

## THE HISTORY AND DEVELOPMENTS OF THE CASSAVA SECTOR IN VIETNAM

*Hoang Kim<sup>1</sup>, Pham Van Bien<sup>1</sup>, Reinhardt Howeler<sup>2</sup>,  
Joel J. Wang<sup>3</sup>, Tran Ngoc Ngoan<sup>4</sup>, Kazuo Kawano<sup>5</sup>, Hernan Ceballos<sup>6</sup>*

### ABSTRACT

In Vietnam cassava has great potential both for export and for domestic consumption. In terms of cassava exports Vietnam ranks 2<sup>nd</sup> or 3<sup>rd</sup> in the world, behind Thailand and Indonesia. Exports of cassava starch are now reaching 350-450 thousand tonnes a year. Major markets of Vietnam's cassava exports are P.R of China and Taiwan, Japan, Singapore, Malaysia, South Korea and countries in Eastern Europe. Cassava research in Vietnam has made remarkable progress since 1988 when Vietnam began its cooperation with CIAT and the Asian Cassava Research Network. Further progress was achieved when Vietnam established its Cassava Research and Extension Network, in close cooperation with starch processing factories, especially Vedan Vietnam Enterprise Corp. Ltd. Presently, we have 36 cassava processing factories in operation with a total installed capacity to process about 2.2-3.8 million tonnes of fresh roots per year (40-70% of cassava production). In 2003/04 about 194,000-240,000 ha of new varieties, such as KM94, KM140, KM98-5, KM98-1, SM937-26, and KM60 were grown; this corresponds to about 52-60% of the total cassava area in the country. New, high-yielding cassava varieties and more sustainable production practices have increased the economic effectiveness of cassava production, especially in the Southeastern region. The use of farmer participatory research (FPR) in the development and transfer of new technologies to cassava producing households has been quite successful in mountainous and hilly areas of the North, the Central Coastal and Southeastern Regions. The use of cassava roots and leaves in animal feed is also being studied. The Vietnam Cassava Research and Development Project promotes the rapid multiplication and wide distribution of high-starch and high-yield varieties, and the adoption of sustainable cassava production practices, especially in the Central Coastal, Central Highland, Northeastern, Northwestern Regions.

### INTRODUCTION

In Vietnam, cassava has rapidly changed its role from a food crop to an industrial crop, with a high rate of growth during the first years of the 21<sup>st</sup> Century. Vietnam has become the third exporter of cassava products, after Thailand and Indonesia. Cassava is one of the seven new agricultural export products, which caught the attention of the government and local authorities. This paper covers three subjects: 1) New developments of the cassava sector of Vietnam; 2) New progress in cassava research and extension; and 3) Investment in cassava development: opportunities and prospects.

### NEW DEVELOPMENTS OF THE CASSAVA SECTOR IN VIETNAM

Cassava in Vietnam is among the four most important food crops. It is a secondary crop but plays an important role in the strategy of national food security. Vietnam is an agricultural country with a population of 80 million. About 20% of farmer households are poor and 5% suffer from hunger. During the past decade of economic renovation, Vietnam has successfully escaped lingering

---

<sup>1</sup> Institute of Agricultural Sciences of South Vietnam (IAS), 121 Nguyen Binh Khiem St., Ho Chi Minh City, Vietnam; [kimharc@hcm.vnn.vn](mailto:kimharc@hcm.vnn.vn)

<sup>2</sup> CIAT Regional Cassava Office for Asia, Dept. of Agric., Chatuchak, Bangkok 10900, Thailand  
[ciat-bangkok@cgiar.org](mailto:ciat-bangkok@cgiar.org)

<sup>3</sup> VEDAN - Vietnam Enterprise Corp. Ltd., Phuoc Thai, Long Thanh, Dong Nai, Vietnam  
[vedan1@hcm.vnn.vn](mailto:vedan1@hcm.vnn.vn)

<sup>4</sup> Thai Nguyen University of Agriculture and Forestry, Thai Nguyen, Vietnam; [tngnoan@vnn.vn](mailto:tngnoan@vnn.vn)

<sup>5</sup> Yamatedai 3,3-13 Ibaraki-shi, Osaka 567-0009 Japan, [ke.kawano@mist.ocn.ne.jp](mailto:ke.kawano@mist.ocn.ne.jp)

<sup>6</sup> CIAT/ Cassava Breeding Unit, Coordinator; Km 17, Recta Cali-Palmira, AA 6713 Cali, Colombia  
[H.Ceballos@cgiar.org](mailto:H.Ceballos@cgiar.org)

**Table 1. Area, yield and production of principle food crops in Vietnam 1999- 2002**

Crop		2001	2002	2003	2004
Rice	Area ('000 ha)	7,492.7	7,504.3	7,449.3	7,400.0
	Yield (t/ha)	4.28	4.59	4.63	4.79
	Production ('000 t)	32,108.4	34,447.2	34,518.6	35,500.0
Maize	Area ('000 ha)	729.5	816.4	909.8	964.6
	Yield (t/ha)	2.96	3.07	3.22	2.49
	Production ('000 t)	2,161.7	2,511.2	2,933.7	2,400.0
Cassava	Area ('000 ha)	292.3	337.0	371.9	370.5
	Yield (t/ha)	12.01	13.17	14.06	14.49
	Production ('000 t)	3,509.2	4,438.0	5,228.5	5,370.0
Sweet potato	Area ('000 ha)	244.6	237.7	219.9	220.0
	Yield (t/ha)	6.76	7.17	7.24	7.50
	Production ('000 t)	1,653.5	1,703.7	1,592.1	1,650.0

*Source: FAOSTAT, 2005*

In Vietnam, there about 41 of 48 cassava processing factories are fully operational with a total processing capacity of 2.2-3.8 million tonnes of fresh roots per year (**Table 2**). Total cassava starch production in Vietnam was about 600,000- 800,000 tonnes in 2004 of which 70% was for export and 30% for domestic use.

