GENETIC IMPROVEMENT OF CASSAVA IN VIETNAM: CURRENT STATUS AND FUTURE APPROACHES

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ABSTRACT

Cassava breeding and varietal dissemination in Vietnam has made continuous progress. During the past decade (1991-2000) the Vietnam Cassava Program (VNCP), in cooperation with CIAT, Vedan and other cassava processing factories, has developed and disseminated six new high-yielding varieties: KM60, KM94, SM937-26, KM95, KM95-3 and KM98-1. In the crop year 2001/02, the area planted to KM94 and other new improved varieties reached about 94,500 ha or close to 33% of the total cassava area in Vietnam. Cassava yield and production in several provinces has doubled, brought about by the construction of new large-scale cassava processing factories, especially in the south of Vietnam.

Currently, the cassava breeding program in Vietnam is evaluating annually about 12,000 hybrid seeds introduced from CIAT/Colombia, and is producing itself more than 3,000 hybrid seeds from 9-15 cross combinations. At Hung Loc Agricultural Research Center there are ten cassava breeding experiments conducted every year, and 18-24 Regional Trials are conducted in different cassava producing regions in collaboration with various institutions, universities and provincial extension offices. New clones, like KM98-5 (early harvestability, high-starch content, high fresh root yield) and KM98-1 (early harvestability, high fresh yield, low cyanogenic potential) are rapidly being multiplied to provide planting material for various purposes. More than 780 promising new clones have been selected, of which KM140, KM146 and KM163 will be further tested and possibly selected for release. The objectives of further genetic improvement of cassava varieties in Vietnam are: 1) to increase the yield potential and starch content, and obtain early harvestability; 2) to improve quality and the nutritional value, especially the carotene and micronutrient content of cassava, in order to reduce blindness and Fe and Zn deficiency in people living in marginal environments.

INTRODUCTION

In Vietnam, cassava is the third most important food crop, following rice and maize. It is planted in about 263,700 ha of agricultural land in Vietnam, producing about 2.8 million tonnes in 2001 (**Table 1**). Cassava plays an important role in the strategy of national food security (**Figure 1**).

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 food deficiency. Cassava is also an important source of cash income to small farmers, who either use it for animal feeding or for sale to starch factories.

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

Crop		1999	2000	2001 prelim.	2002 forecast
Rice	Area ('000 ha)	7,653.5	7,666.3	7,484.3	7,320.0
	Yield (t/ha)	4.10	4.24	4.27	4.34
	Production ('000 t)	31,393.8	32,529.5	31,970.1	31,756.0
Maize	Area ('000 ha)	691.7	730.2	727.3	800.0
	Yield (t/ha)	2.53	2.75	2.92	2.90
	Production ('000 t)	1,753.1	2,005.9	2,122.8	2,320.0
Cassava	Area ('000 ha)	225.5	237.6	263.7	288.4
	Yield (t/ha)	7.98	8.36	10.64	10.90
	Production ('000 t)	1,800.5	1,986.3	2,806.4	3.114.7
Sweet potato	Area ('000 ha)	270.2	254.4	244.7	220.0
	Yield (t/ha)	6.46	6.33	6.76	7.50
	Production ('000 t)	1,744.6	1,611.3	1,655.1	1,650.0

