassava programs in Asia have conducted experiments in collaboration with CIAT on various aspects of cassava agronomy, but with particular emphasis on soil fertility maintenance and erosion control.

Cassava Planting and Harvesting Time

From 1987 to 1989 an experiment was conducted on a sandy loam soil at Sri Racha, Thailand to determine the optimum time of planting and harvesting of two cassava cultivars, Rayong 1 and Rayong 3 (Vichukit *et al.*, 1990). These cultivars were planted every month of the year during two years and were harvested at either 8 or 12 months.

Table 2. Average dry soil losses due to erosion measured in cassava trials in various countries of Asia as well as in Colombia, S. America.

Country	Site	Slope (%)	Soil texture	Organic matter (%)	Dry soil loss (t/ha)
China	-Qifeng - Hainan	8	sandy clay loam	2.4	154
	-SCATC - Hainan	15	clay	1.8	128
	-SCATC - Hainan	25	clay	2.0	144
	-Nanning - Guangxi	12	clay	1.7	16
Indonesia	-Malang - E. Java	8	clay	1.5	42
	-Tamanbogo - Lampung	5	clay	1.8	47
	-Umas Jaya - Lampung	3	clay	2.7	19
Malaysia	-MARDI - Serdang	6	clay	-	10
Philippines	-Baybay - Leyte	25	clay loam	1.9	54
Thailand	-Sri Racha - Chonburi	8	sandy loam	0.6	15
	-Sri Racha (farmer's field)	8	sandy loam	0.5	18
	-Pluak Daeng - Rayong	5	sandy loam	0.7	21
Vietnam	-AC #3 - Bac Thai	5	sandy clay loam	1.6	23
	-AC #3 - Bac Thai	10	sandy clay loam	1.6	39
	-AC #3 - Bac Thai	15	sandy clay loam	1.6	105
Colombia	-Mondomito - Cauca	27	clay	4.7	45
	-Mondomito - Cauca	30	clay	-	2
	-Las Pilas - Cauca	40	clay loam	11.0	3
	-Agua Blanca - Cauca	42	clay loam	5.1	18
	-Popayan - Cauca	15	loam	24.8	15
	-Popayan - Cauca	25	loam	24.8	7

The rainy season in the area usually starts in May-June and ends in Nov-Dec. **Figure 5** shows that during the first year (1987/88) the yields of both cultivars, when harvested at 12 months, were very high when the crop was planted from Sept to Dec; yields decreased but were still quite high when planted during the dry season from Jan-April. During the second year, yields of both cultivars were much lower due to lower rainfall and increased pest incidence during the dry season. Highest yields were obtained when cassava was planted at the end of the rainy season in Nov-Jan, while no yield was

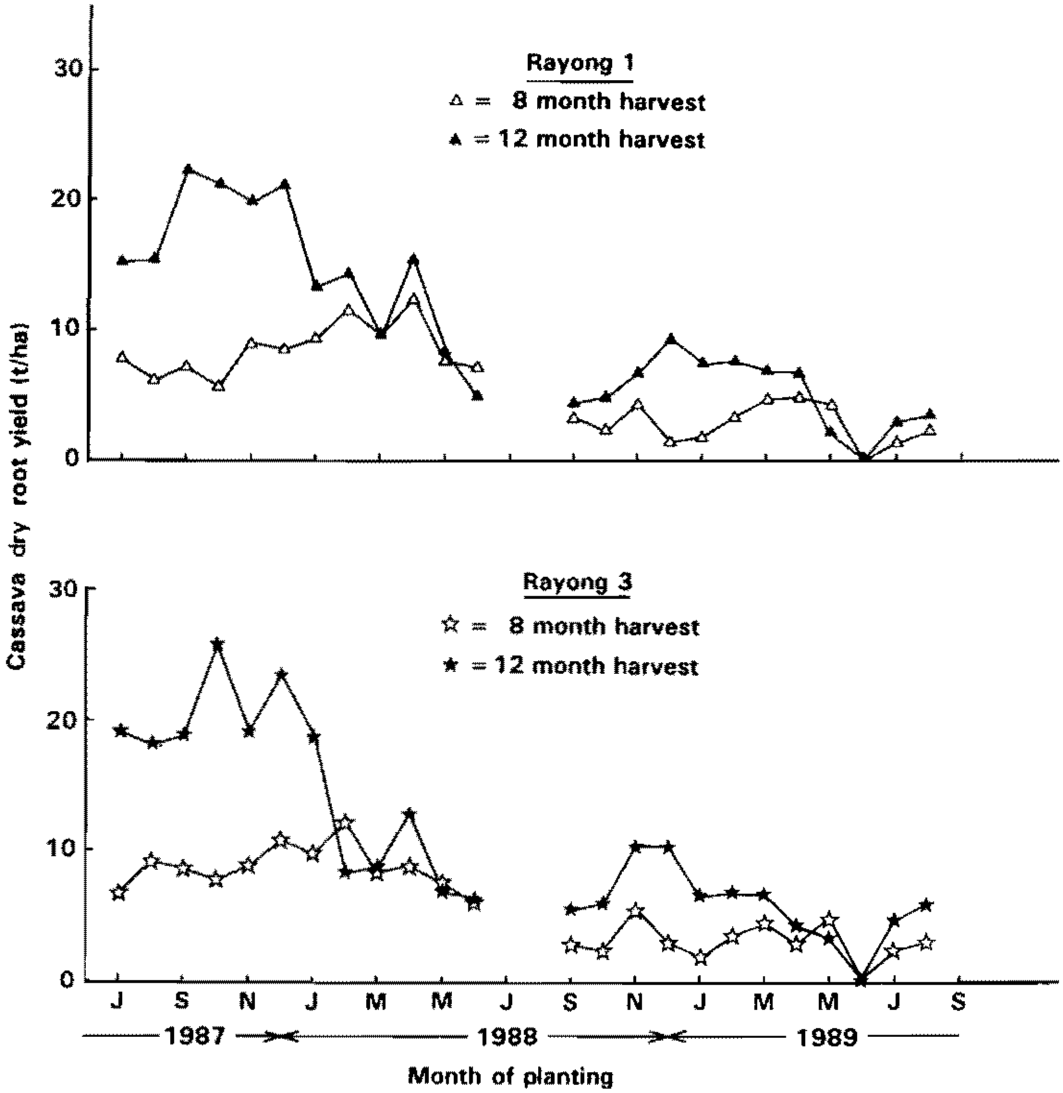


Figure 5. Effect of month of planting on the dry root yield of two cassava cultivars, Rayong 1 and Rayong 3, harvested at either 8 or 12 months in Sri Racha, Cholburi, Thailand.