Recently, Vietnam has become the second or third largest exporter of cassava products, after Thailand and Indonesia. In 2002/03, the trade of cassava products all over the world was about 5.9 million tonnes, including dried chips, pellets and starch. Thailand and Vietnam are now the two main cassava exporting countries (**Table 3**). Major markets of Vietnam's cassava exports are the P.R. of China and Taiwan, Japan, Singapore, Malaysia, South Korea and countries in Eastern Europe. Vedan-Vietnam Enterprise Corp. Ltd. is one of the leading companies in cassava processing. In addition, animal feed factories also contributed significantly to the increasing demand for cassava roots. Although in Vietnam cassava processing is a relatively new business and export volumes are still low, the cassava processing factories are new and modern. That's why Vietnam's cassava products may have a competitive advantage in the world market.

### CASSAVA RESEARCH

Cassava breeding and varietal dissemination in Vietnam have made continuous progress. Before 1985, Gon, H34 and Xanh Vinh Phu were the most popular cassava varietal in Vietnam. From 1986 to 1993, HL20, HL23 and HL24 were selected from the local varieties collection by Hung Loc Agricultural Research Center (HARC); they were grown extensively in South Vietnam with annual areas of about 70,000 to 80,000 ha planted to these varieties. During the past seventeen years (1988-2005) ) the Institute of Agricultural Science of South Vietnam (IAS) and the Vietnam Cassava Research and Extension Network (VNCP), in close cooperation with CIAT, Vedan and other starch processing factories have developed and disseminated new high-yielding varieties: KM60, KM94, KM95, KM95-3, KM98-1, KM98-5, KM140 and SM937-26 (**Table 4**) (Hoang Kim *et al.*, 2001b). The first two varieties, KM60 and KM94, are the renamed Thai varieties Rayong 60 and Kasetsart 50, which were selected from a number of Thai varieties introduced as clonal planting material in 1990 and 1991. The remaining varieties are selections from sexual seed produced in Thailand or Vietnam (**Figure 1**).

**Table 2. Cassava Processing Factories in Vietnam in 2004**

Region	Province	Number of cassava processing factories	Capacity (tonnes of cassava starch /day)	Production ('000 tonnes of fresh roots/year)	Note
Southeastern Region	Tay Ninh	9	670	529.1	in operation
	Binh Phuoc	6	590	370.6	“
	Dong Nai	5	415	284.5	“
	Baria Vungtau	1	175	121.2	“
Mekong River Delta	An Giang	1	60	24.0	“
Central Highlands	Dak Lak	2	110	36.1	“
	Gia Lai	1	50	144.0	“
	Kon Tum	2	150	155.8	“
South Central Coast	Quang Nam	1	100	108.9	“
	Quang Ngai	1	50	63.9	“
	Binh Dinh	1	60	39.0	under construction
	Phu Yen	1	50	33.7	in operation
North Central Coast	Ninh Thuan	1	60	41.5	“
	Binh Thuan	2	110	96.4	“
	Ninh Binh	1	60	46.9	under construction
	Thanh Hoa	2	110	93.1	in operation
	Nghe An	1	60	63.1	“
	Quang Binh	1	60	48.2	“
Northeastern Region	Quang Tri	1	60	27.4	“
	Thua Thien Hue	1	100	28.3	“
	Bac Can	2	180	123.3	under construction
	Yen Bai	1	50	76.2	in operation
	Phu Tho	1	60	92.5	“
Northwestern Region	Son La	3	150	142.8	under construction
<b>Total</b>		<b>48</b>	<b>3,480</b>	<b>2,790.5</b>	