Source: *Adapted from MARD, 2002.*

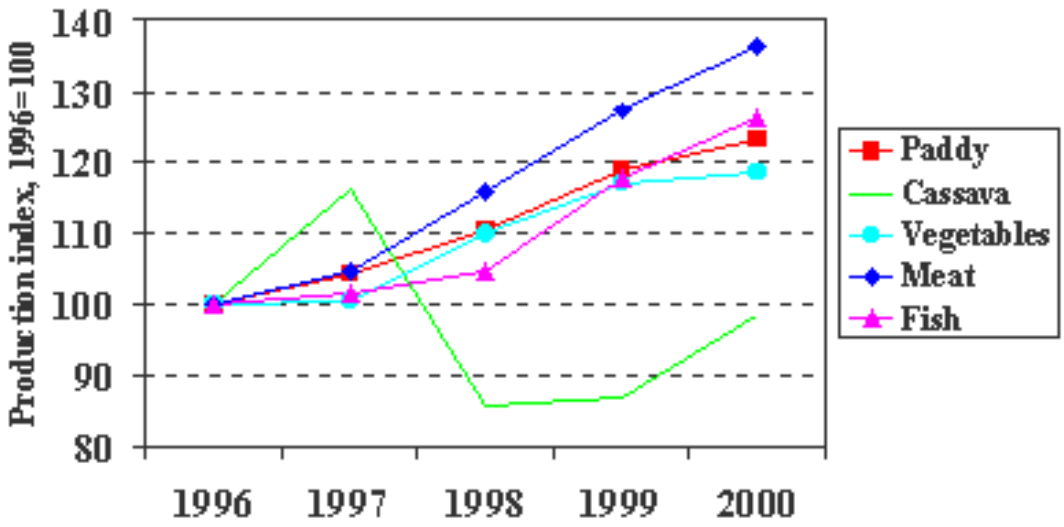

Figure 1. Food production in Vietnam from 1996 to 2000.
Source: *Food Security Programme, MARD, 2002.*

Cassava in Vietnam has been changing its role from a food crop to an industrial crop for starch production and animal feed. In 2001, total cassava starch production in Vietnam was about 500,000 tonnes of which 70% was for export and 30% for domestic use.

In the period of 2001-2005, the Institute of Agricultural Sciences of South Vietnam (IAS) was appointed to be the leader of the Vietnam Cassava Varietal Improvement Project (VNCP) by the Ministry of Agriculture and Rural Development (MARD). This is one of

the 42 most important projects of the National Program of Crops and Animal Breeding Improvement in Agriculture.

Based on the target for cassava production and utilization in the country, the objectives of further genetic improvement of cassava varieties in Vietnam from 2001 to 2010 are: 1) to increase the yield potential and starch content, and enhance early harvestability; 2) to improve eating quality and the nutritional value, especially the carotene and micronutrient content of cassava, in order to reduce blindness and Fe and Zn deficiency in people living in marginal environments. This can be achieved through an effective integration of advanced biotechnology techniques and conventional breeding methods.

RECENT PROGRESS IN CASSAVA VARIETAL IMPROVEMENT

Cassava Varietal Dissemination

Cassava breeding and varietal dissemination in Vietnam have made stable and reliable progress. During the past decade (1991-2000) the Vietnam Cassava Program (VNCP), in cooperation with CIAT, Vedan and other cassava processing factories, has developed and disseminated six new high-yielding varieties: KM60, KM94, SM937-26, KM95, KM95-3 and KM98-1 (Hoang Kim *et al*., 2001b).

New clones, like KM98-5 (selected from F_1 hybrid seeds introduced from the Thai-CIAT program in 1996; pedigree Rayong 1 x Rayong 5; high fresh yield, high starch content, early harvestability) and KM98-1 (selected from F_1 hybrid seeds introduced from the Thai-CIAT program in 1995; pedigree Rayong 1 x Rayong 5; early harvestability, high fresh yield, low cyanogenic potential) are rapidly being multiplied to provide planting material for various purposes (**Table 2**).

Table 2. Results of Regional Yield Trials conducted by Hung Loc Agricultural Research Center in central and south Vietnam (1999-2001).

No. of trials	Variety	Growing period (months)	Fresh root yield (t/ha)	Dry matter content (%)	Starch content (%)	Starch yield (t/ha)	Harvest index (%)
31	KM98-5	8-10	34.5	40.5	28.5	9.8	63
35	KM94	9-11	33.0	40.2	28.7	9.5	58
30	KM98-1	8-10	32.2	38.8	27.6	8.9	66
19	KM60	8-10	24.5	38.7	27.4	6.7	56
35	Local check	9-12	16.5	36.3	25.3	4.2	53

Source: *Hoang Kim et al., 2000; 2001b.*

In the crop year 2001/02, the area planted to KM94 and other new improved varieties reached about 94,500 ha or close to 33 % of the total cassava area in the country. Cassava yield and production in several provinces has doubled, partially brought about by the construction of new large-scale cassava processing factories, especially in the south of Vietnam (Hoang Kim *et al*., 2001a).

Collection, Breeding and Selection of Cassava Germplasm

Currently, the cassava breeding program in Vietnam is evaluating annually about 12,000 hybrid seeds introduced from CIAT/Colombia, and is producing itself more than 3,000 hybrid seeds from 9-15 cross combinations. At Hung Loc Agricultural Research Center there are ten cassava breeding experiments conducted every year, and 18-24 regional trials are conducted in different cassava producing regions in collaboration with various institutions, universities and provincial extension offices.