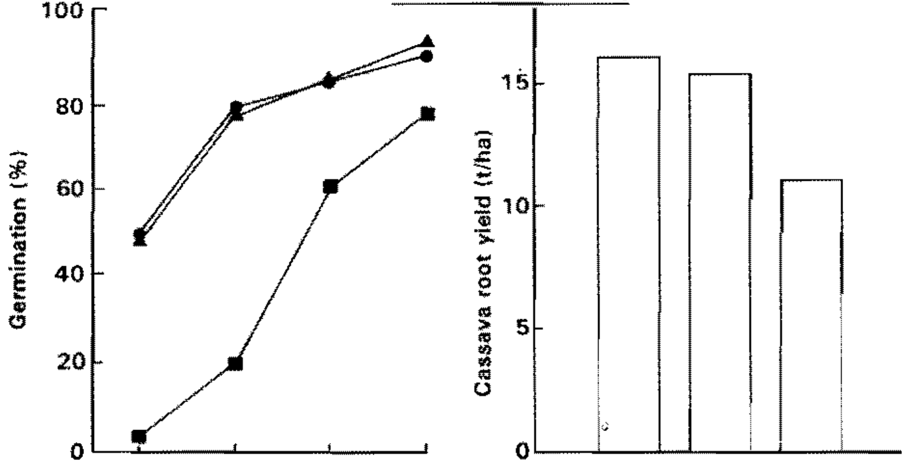
obtained when planted in June due to an unusually long dry spell during the following three months. When cassava was harvested already at eight months, dry root yields were highest when planted in the dry season in Feb-April (harvest Oct-Dec). For both cultivars, root starch content was highest in the early dry season (Nov-Jan) and dropped markedly when harvested in the late dry season and early rainy season (March-June) (Tongglum *et al.*, 1992). Thus, when adequate moisture is available for germination, cassava in eastern Thailand can best be planted in Nov-Dec for a 12 months harvest, or in Feb-April for an 8 months harvest; in both cases the harvest occurs in the early dry season when starch content is high and weather conditions are favorable for sun drying.

A similar trial conducted in Hainan island of China, with low rainfall and low temperature during the winter months of Dec-March, indicates that highest fresh root yields (harvested at 8 months) were obtained when cassava was planted in Feb-May (harvest Oct-Jan), while very low yields were obtained when planted in Sept-Oct (harvest May-June). Highest starch contents were observed in the cool dry months of Feb-March.

Stake Postion and Method of Planting

Farmers in Thailand are harvesting and replanting cassava more and more during the dry season in order to reduce weed problems and erosion and to spread labor requirements more evenly over the year. Planting during the dry season is more risky as low soil moisture can seriously affect germination, but farmers can reduce risks by planting after an occasional rainstorm and by using the most suitable planting method. To determine the best planting method, the Rayong Field Crops Research Institute (RTCRI) has conducted two sets of trials, each during three years, planting both in the beginning of the wet and the dry seasons. **Figure 6** shows that vertical or inclined planting resulted in faster germination and significantly higher yields in both planting seasons, but particularly at the beginning of the dry season. During the dry season the horizontally planted stakes did not germinate well in the hot and dry surface soil. In contrast, the bottom of vertically planted stakes could absorb moisture from deeper soil layers and were thus more resistant to drought. Deeper planting (at 15 cm depth) also significantly increased yields in the dry season planting, but had no effect in the wet

Rainy season planting



Dry season planting

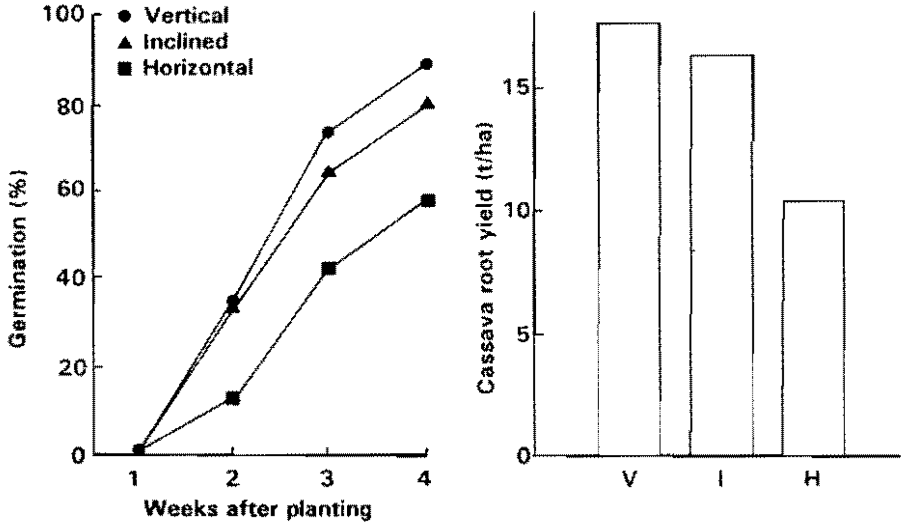


Figure 6. Percent germination and root yield of cassava, cv Rayong 1, planted with three stake positions in the beginning of the rainy as well as the dry seasons in Rayong, Thailand. Date are averages of three years.

season. Ridging had no significant effect on yield in either season (Tongglum *et al.*, 1992).

Similar trials conducted in South Vietnam, in Guangxi province of China and in Bohol island of the Philippines, all planted at the beginning of the rainy season, have shown no significant effect of stake position on yield. However, when cassava in Guangxi in 1991 suffered from moisture stress after planting, vertical planting resulted in significantly better germination and greater plant height than inclined or horizontal planting. Thus, it is clear that vertical or inclined planting is better than horizontal planting during periods of drought, but that stake position is of little importance under conditions of adequate soil moisture.

Short- and Long-term Fertilizer Requirements

To determine both the short- and long-term fertilizer requirements of cassava, simple long-term NPK trials have been established in 13 locations in five countries. These trials generally have 12 treatments with four levels of N, P, and K in such a way that the response to each element can be determined while the other two nutrients are applied at near optimum levels.

Figure 7 is an example of the response of two cultivars to the application of N, P, and K in a third-year planting in Guangzhou and in Nanning, both in China. In Guangzhou, there was a significant response to N, P, and K in case of SC205, but only to N in case of SC201. In Nanning there was only a significant response to N in case of SC205, but no response to P or K in either cultivar. Thus, there are clear varietal differences in fertilizer response, with SC205 being more responsive to fertilizer application than SC201. In Guangzhou yields of SC205 increased from 7 to 26 t/ha with the application of 200 kg N, 100 kg P_2O_5 and 200 kg K_2O/ha.