**Table 3. World trade of cassava products (dried chips, pellets and starch) in millions of tonnes.**

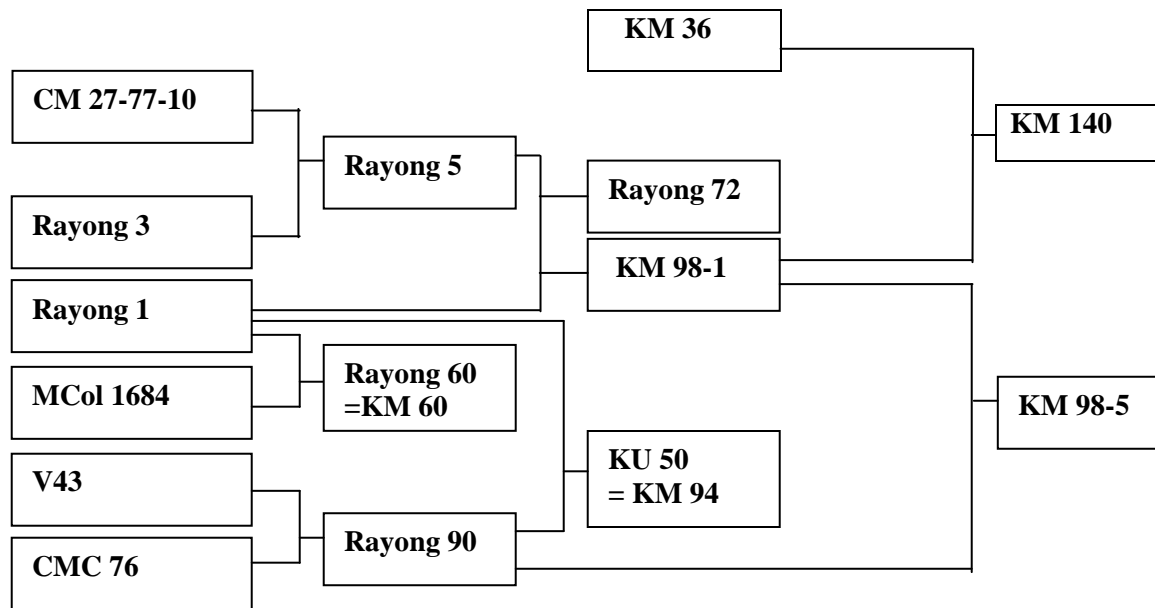
Market Region	Average of '83-'85	Average of '92-'93	Average of '95-'96	1998	2000	2001	2002 prelim.
<b>World Exports</b>	<b>7.0</b>	<b>9.8</b>	<b>5.9</b>	<b>7.0</b>	<b>6.9</b>	<b>7.4</b>	<b>5.9</b>
Thailand	6.4	8.3	4.6	6.4	6.5	7.1	5.7
Indonesia	0.4	1.1	0.6	0.3	0.2	0.1	0.1
China & Taiwan	0.1	0.3	0.4	-	-	-	-
Other countries	0.1	0.1	0.3	0.2	0.2	0.1	0.1
+ Vietnam	-	-	(0.1)	(0.2)	(0.2)	(0.2)	(0.3)
<b>World Imports</b>	<b>6.6</b>	<b>9.7</b>	<b>5.9</b>	<b>7.0</b>	<b>6.9</b>	<b>7.4</b>	<b>5.9</b>
EU	5.5	6.5	3.5	4.3	3.7	2.7	1.5
China & Taiwan	0.3	0.9	0.7	1.1	0.9	2.6	2.5
Japan	0.3	0.5	0.4	0.5	0.6	0.7	0.7
South Korea	0.2	0.7	0.3	0.1	0.1	0.2	0.1
Other countries	0.3	1.1	1.0	0.9	(1.6)	(1.2)	(1.3)
+ Malaysia					0.2	0.2	0.2
+ Indonesia					0.5	0.2	0.1
+ USA					0.1	0.1	0.1

*Source: Hoang Kim adapted from FAO/FIEWS-Food Outlook No.4- Oct.2003; Pham Van Bien, et al., 2001; FAO/FIEWS-Food Outlook No.4 -Oct.2001; Hoang Kim et al., 2000; Henry and Hershey, 1998, Henry and Gottret, 1996.*

**Table 4. Average results of Regional Yield Trials conducted by Hung Loc Agricultural Research Center in central and south Vietnam (2001-2003).**

Variety	Growing period (months)	Fresh root yield (t/ha)	Starch content (%)	Starch yield (t/ha)	Harvest index (%)	Plant type & stake quality (1-10)	Root shape & uniformity (1-10)
HL23 (local check)	9-11	16.5	25.3	4.2	53	8	7
KM94	9-11	33.0	28.7	9.5	58	8	9
KM98-1	8-10	32.2	27.6	8.9	66	8	9
KM98-5	8-10	34.5	28.5	9.8	63	9	9
KM140	8-10	35.0	28.7	10.0	65	10	9

*Source: Tran Cong Khanh, 2004; Hoang Kim et al., 2004.*



**Figure 1.** The pedigree of KM60, KM94, KM98-1, KM98-5 and KM140

Note: KM 36 is a local variety from north Vietnam, similar to Xanh Vinh Phu

New high-yielding cassava varieties and more sustainable production practices have increased the economic effectiveness of cassava production. Many farmers have become rich by growing cassava. For example, in An Vien and Doi 61 communes in Trang Bom district of Dong Nai province, 97% of the agricultural land has poor gray sandy soil. Cassava is the main crop (1,099 ha), followed by cashew (534 ha) and other minor crops. Previously, farmers grew the old cassava varieties Gon and HL23 with average yields about 9-12 t/ha. In recent years, by growing new high-yielding varieties and applying improved cultural practices, the average yield in this commune increased up to 16-32 t/ha. Many farmers are now growing varieties KM94, KM140, KM98-5, obtaining 25-35 t/ha in areas of 3-5 hectares (**Table 5**).

In 2003/04 about 194,000-240,000 ha of cassava in Vietnam were planted with new varieties; this corresponds to about 52-60% of the total cassava area in the country (**Table 6**). Cassava yield and production in several provinces have doubled, partially brought about by the construction of new large-scale cassava processing factories.

**Table 5. Impact of the adoption of new cassava varieties KM94, KM140, KM98-5 in An Vien and Doi 61 communes in Trang Bom district of Dong Nai province in 2003/04.**

No	Name of farmer	Cassava area (ha)	Fresh root yield (t/ha)	Starch content (%)	Growing period (months)
01	Duong Minh Giang	4	34	28.5	9
02	Nguyen Van Dung	2	32	28.0	9
03	Nguyen Hong Minh	5	32	26.0	10.5
04	Nguyen Viet Tuan	3	30	29.0	9
05	Pham Van Manh	2	30	27.5	10
06	Nguyen Van Rung	5	42	27.0	10
07	Nguyen Tan Hung	2	30	24.5	11
08	Nguyen Van Hoi	1	34	27.5	10
09	Vo Van Dong	5	31	28.0	9.5
10	Nguyen Hung Cuong	5	30	29.0	9
11	Truong Minh Luc	2	28	29.2	10
12	Vo Hoang Duu	4	30	28.0	10
13	Ngo Hoang Minh	2	33	27.9	10
14	Truong Minh Nghia	3	27	29.5	10
15	Hoang Minh Thu	5	27	29.0	10
16	Pham Huu Tai	0.5	31	28.7	10
17	Ngo Minh Phuc	1.5	32	26.5	10.5
18	Ngo Van Quach	2	30	27.3	9.5
19	Ngo Thi Hai	2	28	28.0	10
<b>Total</b>		<b>52</b>	<b>31</b>	<b>27.8</b>	

Source: Tran Cong Khanh, Hoang Kim et al., 2004.

**Table 6. Approximate cassava area, production and yield as well as the spread of new varieties in various regions of Vietnam in 2003/2004.**

Regions	Cassava production (‘000 t)	Fresh root yield (t/ha)	Total area (‘000 ha)	Total area with new varieties (‘000 ha)	% with new cassava varieties
<b>Total Vietnam</b>	<b>5,228.2</b>	<b>14.07</b>	<b>371.9</b>	<b>194.0</b>	<b>52</b>
-Red River Delta	87.2	11.63	7.7	2.2	28
-Northeastern Region	527.7	11.11	47.5	12.7	26
-Northwestern Region	326.2	8.70	37.5	5.8	15
-North Central Coast	460.5	10.33	44.6	17.7	40
-South Central Coast	637.8	12.94	49.3	27.3	55
-Central Highlands	934.8	14.27	65.5	30.6	47
-Southeastern Region	2,119.3	19.30	109.8	93.5	85
-Mekong River Delta	135.0	13.50	10.0	4.2	42

Source: adapted from General Statistical Yearbook, 2004; and MARD, 2004.

Market demand for cassava products increased and new high-yielding cassava varieties are being disseminated widely, resulting in higher profits for cassava farmers. The establishment of new processing factories and increases in yield and starch content resulted in increased production of 2,256,000 tonnes of fresh roots (371,700 ha x 6.07 t/ha= 2,256,000 tonnes or about 600,000 tonnes of starch; this means that approximately 814 billion VND (51,89 million US\$) per year were added to farmers’ income in 2003 as compared to 1999 (Table 7).

**Table 7. Estimated increase in gross income of cassava farmers in China, Thailand Vietnam as a result of increased cassava yields in 2003 as compared to 1999.**

Country	Cassava area in 2003 (ha) <sup>1)</sup>	Cassava yield (t/ha)		Yield increase (t/ha)	Cassava price (US\$/ tonne)	Increased gross income due to higher yields (US\$)
		1999	2003			
China	240,108	15.96	16.24	0.28	26	1,748,000
Thailand	1,050,000	15.49	17.55	2.06	23	49,749,000
Vietnam	371,700	7.99	14.06	6.07	23	51,893,000

<sup>1)</sup> *Source: FAOSTAT 2004*

## **NEW PROGRESS IN CASSAVA RESEARCH AND EXTENSION**

### ***Selection and development of cassava varieties with high fresh root yield and high starch content.***

During the 2001-2005 period, VNCP promoted the rapid multiplication and wide distribution of high-yield with high-starch varieties, and the adoption of sustainable cassava production practices, especially in the Central Coast, Central Highlands and Northern mountains and uplands. Up to now, ten million stakes of new varieties, mainly KM94, KM98-5 and KM140, were distributed to various provinces in this project.

About 250 cassava accessions are being maintained in the germplasm bank. We have also evaluated about 24,300 hybrid seeds introduced from CIAT/Colombia and the Thai-CIAT program, and we have produced ourselves more than 6,300 hybrid seeds from 9-15 cross combinations; KM98-5 and KM140 are advanced cultivars selected from our own crosses, which are now ready for release (Hoang Kim *et al.*, 2002b; 2003).

### ***Selection of cassava doubled haploid lines derived from materials of CIAT and applying mutation in cassava breeding.***

Farmers in Vietnam requested early maturing varieties which have a duration shorter than 7 months to escape from floods in the rainy season and for crop rotation. These varieties also need to have fresh root yields of about 26-30 t/ha and starch contents of about 25-27%. The introduction and development of doubled haploid cassava (DH) plants from CIAT, and the use of mutation breeding in cassava could become an important tool to support hybrid cassava breeding. In the period 2002-2005, at HARC, 20,000 seeds of 5 advanced cassava varieties have been subjected to different doses of Gamma rays of <sup>60</sup>Co to create different mutants for selecting. More than 96 promising new clones have been selected, of which KM228 will be further tested (Hoang Kim *et al.*, 2004). We participate in a collaborative program with Dr. Hernan Ceballos of CIAT-Colombia in evaluating new breeding lines in Vietnam. It is hoped that within the next few years, several new high-quality varieties will be released to farmers.