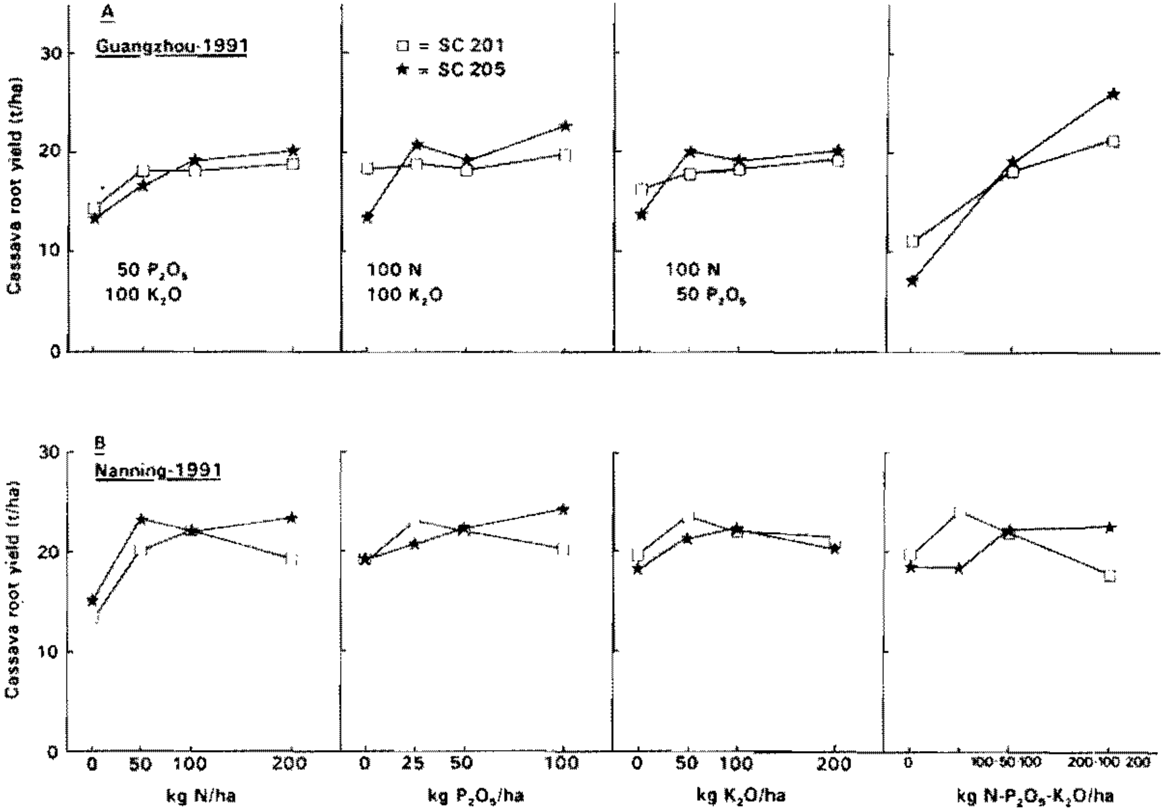


Figure 7. Response of two cassava cultivars to the application of N, P and K during the third year at Guangzhou, Guangdong (A) and at Nanning, Guangxi (B) in China during 1991.

Figure 8 shows the locations where these NPK trials are being conducted as well as the short- and long-term nutrient responses. In nine out of 13 sites there was an initial significant response to N, in four sites there was a response to P and in only three sites to K. However, four long-term trials, which were initiated many years ago in Malaysia, Thailand and India, all indicate that K became the main limiting nutrient after continuous cassava cultivation. **Figure 9** shows that in Khon Kaen in Thailand, K became the main limiting nutrient already after the second year, while in another location, Banmai Samrong, a significant K response was only observed after 12 years of continuous cropping (Sittibusaya, personal communication). In this latter location the soil K content was orginally as high as 200 ppm, but after 8 years of cropping it had dropped to 100 ppm and a significant K response was observed only after the exchangeable soil K level had dropped below 60 ppm, which is the critical soil K level for cassava (Howeler and Cadavid, 1990). **Figure 9** indicates that without K application in Khon Kaen yields decreased steadily from 28 t/ha in the first year to a level of only 5 t/ha after 15 years of cropping. With the annual application of 50 kg K_2O/ha yields could be maintained at 20-25 t/ha. The incorporation of plant tops after each harvest increased yields from 5 to 11 t/ha in the absence of any fertilizers, and from 28 to 31 t/ha in the presence of fertilizers. Thus, for long-term fertility maintenance in cassava fields it is very important to incorporate plant residues after harvest and to apply adequate amounts of K to counteract the considerable K removal in the root harvest. An annual application of 80-100 kg K_2O/ha is recommended to maintain high yields.

Fertility Enhancement Through the Use of Legumes

If farmers do not have the resources to buy adequate amounts of fertilizers, they can enhance soil fertility through the use of legumes by intercropping cassava with grain legumes, by green manuring, by under-cropping or by alley-cropping. **Table 3** shows the characteristics of several potential legumes when they were grown in Rayong, Thailand. In other locations, however, depending on soil and climatic conditions, there may be a different pattern of adaptation.

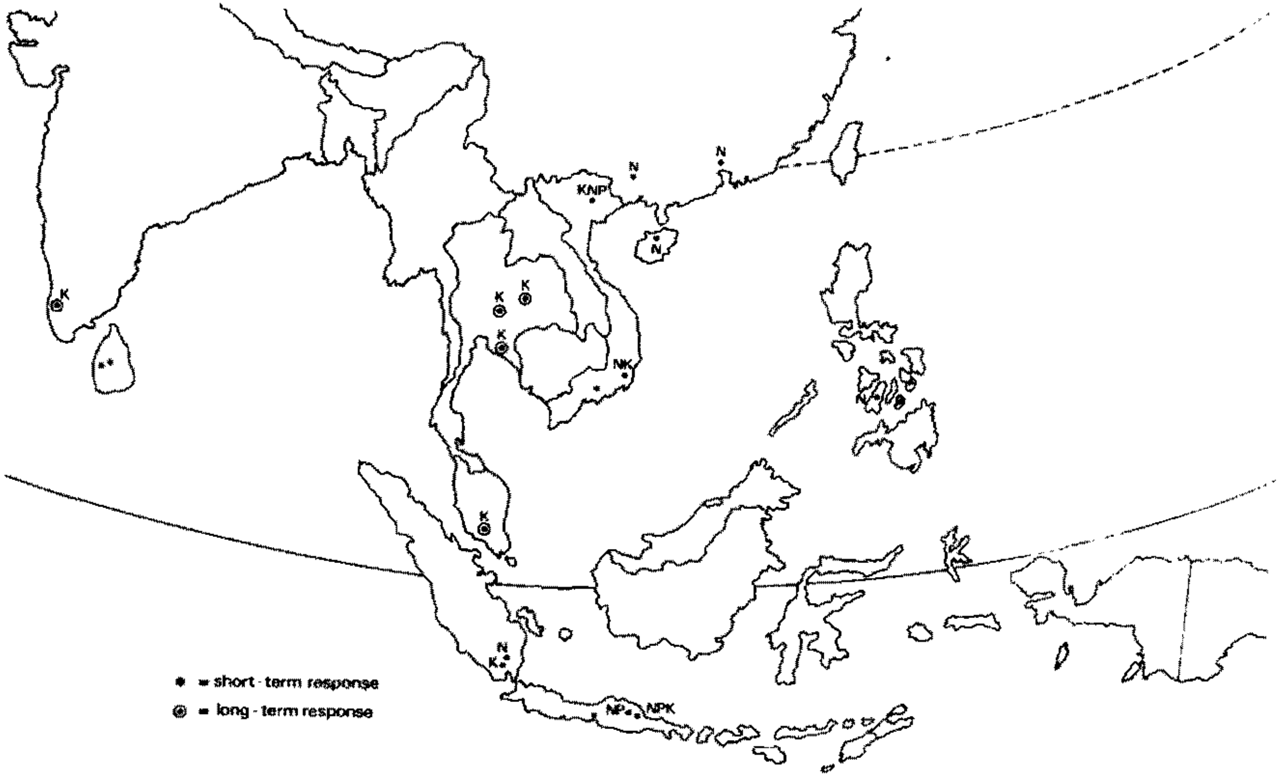


Figure 8. Short-and long-term response of cassava to the application of N, P and K in long-term fertility trials conducted in various locations in Asia.

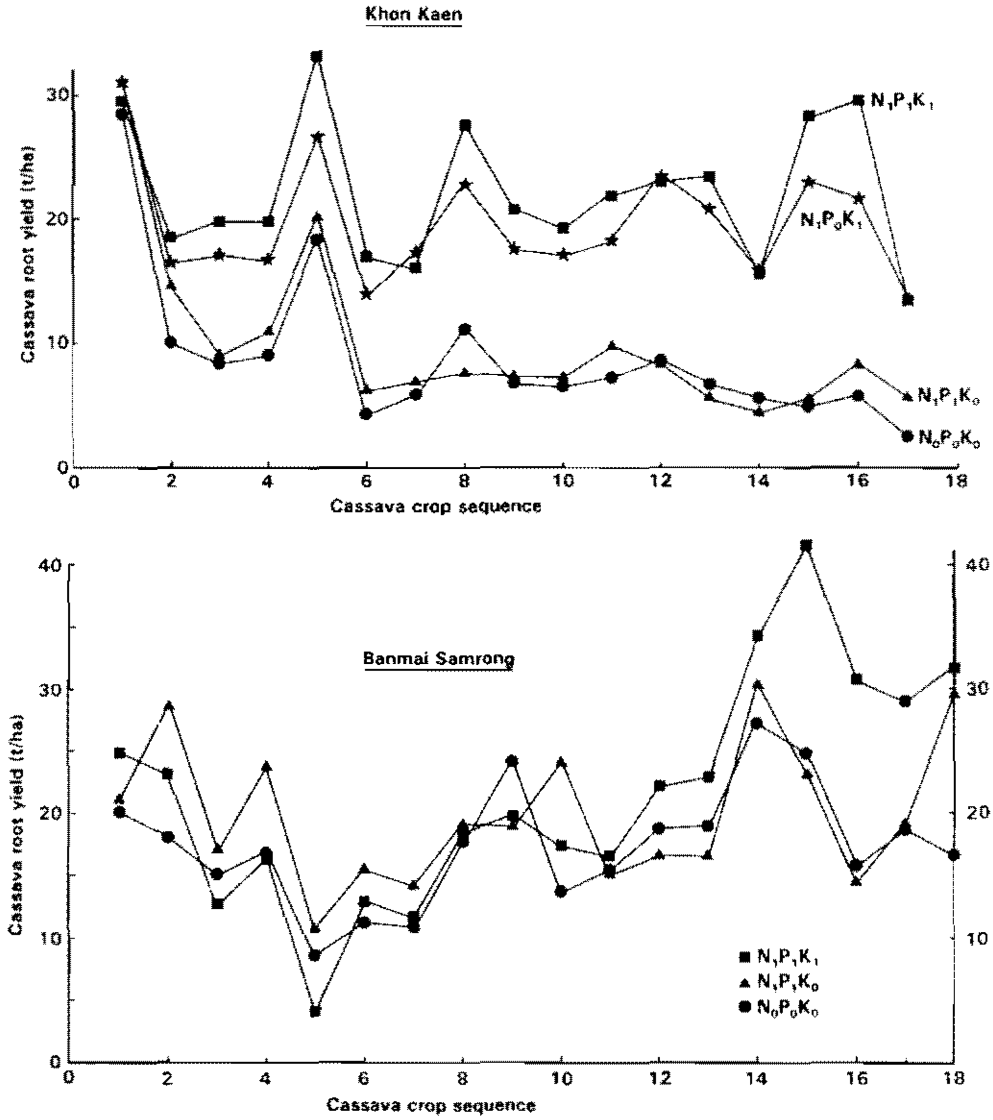


Figure 9. Effect of annual applications of N, P and K on the yield of cassava, cv. Rayong 1, grown continuously for 15 and 16 years in Khon Kaen and Banmai Samrong in Thailand, respectively. N_1, P_1 and K_1 correspond to applications of 50 kg/ha of N, P_2O_5 and K_2O, respectively.

Table 3. Growth and nutrient uptake of leguminous species grown at Rayong Field Crops Research Center, Rayong, Thailand in 1987.

	Days to 50 % flowering	Seed yield (t/ha)	Stem + leaf weight (t/ha)[1]		Nutrient uptake (kg/ha)		
			fresh	dry	N	P	K
Grain legumes							
Peanut (Tainan 9)	32	0.48	13	4	42	6	73
Mungbean (U-Thong 1)	32	0.24	4	1	10	1	13
Cowpea (Local variety)	33	1.55	9	2	47	5	39
Cowpea (TVX 1193-059)	36	3.78	16	3	83	9	69
Soybean (SJ 5)	32	0.44	3	1	15	3	14
Pigeon pea from ICRISAT	54	0.35	26	10	240	23	112
Pigeon pea from USA	184	0.25	106	40	980	77	867
Lablab purpureus	173	0.94	29	7	171	19	119
Green manures							
Sesbania aculiata from IRRI	60	0.60	19	7	80	13	71
Sesbania aculiata	67	0.85	28	12	170	17	113
Sesbania speciosa	127	0.52	56	19	281	27	213
Sesbania rostrata from IRRI	67	0.78	16	7	89	18	66
Sesbania rostrata	71	1.89	19	8	81	8	78
Indigofera	106	1.59	43	18	457	32	195
Canavalia ensiformis	50	1.30	22	4	113	9	59
Mucuna sp. from CIAT	131	0.30	38	8	224	16	135
Mucuna fospeada	122	1.82	42	11	244	20	119
Crotalaria juncea	67	0.00	21	10	130	11	86
Crotalaria spectabilis (Brazil)	60	0.15	28	8	134	14	112
Crotalaria spectabilis (CIAT)	54	0.06	20	6	95	13	31
Crotalaria mucronata 7790	60	0.38	39	11	295	17	157
Crotalaria mucronata 9293	54	0.02	22	6	120	13	100
Cover crops							
Macroptillium atropurpureum	50	0.22	44	11	235	20	214
Mimosa envisa	147	0.87	51	18	262	29	248
Calopogonium	149	0.06	22	7	159	20	103
Pueraria phaseoloides	146	-[2]	33	9	209	21	148
Stylosanthes hamata	50	1.22	29	11	237	14	113
Centrosema pubescens	153	0.09	13	4	101	11	66
Alley crop hedgerow species							
Sesbania javanica	114	0.14	21	8	137	12	85

[1] Stem weight, weighed at cutting (5 months), except soybean, peanut and mungbean weighed at harvest of each species.

[2] Drought at flowering caused no pod set.

Source: *Rayong Field Crops Research Center, Annual Report 1988.*

A. Intercropping with grain legumes

Intercropping cassava with grain legumes or other economic crops (mainly upland rice and maize) is a practice often used by farmers in Indonesia, and less commonly in the Philippines, Vietnam, China and India, i.e. in countries with a high population density and small farm size. The practice optimizes the productivity per unit of land, it reduces risk of crop failure, it provides a more varied and balanced diet for subsistence farmers, and it may enhance soil fertility through biological N-fixation and by reducing erosion. However, additional fertilizers may need to be applied to counter the additional nutrient off-take by the intercrops.

Intercropping cassava with other crops usually decreases the yields of the component crops, but increases the total productivity and farmer's income. At Hung Loc station in southern Vietnam, intercropping consistently reduced cassava yields; growing cassava in single rows (1.0x1.0 m) produced better yields and net income than planting in double rows (2.0x0.8x0.71 m). **Figure 10** shows that mungbean and soybean were the least competitive intercrops; groundnut, mungbean and maize produced the highest net income. Cassava monocropping, however, gave higher economic returns than any of the intercropping systems.