### ***Research on integrated cultivation techniques to increase the productivity and economic efficiency of cassava production in different eco-regions.***

The project of "Improving the Sustainability of Cassava-based Cropping Systems in Vietnam" financially supported by the Nippon Foundation, was implemented with CIAT's technical support (Howeler, 2004). The use of Farmer Participatory Research (FPR) in the development and transfer of new technologies to cassava households has been quite successful in mountainous and hilly areas of the North, the Central Coast and the Southeastern Region. Several suitable cassava cultural practices were developed: 1) erosion control by growing vetiver grass and other plant species along contour lines; 2) balanced fertilizer application of about 60 kg N, 40 P<sub>2</sub>O<sub>5</sub> and 120 K<sub>2</sub>O/ha, together with animal manures; 3) intercropping of cassava with peanut and/or mungbean; 4) planting new high-yielding varieties; 5) using the herbicide Dual (2.4 l/ha); and 6) using silage of

cassava leaves and roots for animal feeding (Tran Ngoc Ngoan and Howeler, 2002; Nguyen Huu Hy *et al.*, 2002; Thai Phien and Nguyen Cong Vinh, 2002). The project was actively supported by farmers, because it helped them make effective use of available local resources and developed better cassava cultural practices through their own selection (Nguyen The Dang, 2002; Le Van An *et al.*, 2002; Nguyen Thi Cach *et al.*, 2002; Tran Thi Dung and Nguyen Thi Sam, 2002).

#### ***Use of Cassava Leaves and Roots in Animal Feeds and Food Processing.***

Cassava leaves have a high protein content (20-25% of dry leaves), while cassava roots have 25-30% starch but are low in protein (1-3%). High yielding cassava varieties usually have high HCN contents, limiting the use of roots and leaves for animal feed. Drying or ensiling of cassava leaves and roots will markedly reduce their HCN content. Many studies have shown the effect of different processing methods on the chemical contents and nutritional values of cassava leaves and roots (Pham Sy Tiep, 2001); the use of cassava root and leaves for feeding pigs (Le Duc Ngoan and Nguyen Thi Hoa Ly, 2002); young stems and leaves for feeding cows (Doan Duc Vu, 2001); the use of cassava dried leaf powder as animal feed for chickens and pigs (Duong Thanh Liem *et al.*, 1998); feeding cassava leaves to silkworms (Tran Cong Tien *et al.*, 2001); using cassava stems to grow mushrooms (KCM TN, 2002). Studies about the use of cassava leaves in industrial processing and for feed by Glon-Sanders Inc. and Proconco Company were conducted in the Southeastern Region (Froehlich and Thai Van Hung, 2001).

### **INVESTMENT FOR CASSAVA: OPPORTUNITIES AND PROSPECT**

#### ***Increasing Demand for Cassava.***

Cassava roots have multiple end-uses, such as for the starch industry, for food and feed processing, for the pharmaceutical industry and for export. Cassava is an easy crop to grow. It can grow in poor soils and produces high yields with suitable management. The crop can be grown in many areas. The average yield of cassava is now only about 14 t/ha, but the yield can be doubled in many provinces. Previously, people were reluctant to grow cassava, because they thought that cassava caused soil degradation and produced low profits. But in reality one hectare of cassava can produce 60-80 tonnes of fresh roots and leaves. The situation has changed because of the development of sustainable cultivation techniques and new high-yielding varieties. Cassava has become a cash crop in many provinces of Vietnam. Cassava starch is now being produced competitively, and cassava markets are promising. The combination of growing and processing cassava has created many jobs, has increased exports, attracted foreign investment, and contributed to industrialization and modernization of several rural areas.

#### ***Development of the Vietnam Cassava Program.***

After 15 years of development (1991-2005), intensive cassava research and extension have changed cassava from being a food crop to being an industrial crop. Vietnam cassava starch is now very promising, both for export and domestic use.

During the tenth Vietnam Cassava Workshop it was agreed to emphasize the following seven topics (Pham Van Bien *et al.*, 2001):

- 1) Determination of an appropriate strategy for cassava research and development
- 2) Selection and dissemination of high-yielding varieties with high starch contents
- 3) Transfer of appropriate cultivation techniques to farmers in different areas
- 4) Cooperation with processing factories in establishing areas with a stable source of raw materials
- 5) Research on the development of cassava processing technologies
- 6) Structural improvement and development of the extension network