In Rayong, Thailand, planting cassava in either single (1.8x0.55 m) or double (3.0x1.0x0.55 m) rows had no consistent effect on cassava or intercrop yields (**Table 4**). The intercrop yields were significantly higher in the single row system in two of the three years; however, the double row system allows the planting of a second intercrop after the first crop has been harvested, thereby increasing the total income of the farmer. In the same location, the optimum spatial arrangement of peanut, mungbean and soybean intercrops was studied when cassava was grown in single rows at 1.8x0.55 m. The results indicate (Tongglum *et al.*, 1992) that only intercropping cassava with peanut produced a higher gross income than growing cassava in monoculture. There was not much difference in yield or gross income between two or three rows of intercrops between cassava rows, but keeping intercrops 60 cm from the cassava rows resulted in higher cassava yields and gross income than when intercrops were planted at 45 cm from cassava rows.

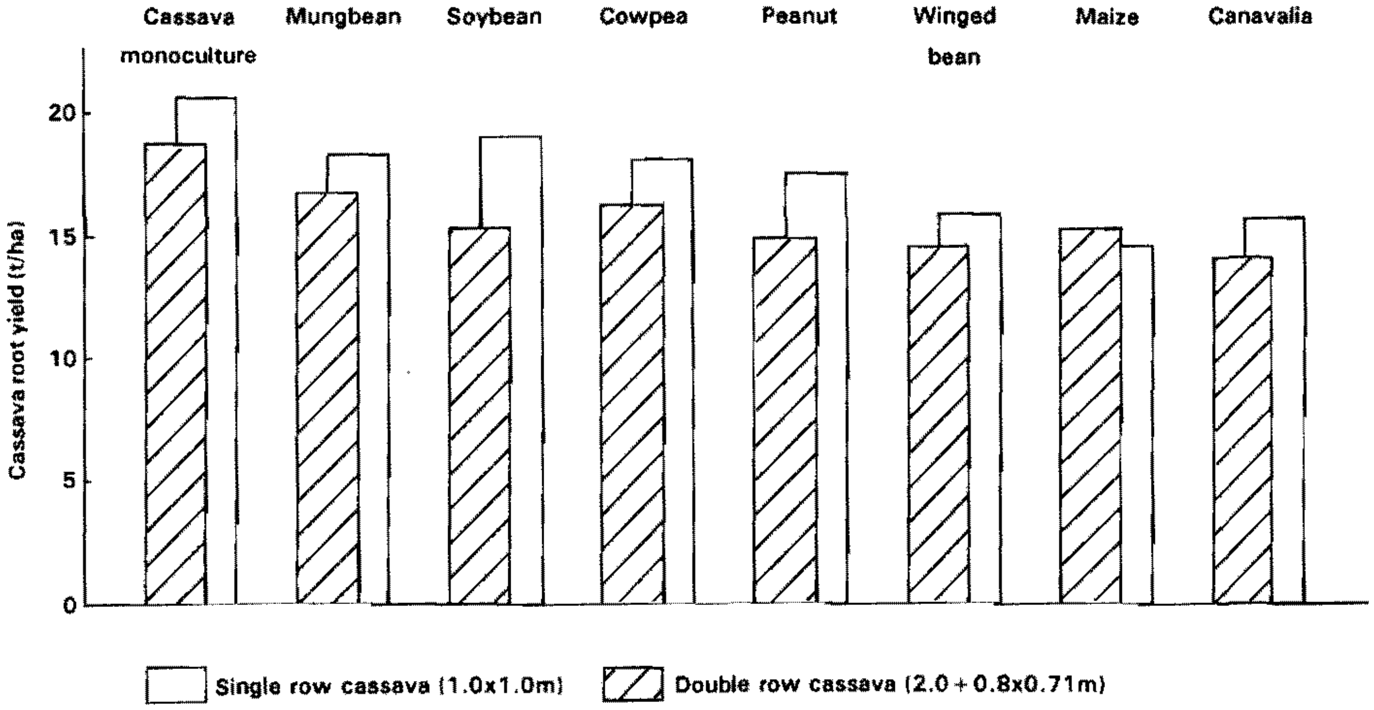


Figure 10. Effect of intercropping with various crops on the root yield of cassava, cv. M-23, grown in either single or double rows in Hung Loc Center, Dong Nai, Vietnam. Data are average values for 1989, 1990, 1991 and 1992.

Table 4. Effect of cassava planting arrangement on yield in monoculture cassava and in various intercropping systems at Rayong Field Crops Research Center, Thailand.

Cropping system	Cassava root yield (t/ha)						Intercrop yield (kg/ha)						
	1988/89		1989/90		1990/91		1988/89		1989/90		1990/91		
	A	B	A	B	A	B	A	B	A	B	A	B_1	B_2
Cassava monocrop	14.56	17.52	16.06	10.81	28.84	27.79	-	-	-	-	-	-	-
C+cowpea (TVX 1193-059 D)	10.02	14.27	14.25	12.56	16.71	23.99	375	350	436	412	596	327	572
C+cowpea (S-11)	16.16	12.28	13.69	11.56	25.58	29.45	556	406	106	164	372	205	275
C+cowpea (Local variety)	6.10	7.36	11.50	8.69	19.81	18.67	819	600	375	341	576	311	705
C+cowpea (Vita 3)	7.49	7.90	14.69	11.94	16.85	23.69	650	544	308	289	298	277	296
C+peanut (Tainan 9)	16.29	18.30	13.44	11.87	24.71	25.88	375	231	287	416	637	944	-
C+mungbean (U-thong 1)	11.28	18.50	17.37	14.25	27.99	24.40	519	494	128	467	827	327	427
C+mungbean (Chainat 60)	-	-	17.19	12.06	25.33	23.79	-	-	234	142	388	289	489
C+soybean (SJ-5)	11.47	9.02	-	-	-	-	569	362	-	-	-	-	-
Average	11.67	13.15	14.77	11.71	23.23	24.71	552	427	268	276	528	383	395

A = Single-cassava row (1.80x0.55 m).
B = Double-cassava rows (3x1x0.5 m).
B_1 = first intercrop.
B_2 = second intercrop.

In Yogyakarta, Indonesia, the effect of cassava row width was studied for two years in two intercropping systems with upland rice, maize, peanut, and soybean. **Figure 11** shows that increasing the cassava population and decreasing the row width consistently increased cassava yields and total crop value; maximum cassava yields and total gross income were obtained when cassava was grown at a normal 1.0x1.0 m spacing. However, it was found that while decreasing the cassava row width increased the contribution of cassava to the total crop value, it significantly decreased the contribution from the second intercrop (soybean), while the yields of the first intercrops were little affected (Wargiono *et al.*, 1992). Thus, farmers that rely on the intercrops to feed their families, may still prefer to plant cassava at a row spacing of 2.0 or 2.5 m to allow for a reasonable production of the second intercrop.

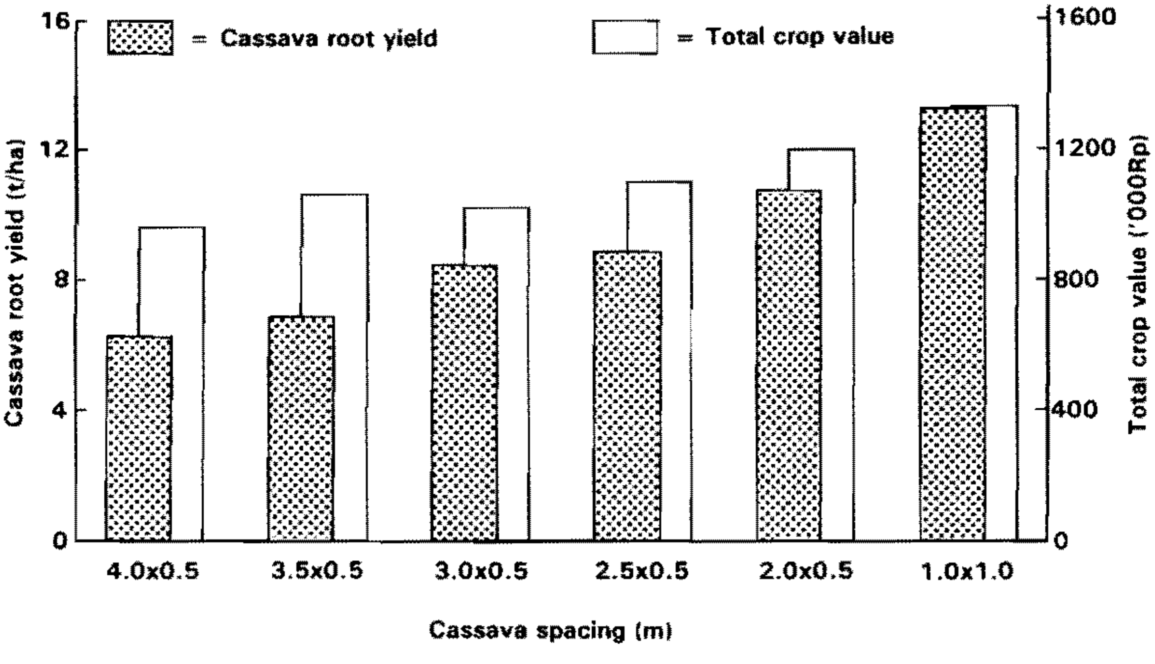


Figure 11. Effect of cassava plant spacing on average cassava root yield as well as on total crop value in two intercropping systems of cassava with either rice or peanut, followed by soybean in Yogyakarta. Data are average for two years.

B. Green manuring

Planting a green manure crop in the early part of the rainy season may be one way to increase soil OM and supply N to the cassava crop, which is planted after incorporating or mulching of the green manure. **Table 5** shows the results of a three year green manure trial conducted in Pluak Daeng, Thailand. In the first two years, cassava yields were very low because the crop could be planted only towards the middle or end of the rainy season, thus significantly reducing the number of months with adequate soil moisture. In the third year, yields were higher because cassava was harvested later, several months into the next wet season, which would preclude the use of the same land for continuous cassava production. *Crotalaria juncea, Sesbania rostrata, Crotalaria spectabilis* and *Canavalia ensiformis* were the most promising green manure species. Soil analyses indicated that green manuring during three years had no significant effect on soil OM.

Table 5. Effect of incorporating green manures on cassava root yield in three trials at Pluak Daeng, Thailand.

Green manure/fertilizer treatments	Cassava root yield (t/ha)		
	1988/89	1989/90	1990/91
No green manure, no fertilizer	3.21 cd	5.75 bcd	16.36
Sesbania rostrata, no fertilizer	9.29 a	5.37 bcd	15.04
Sesbania speciosa, no fertilizer	5.61 abcd	4.46 cd	17.52
Sesbania aculiata, no fertilizer	5.19 bcd	4.42 cd	13.23
Crotalaria juncea, no fertilizer	9.04 ab	8.83 a	17.29
Crotalaria mucronata, no fertilizer	6.71 abc	5.17 bcd	11.77
Crotalaria spectabilis, no fertilizer	5.81 abcd	3.96 d	17.64
Canavalia ensiformis, no fertilizer	5.37 bcd	7.00 abc	14.67
Indigo, no fertilizer	5.37 bcd	5.08 bcd	16.61
Mucuna fospeada, no fertilizer	5.21 bcd	6.08 abcd	16.45
Pigeon pea, no fertilizer	2.06 d	4.50 cd	14.79
No green manure, with fertilizers[1)]	8.75 ab	7.71 ab	17.04
F-test	$P \leq 0.01$	$P \leq 0.05$	NS

[1)] 100 N, 0 P, 50 kg K_2O/ha.

In order to be able to plant cassava in the early part of the rainy season it may be better to plant some of the non-climbing green manure species intercropped with cassava, cutting or pulling up the green manures after 2-3 months and leaving the residue as a mulch between cassava plants in order to reduce weeds and erosion. Alternatively, it may be possible to plant some of the drought-tolerant green manures, like pigeon pea, *Crotalaria juncea* and *Canavalia ensiformis*, at the end of the rainy season when cassava is 6-8 months old, in order to produce a green manure or mulch crop at the time of replanting cassava in the early wet season. Leaving the green manure as a mulch on the soil surface and planting cassava without tillage may reduce weeds as well as erosion.

C. Cover-cropping

The use of cover crops as live mulch growing between cassava may be another way to control erosion and weeds, and to supply N to cassava. In Pluak Daeng, Thailand, nine cover crops were planted between cassava rows (1.8x0.55 m). During the first year the cover crops were allowed to compete freely with cassava; however, before the second and third cassava planting the cover crops were slashed back and about 60 cm wide strips were cleared, either by small hand tractor or by spraying with herbicide (Paraquat). Cassava was planted in these cleared strips at 1.1x0.9 m. **Table 6** shows that cassava yields during the first two years were markedly reduced by competition from the cover crops. During the third year the cover crops were slashed back more frequently and cassava yields were less seriously affected. *Centrosema acutifolium* was the least competitive cover crop, while the two *Stylosanthes* species were overly competitive. Ideally, the cover crops should be easily established, low growing and deep rooted, so as not to compete with cassava for light, water and nutrients. So far, none of the species tested seem particularly promising, as most are either too competitive for cassava or not competitive enough to suppress the weeds.

Table 6. Effect of intercropping cassava[1] with leguminous cover crops on cassava root yield in three trials at Pluak Daeng, Thailand.

Cover crops	Cassava root yield (t/ha)		
	1988/89	1989/90	1990/91
No cover crop	11.68 a	7.79 a	19.62 a
Cover crop of *Stylosanthes hamata*	10.27 ab	3.91 c	4.45 de
Cover crop of *Arachis pintoi*	8.46 bc	6.56 ab	9.71 cd
Cover crop of *Centrosema acutifolium*	7.66 bc	6.69 ab	15.33 ab
Cover crop of *Centrosema pubescens*	7.51 bc	5.60 bc	6.17 d
Cover crop of *Mimosa envisa*	7.49 bc	6.48 ab	13.33 bc
Cover crop of *Desmodium ovalifolium*	7.26 bc	6.78 ab	13.46 bc
Cover crop'of *Macroptillium atropurpureum*	6.61 c	7.70 a	8.96 cd
Cover crop of *Stylosanthes guianensis*	3.21 d	6.56 ab	0.83 e
Cover crop of *Indigo*	3.05 d	6.36 ab	8.50 c
F-test	$P \leq 0.01$	$P \leq 0.05$	$P \leq 0.01$

[1] Cassava recieved 25 kg N, 25 kg P_2O_5, 25 kg K_2O/ha;
tractor preparation of cassava planting strips in 1989 and 1990.