## 7) Development of local and export markets for cassava products

**REFERENCES**

- Doan Duc Vu. 2001. The use of cassava young stems and leaves for feeding cows. IAS Annual report 2001, No. 2. (in Vietnamese with English Summary)
- Duong Thanh Liem, Nguyen Phuc Loc, Nguyen Van Hao, Ngo Van Man, Bui Huy Nhu Phuc and Bui Xuan An. 1998. The use of cassava dried leaf powder as animal feed. *In: VNCP-IAS-CIAT-VEDAN. Hoang Kim and Nguyen Dang Mai (Eds.). Progress in Cassava Research and Extension in Vietnam. Proc. 7<sup>th</sup> Vietnamese Cassava Workshop, held March 4-6, 1997 in IAS, Ho Chi Minh city, Vietnam. pp.256-265. (in Vietnamese with English Summary)*
- Food and Agricultural Organization (FAO). 2001,2003. FAO/GIEWS-Food Outlook No. 4 Oct. 2001; FAO/GIEWS-Food Outlook No. 4, Oct 2003.
- Froehlich and Thai Van Hung. 2001. Studies about the use of cassava leaves in industrial processing and for feed. *In: VNCP-IAS-CIAT-VEDAN. Hoang Kim and Nguyen Dang Mai (Eds.). Progress in Cassava Research and Extension in Vietnam. Proc. 10<sup>th</sup> Vietnamese Cassava Workshop, held March 13-14, 2001 in IAS, Ho Chi Minh city, Vietnam. pp.172-178. (in Vietnamese with English Summary)*
- Henry, G. and V. Gottret. 1996. Global Cassava Trends: Reassessing the Crop's Future. CIAT Working Document No. 157. Cali, Colombia. 45 p.
- Henry, G. and C.H. Hershey. 1998. Trends, constraints and opportunities of the Asian cassava sector: An assessment. *In: R.H. Howeler (Ed.). Cassava Breeding, Agronomy and Farmer Participatory Research in Asia. Proc. 5<sup>th</sup> Regional Workshop, held in Danzhou, China. Nov 3-8, 1996. pp. 3-20.*
- Hoang Kim, Luong Thu Tra, Bui Trang Viet, Hernan Ceballos, Phan Ngo Hoang, Ngo Vi Nghia, Tang Phu An, Nguyen Thi Thuy, Phan Thi Yen Nhi and Pham Danh Tuong, 2004. Cassava improvement by using nuclear techniques. Working paper, 24 p. (in Vietnamese with English Summary)
- Hoang Kim, Tran Ngoc Ngoan, Trinh Phuong Loan, Bui Trang Viet, Vo Van Tuan, Tran Cong Khanh, Tran Ngoc Quyen and Hernan Ceballos. 2002. Genetic improvement of cassava in Vietnam: Current status and future approaches. *In: R.H. Howeler (Ed.). Cassava Research and Development in Asia: Exploring New Opportunities for an Ancient Crop. Proc. 7<sup>th</sup> Regional Cassava Workshop, held in Bangkok, Thailand. Oct 28-Nov 1, 2002. [http://www.ciat.cgiar.org/asia\\_cassava](http://www.ciat.cgiar.org/asia_cassava) (in preparation)*
- Hoang Kim, Pham Van Bien and R.H. Howeler. 2001. Status of cassava in Vietnam: Implications for future research and development. *In: A Review of Cassava in Asia with Country Case Studies on Thailand and Vietnam. Proc. Validation Forum on the Global Cassava Development Strategy, held in Rome, Italy. April 26-28, 2000. Volume 3. pp. 103-184.*
- Howeler, R.H. 2004. Intergrated Cassava-based Cropping Systems in Asia: Farming Practices to Enhance Sustainability. End of Project Report - Second Phase of the Nippon Foundation Cassava Project in Asia 1999-2003. CIAT Bangkok, Thailand, April, 2004, 120 p.
- Le Duc Ngoan and Nguyen Thi Hoa Ly. 2002. The use of cassava root and leaves for feeding pigs in Vietnam. *In: R.H. Howeler (Ed.). Cassava Research and Development in Asia: Exploring New Opportunities for an Ancient Crop. Proc. 7<sup>th</sup> Regional Cassava Workshop, held in Bangkok, Thailand. Oct 28-Nov 1, 2002. [http://www.ciat.cgiar.org/asia\\_cassava](http://www.ciat.cgiar.org/asia_cassava) (in preparation)*
- Le Van An, Hoang Thi Sen, Nguyen Xuan Hong, Hoang Huu Hoa, Le Quang Bao, Nguyen Thi Cach, Nguyen Thi My Van and Peter Kerridge. 2002. Use of participatory approaches in ensuring sustainable livelihoods for poor communities in the steep uplands of Central Vietnam. *In: R.H. Howeler (Ed.). Cassava Research and Development in Asia: Exploring New Opportunities for an Ancient Crop. Proc. 7<sup>th</sup> Regional Cassava Workshop, held in Bangkok, Thailand. Oct 28-Nov 1, 2002 [http://www.ciat.cgiar.org/asia\\_cassava](http://www.ciat.cgiar.org/asia_cassava) (in preparation)*
- Ngo Ke Suong and Hoang Kim Anh. 2001. The hydrolysis of cassava starch by amylase enzyme for alcohol production. *In: VNCP-IAS-CIAT-VEDAN. Hoang Kim and Nguyen Dang Mai (Eds.) Progress in Cassava Research and Extension in Vietnam. Proc. 10<sup>th</sup> Vietnamese Cassava Workshop, held March 13-14, 2001 in IAS, Ho Chi Minh city, Vietnam. pp.195-204. (in Vietnamese with English Summary)*
- Nguyen Huu Hy, Nguyen The Dang, Pham Van Bien and Nguyen Thi Dung. 2002. Cassava agronomy research in Vietnam. *In: R.H. Howeler (Ed.). Cassava Research and Development in Asia: Exploring New Opportunities for an Ancient Crop. Proc. 7<sup>th</sup> Regional Cassava Workshop, held in Bangkok, Thailand. Oct 28-Nov 1, 2002. [http://www.ciat.cgiar.org/asia\\_cassava](http://www.ciat.cgiar.org/asia_cassava) (in preparation)*
- Nguyen The Dang. 2002. Farmer participatory research (FPR) on soil erosion control and fertilizer use for cassava in Vietnam. *In: R.H. Howeler (Ed.). Cassava Research and Development in Asia: Exploring New*