D. Alley-cropping

Growing cassava between contour hedgerows of leguminous trees is called alley-cropping, and is another alternative to improve soil fertility and reduce erosion. The space between hedgerows can be varied, but is usually around 4-5 meters, so that less than 20% of total land area is occupied by the hedgerows. The hedgerows are pruned before and at regular intervals after cassava planting and the prunings are distributed among casava plants to serve as a mulch, to supply nutrients (esp. N), and to control weeds and erosion.

Various leguminous tree species are presently being tested in Rayong, Thailand, to determine their general adaptation, ease of establishment, productivity of leaf/stem biomass, resistance to regular pruning and drought tolerance. **Table 7** shows some preliminary results. Several species of *Sesbania* were highly productive in the first year, but did not resist regular pruning. Perennial pigeon pea varieties were easy to establish, were highly productive and drought tolerant, but they will probably last only a few years. *Leucaenae leucocephala, Gliricidia sepium* and *Cassia siamea* were more difficult and slow to establish, but once established they were highly productive, resistant to pruning and very persistent. *Cassia siamea* is a non-N-fixing legume tree and serves mainly to produce biomass as mulch, to recycle nutrients and protect the soil from erosion. Other species like *Flemingia macrophilla* and *Thephrosia candida* have been used successfully in other countries. Using a mixture of fast-growing pigeon pea with a slower growing but more persistent tree species like *Leucaena* may be another alternative.

Table 7. Total dry weight of prunings at three harvests as well as total nutrient content of the prunings of alley crop hedgerow species grown at Rayong Field Crops Research Center, Rayong, Thailand in 1990/91.

Alley crop hedgerow species	Total dry matter (t/ha) months after planting			Total nutrient content[1] (kg/ha)		
	3	6	13.5	N	P	K
Leucaena leucocephala	0.00	0.55	11.97	-	-	-
Gliricidia sepium	0.10	0.02	0.68	19.81	1.63	28.19
Cassia siamea	0.18	1.22	25.40	525.69	37.25	668.12
Sesbania grandiflora	1.08	0.42	0.32	48.94	3.31	51.12
Sesbania sesban	2.97	2.52	0.00	79.00	8.12	115.56
Sesbania aculeata	4.81	1.31	0.39	130.12	12.37	125.75
Sesbania javanica	1.63	0.67	0.36	52.50	3.93	52.12
Sesbania rostrata	3.67	1.17	0.00	77.19	5.25	73.31
Pigeonpea from USA	2.30	3.69	14.99	388.25	26.37	480.12
Pigeonpea ICP 8094	3.74	2.68	12.44	345.43	22.62	403.00
Pigeonpea ICP 8860	3.63	4.55	14.64	383.75	28.19	527.06
Pigeonpea ICP 11890	3.96	3.20	20.94	517.25	33.44	564.75

[1] Sum of nutrients in leaves and stems from 3 harvest.
Source: *Utai Cenpukdee, RFCRC, Rayong.*

The use of hedgerows of *Leucaena* and *Gliricidia* in a cassava field has been investigated for several years in Malang, Indonesia. The two hedgerow species were initially difficult to establish and during the first three years they had no significant effect on cassava yield or erosion (Wargiono *et al.*, 1992). However, in the fourth year, when cassava in other plots suffered from severe N-deficiency after intercropping with maize, the cassava plants in the alley-cropped treatments were tall and had dark green leaves, indicating that the prunings of the hedgerows had supplied considerable amounts of N. **Table 8** indicates that during the fourth year the two alley-cropped treatments produced by far the highest cassava yields and the lowest levels of erosion (by enhancing early canopy cover). These two treatments also resulted in the highest levels of soil OM., the lowest bulk density and the highest infiltration rates and soil aggregate stability. Thus, once well-established, hedgerows can significantly enhance soil fertility and improve the soil's physical characteristics. However, in less fertile soils or in areas with a long dry season, the hedgerows can severely compete with neighboring cassava for water and nutrients; they also require additional labor to keep properly pruned to prevent light competition.

Erosion Control

Whether or not cassava causes more or less erosion than other crops depends mainly on the soil and climatic characteristics of the region as well as on the way each crop is managed. To determine the best soil and crop management practices that will result in high yield and low levels of erosion, simple erosion control experiments have been set up in eight locations in five countries. In each trial, various management practices were established on plots located on a uniform slope. Along the lower end of each plot a contour ditch, 40 cm deep and 40 cm wide, was dug and covered with plastic so that the eroded soil would collect in the ditch. Small holes in the plastic allowed run-off water to drain out. Once a month the eroded sediments in each ditch were weighed and a sample was taken to determine its moisture content; from this the monthly dry soil loss due to erosion could be calculated.

Table 8. Effect of various agronomic practices on cassava yield, soil loss due to erosion and soil physical and chemical characteristics in Jatikerto, Malang, Indonesia, 1990/91 (4th consecutive year).

Treatments	Cassava yield (t/ha)	Dry soil loss (t/ha)	Soil OM (%)	Bulk density (t/m^3)	Infiltration rate (cm/h)	Aggregate stability (MWD) (mm)
1. Contour ridges, no live barriers	17.77	18.6	1.16	1.24	0.40	0.18
2. Contour ridges, elephant grass barriers	18.66	12.9	1.41	1.24	2.00	0.24
3. Contour ridges, setaria grass barriers	16.66	12.6	1.39	1.27	1.80	0.24
4. Contour ridges, peanut barriers	16.10	16.5	1.56	1.31	1.20	0.21
5. Contour ridges, *Gliricidia sepium* barriers	25.55	7.5	2.12	1.16	3.00	0.39
6. Contour ridges, *Leucaena leucocephala* barriers	27.77	10.9	1.94	1.17	2.20	0.38
7. No ridges, peanut bariers	13.88	26.5	1.42	1.29	1.40	0.14
8. No ridges, setaria grass barriers	13.30	24.3	1.47	1.30	0.80	0.20

Figure 12 shows the effect of various management treatments on accumulative dry soil loss due to erosion in two trials conducted on 15 and 25% slope in Hainan island of China. Highest levels of erosion were observed in those plots that had not been fertilized. Erosion was markedly reduced by contour ridging and by the use of live barriers of *Stylosanthes guianensis* and *Brachiaria decumbens*. Extremely high levels of erosion of over 250 t/ha were observed when cassava was grown without ridging after twice plowing and discing with oxen. Contour ridging again markedly reduced erosion. Lowest levels of erosion were observed with a single plowing without ridging. This practice leaves a rather rough soil surface which enhances water infiltration without negatively affecting cassava yields. **Table 9** shows the average soil losses and cassava yields during three years. Most effective in reducing erosion were the reduced tillage treatments of single plowing without ridging, planting cassava in hand-prepared holes or planting without any land preparation. Highest yields were obtained with intensive land preparation followed by contour ridging. The reduced tillage treatments reduced ,yields only slightly, while markedly reducing production costs.

Table 9. Effect of land preparation methods on average dry soil loss due to erosion and on fresh root yields of cassava, cv SC205, grown on 25% slope in SCATC, Hainan, China (data are average of trials in 1989, 1990 and 1991).