- Opportunities for an Ancient Crop. Proc. 7<sup>th</sup> Regional Cassava Workshop, held in Bangkok, Thailand. Oct 28-Nov 1, 2002. [http://www.ciat.cgiar.org/asia\\_cassava](http://www.ciat.cgiar.org/asia_cassava) (in preparation)
- Nguyen Thi Cach, Trinh Thi Phuong Loan, Tran Ngoc Ngoan, Hoang Kim, Vo Van Tuan and Tran Thi Dung. 2002. Farmer participatory variety trials conducted in Vietnam. *In*: R.H. Howeler (Ed.). Cassava Research and Development in Asia: Exploring New Opportunities for an Ancient Crop. Proc. 7<sup>th</sup> Regional Cassava Workshop, held in Bangkok, Thailand. Oct 28-Nov 1, 2002. [http://www.ciat.cgiar.org/asia\\_cassava](http://www.ciat.cgiar.org/asia_cassava) (in preparation)
- Pham Sy Tiep. 2001. The effect of different processing methods on the chemical contents and nutritional values of cassava leaves and roots. *In*: VNCP-IAS-CIAT-VEDAN. Hoang Kim and Nguyen Dang Mai (Eds.). Progress in Cassava Research and Extension in Vietnam. Proc. 10<sup>th</sup> Vietnamese Cassava Workshop, held March 13-14, 2001 in IAS, Ho Chi Minh city, Vietnam. pp. 167-171. (in Vietnamese with English Summary)
- Pham Van Bien, Hoang Kim, Joel J. Wang and R.H. Howeler. 2001. Present situation of cassava production and the research and development strategy in Vietnam. *In*: R.H. Howeler and S.L.Tan (Eds.). Cassava's Potential in the 21<sup>st</sup> Century: Present Situation and Future Research and Development Needs. Proc. 6<sup>th</sup> Regional Workshop, held in Ho Chi Minh city, Vietnam. Feb 21-25, 2000. pp. 16-24.
- Statistical Yearbook. 2001, 2002, 2003, 2004. Area, yield and production of cassava by province in Vietnam.
- Thai Phien and Tran Cong Vinh 2002. Soil organic matter management for sustainable cassava production in Vietnam. *In*: R.H. Howeler (Ed.). Cassava Research and Development in Asia: Exploring New Opportunities for an Ancient Crop. Proc. 7<sup>th</sup> Regional Cassava Workshop, held in Bangkok, Thailand. Oct 28-Nov 1, 2002. [http://www.ciat.cgiar.org/asia\\_cassava](http://www.ciat.cgiar.org/asia_cassava). (in preparation)
- Tran Ngoc Ngoan and R.H. Howeler. 2002. The adoption of new technologies and the socio-economic impact of the Nippon Foundation project in Vietnam. *In*: R.H. Howeler (Ed.). Cassava Research and Development in Asia: Exploring New Opportunities for an Ancient Crop. Proc. 7<sup>th</sup> Regional Cassava Workshop, held in Bangkok, Thailand. Oct 28-Nov 1, 2002. [http://www.ciat.cgiar.org/asia\\_cassava](http://www.ciat.cgiar.org/asia_cassava). (in preparation)
- Tran Thi Dung and Nguyen Thi Sam. 2002. FPR trials on cassava intercropping systems in Vietnam. *In*: R.H. Howeler (Ed.). Cassava Research and Development in Asia: Exploring New Opportunities for an Ancient Crop. Proc. 7<sup>th</sup> Regional Cassava Workshop, held in Bangkok, Thailand. Oct 28-Nov 1, 2002. [http://www.ciat.cgiar.org/asia\\_cassava](http://www.ciat.cgiar.org/asia_cassava) (in preparation)
- Tran Cong Khanh, Hoang Kim, Vo Van Tuan, Nguyen Huu Hy, Pham Van Bien and R.H. Howeler. 2004. Cassava variety KM98-5. Working paper. 36 p. (in Vietnamese with English Summary)

**Appendix 1: Approximate cassava area, production and yield as well as the spread of new varieties in various provinces and various regions of Vietnam in 2003/2004.**