Land preparation treatments	Dry soil loss (t/ha)	Cassava root yield (t/ha)
2x oxen plowing + 2x discing + ridging	125	27.0
2x oxen plowing + 2x discing, no ridging	198	24.6
1x oxen plowing, no ridging	121	23.6
4 m wide plowed strips alternated 1 m unprepared strips	200	24.0
2 m wide plowed strips alternated 0.5 m unprepared strips	136	22.9
Preparation of planting holes (30x30 cm) with hoe	113	24.6
No preparation	116	22.8

Source: *Zhang Weite, SCATC, Baodao.*

Figure 13 shows the results of a another trial conducted on 5% slope in Tamanbogo, Sumatra, Indonesia, to determine the effect of cassava row spacing in various mono- and intercropping systems on cassava yield, total crop value and erosion. In monocropped cassava, erosion losses increased significantly as the row spacing increased. Erosion losses in cassava were always higher than in peanuts, rice and maize; in the latter crops erosion diminished after the initial month of establishment, while in

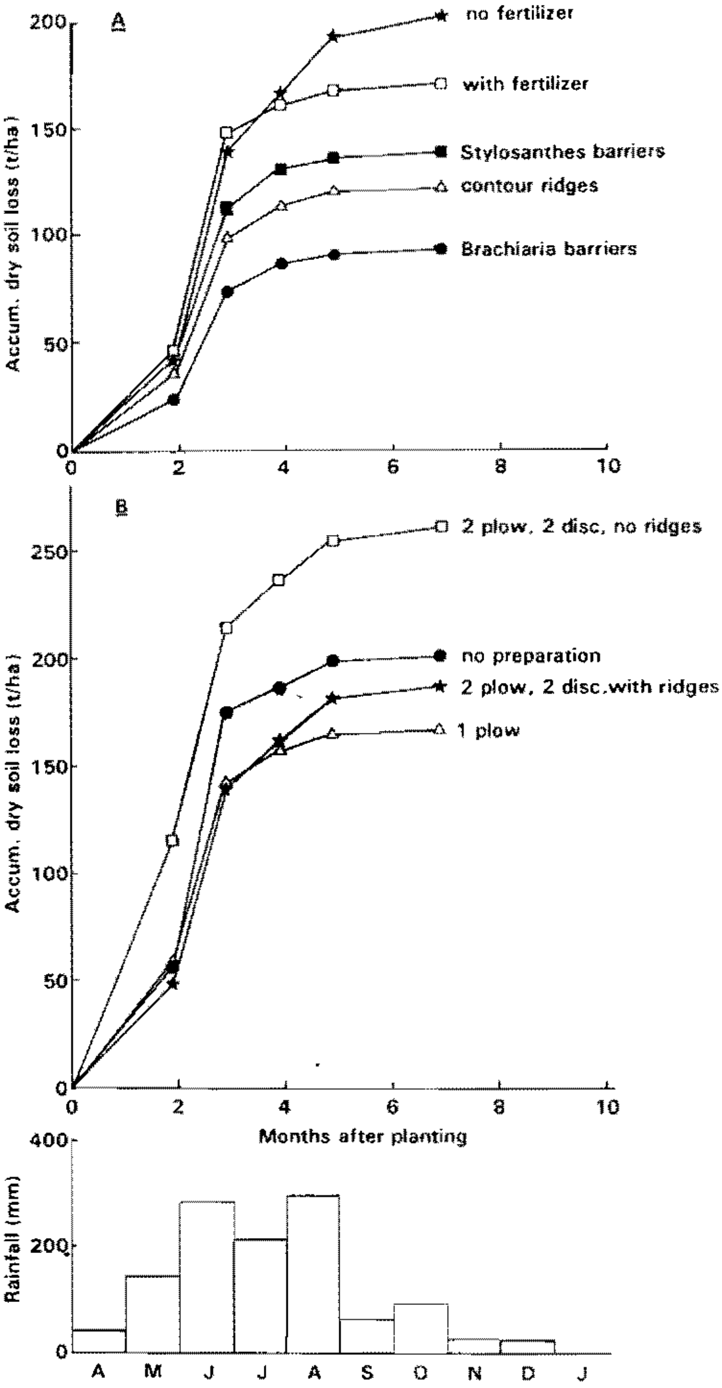


Figure 12. Effect of cultural practices (A) or land preparation methods (B) on the accumulative soil loss due to erosion when cassava, SC205, was grown on 15 and 25% slope, respectively, at SCATC, Hainan, China in 1991. Below is shown the rainfall during the growth cycle.

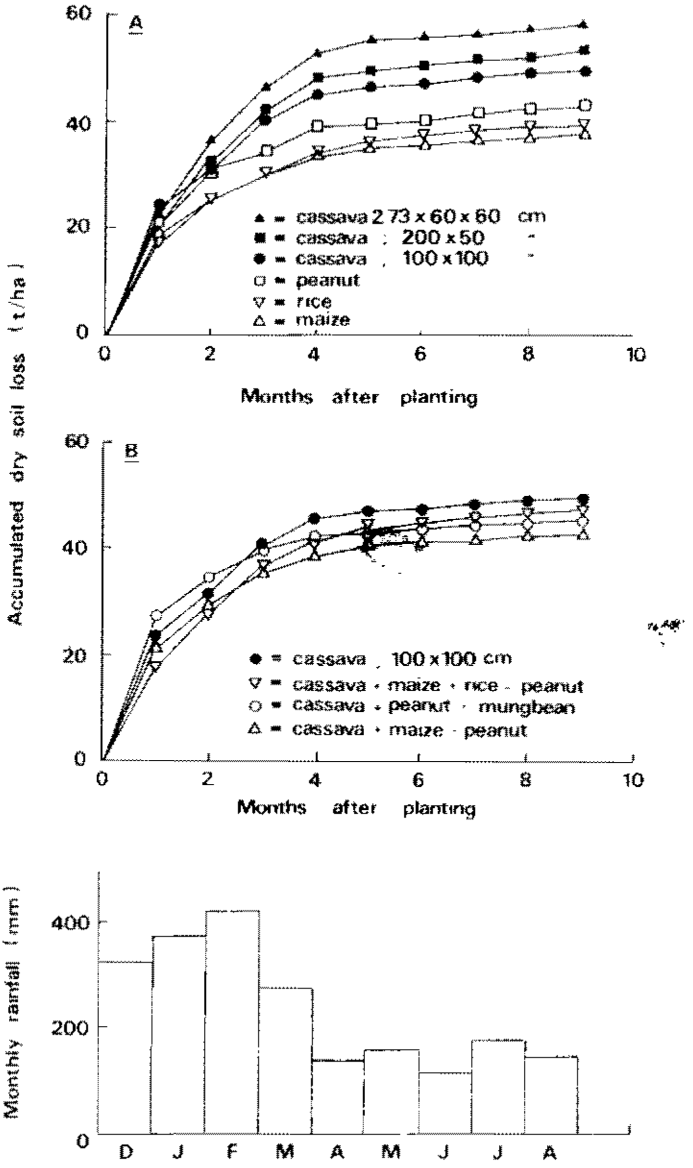


Figure 13. Accumulated dry soil loss by erosion in various monocrop (A) and intercropping (B) systems during a 9 month cropping cycle on 5% slope in Tamanbogo, Lampung, Indonesia in 1989/90. The rainfall distribution is shown below.