Region/province	Cassava planted area (‘000 ha)	Cassava yield (t/ha)	Cassava production (‘000 tonnes)	Total area with new varieties (‘000 ha)	% with new cassava varieties
<b>TOTAL VIETNAM</b>	<b>371.9</b>	<b>14.07</b>	<b>5,228.2</b>	<b>194.0</b>	<b>52</b>
<b>Red River Delta</b>	<b>7.7</b>	<b>11.63</b>	<b>87.2</b>	<b>2.2</b>	<b>28</b>
Ha Noi	0.3	6.33	1.9		
Hai Phong	0.1	11.00	1.1		
Vinh Phuc	2.2	9.82	21.6	0.2	
Ha Tay	2.7	11.81	31.9	1.3	
Bac Ninh	0.1	3.00	0.3		
Hai Duong	0.1	7.00	0.7		
Ha Nam	0.9	14.11	12.7	0.3	
Nam Dinh	0.3	8.00	2.4		
Thai Binh	0.1	4.00	0.4		
Ninh Binh	0.9	15.78	14.2	0.4	
<b>Northeast Region</b>	<b>47.5</b>	<b>11.11</b>	<b>527.7</b>	<b>12.7</b>	<b>26</b>
Ha Giang	2.6	7.65	19.9		
Cao Bang	1.7	8.12	13.8		
Lao Cai	6.3	10.76	67.8		
Bac Kan	3.0	10.20	30.6	0.2	
Lang Son	4.2	8.57	36.0		
Tuyen Quang	3.5	10.94	38.3	1.0	
Yen Bai	10.2	15.48	157.9	6.0	
Thai Nguyen	3.9	9.15	35.7	2.0	
Phu Tho	7.8	11.32	88.3	3.5	
Bac Giang	3.0	9.53	28.6		
Quang Ninh	1.3	8.31	10.8		
<b>Northwest Region</b>	<b>37.5</b>	<b>8.70</b>	<b>326.2</b>	<b>5.8</b>	<b>15</b>
Lai Chau	9.9	6.97	69.0	0.2	
Son La	17.9	9.60	171.9	3.5	
Hoa Binh	9.7	8.79	85.3	2.1	
<b>North Central Coast</b>	<b>44.6</b>	<b>10.33</b>	<b>460.5</b>	<b>17.7</b>	<b>40</b>
Thanh Hoa	15.2	8.26	125.5	4.5	
Nghe An	11.3	13.29	150.2	5.5	
Ha Tinh	3.1	7.45	23.1	0.3	
Quang Binh	4.0	9.45	37.8	1.8	
Quang Tri	5.4	12.52	67.6	2.9	
Thua Thien – Hue	5.6	10.05	56.3	2.7	
<b>South Central Coast</b>	<b>49.3</b>	<b>12.94</b>	<b>637.8</b>	<b>27.3</b>	<b>55</b>
Da Nang	0.5	5.80	2.9		
Quang Nam	12.6	12.95	163.2	6.5	
Quang Ngai	15.7	11.98	188.1	7.8	
Binh Dinh	11.3	12.88	145.6	7.0	
Phu Yen	4.7	16.21	76.2	3.5	
Khanh Hoa	4.5	13.73	61.8	2.5	

**Appendix 1: (continued)**

Region/province	Cassava planted area (‘000 ha)	Cassava yield (t/ha)	Cassava production (‘000 tonnes)	Total area with new varieties (‘000 ha)	% with new cassava varieties
<b>Central Highlands</b>	<b>65.5</b>	<b>14.27</b>	<b>934.8</b>	<b>30.6</b>	<b>47</b>
Kon Tum	23.4	12.85	300.6	9.0	
Gia Lai	24.3	10.70	260.1	8.7	
Dak Lak	16.6	21.73	360.8	12.5	
Lam Dong	1.2	11.08	13.3	0.4	
<b>Southeastern Region</b>	<b>109.8</b>	<b>19.30</b>	<b>2,119.3</b>	<b>93.5</b>	<b>85</b>
TP Ho Chi Minh	0.2	11.00	2.2		
Ninh Thuan	2.3	6.83	15.7	0.1	
Binh Phuoc	24.7	21.66	534.9	23.0	
Tay Ninh	35.6	22.41	797.9	33.0	
Binh Duong	6.9	18.62	128.5	5.7	
Dong Nai	17.0	20.09	341.5	16.2	
Binh Thuan	15.9	10.15	161.4	9.5	
Ba Ria – Vung Tau	7.2	19.06	137.2	6.0	
<b>Mekong River Delta</b>	<b>10.0</b>	<b>13.50</b>	<b>135.0</b>	<b>4.2</b>	<b>42</b>
Long An	1.4	6.71	9.4		
An Giang	4.5	19.58	88.1	4.0	
Tien Giang	0.3	11.33	3.4	0.1	
Vinh Long	0.2	10.50	2.1	0.1	
Ben Tre	0.5	9.20	4.6		
Kien Giang	0.4	5.75	2.3		
Can Tho	0.0	15.50	0.4		
Tra Vinh	1.1	13.27	14.6		
Soc Trang	0.5	8.40	4.2		
Bac Lieu	0.5	6.40	3.2		
Ca Mau	0.6	4.50	2.7		

*Source: General Statistics Office, 2004*

**Appendix 2. Results of a Standard Yield Trial for selection of cassava varieties with short duration and high root yield, harvested at 7 months after planting at Hung Loc Agric. Research Center. Dry seed of KM94 variety had been subjected to 2.5, 4.0 and 6.0 Kr doses of Gamma rays of <sup>60</sup>Co to induce mutations.**

Variety	Fresh root yield (t/ha)	Starch content (%)	Starch yield (t/ha)	Cooking quality (1-10)	Harvest index (%)	Plant type & stake quality (1-10)	Root shape & uniformity (1-10)
KM228-3	40.9 a	25.7 a	10.51	8	66	8	9
KM228-2	36.0 b	22.6 c	8.14	7	63	9	9
KM228-1	32.8 bc	24.7 b	8.10	8	67	8	9
KM227	30.2 cd	26.4 a	7.92	8	65	9	9
KM228-4	29.5 c	23.8 b	7.02	8	65	9	8
KM229	27.8 de	21.3 d	5.90	7	68	8	8
KM228-5	24.6 e	22.5 c	5.53	7	62	9	9
KM140	29.6 c	26.7 a	7.90	8	65	10	9
KM94	24.0 e	26.5 a	6.36	5	58	8	9
CV%	6.9	4.5					
LSD 0,05	4.0	1.1					

*Source: Hoang Kim, Luong Thu Tra, Bui Trang Viet and Hernan Ceballos, 2004.*