More than 780 promising new clones have been selected, of which KM140, KM146, KM163 will be further tested and possibly selected for release. KM140 is a hybrid between an advanced cultivar and a CIAT-Thai introduction. The fresh root yield is 33-38 t/ha, while it has a high dry matter content. Crop duration is 8-10 months. It has good plant type and good stake quality (**Table 3**).

Table 3. Agronomic traits of KM140 compared to three recommended varieties in the Southeastern Region of Vietnam (data from 7 trials conducted in 2001, harvested 10 months after planting).

Variety	Growing period (months)	Fresh root yield (t/ha)	Root starch content (%)	Starch yield (t/ha)	Plant type & stake quality (1-10)	Root shape & uniformity (1-10)
KM140	8-10	36.0	25.6	9.23	10	9
KM98-5	8-10	34.2	25.8	8.82	9	9
KM98-1	8-10	32.3	24.2	7.81	8	9
KM94	9-11	30.6	25.3	7.74	8	9

Source: *Hoang Kim et al., 2001b.*

KM146 was selected from F_1 hybrid seeds introduced from the Thai–CIAT program in 1997. It has a high fresh root yield and very early harvestability, good root shape and white flesh. KM163 was selected from F_1 hybrid seeds introduced from the Thai–CIAT program in 1998. It has high fresh root yield and a crop duration of 9-11 months (**Table 4**).

Table 4. Results of three Advanced Yield Trials at Hung Loc Center in 1999-2001, based on selections from hybrid seeds introduced from the Thai-CIAT program.

Variety	Growing period (months)	Fresh root yield (t/ha)	Root starch content (%)	Starch yield (t/ha)	Plant type & stake quality (1-10)	Root shape & uniformity (1-10)
KM163	9-11	33.4	27.0	9.02	9	9
KM146	7-10	31.3	25.6	8.02	8	10
KM123	8-10	24.5	26.8	6.56	8	9
KM134	8-10	22.3	27.8	6.20	7	9
KM94	9-11	27.6	28.1	7.75	8	9

Source: *Hoang Kim et al., 2001b.*

Tissue Culture and Mutation in Cassava Breeding

Plant breeders in Brazil and Mexico have developed new cassava varieties by using inter-specific hybridization (Nassar, 1986; 2001; Nassar *et al*., 2001)**.** We are studying this method in Vietnam by developing an *in vitro* grafting method (Phan Ngo Hoang and Bui Trang Viet, 2001), crossing and applying biotechnology in breeding.

Cultures of *Manihot esculenta* and *Manihot glaziovii* were established from the shoot tips or lateral buds collected from two-month old *in vitro* plants. The shoot multiplication was achieved from shoot tips, on the MS medium supplemented with 0.2 mg/l BA, 0.1mg/l NAA and 0.05 mg/l GA_3. The growth of shoot tips or axillary buds occurred on the hormone-free MS medium, from the explants containing shoot apical meristem or 1-2 axillary buds. The role of the plant growth regulators have been studied (Nguyen Xuan Dung *et al.*, 2002).

Mutation breeding is also underway with the specific objectives of developing early harvestability, high starch content and high fresh root yield. Seeds and *in vitro* plants of five cassava varieties have been studied under different doses of Gamma rays of ^{60}Co to create different mutants for selection.

STRENGTHENING FUTURE GENETIC IMPROVEMENT

In the immediate future, research in cassava genetic improvement is very important. The people of Vietnam have an idiom: “Nuoc, Phan, Can, Giong” (Water, Fertilizer, Good Labor, Variety). These are the four main factors affecting field crops production. Cassava breeding and varietal dissemination are among the key solutions for development.

Cassava plays an important role in the processing industry and in livestock production in Vietnam. Especially, cassava starch for food and industry is becoming increasingly important in creating future demand for cassava (Pham Van Bien *et al*., 2001). The Ministry of Agriculture and Rural Development (MARD) initiated a five-year project, starting in 2001, to rapidly multiply stakes of the improved varieties that have high starch yield and to distribute these to the farmers. CIAT, Vedan and other cassava processing factories have also helped to implement this project.

High Starch Yield and Short Duration of Cassava Variety

Today, cassava varieties with high starch yield have been adopted widely in Vietnam, because these varieties have higher fresh root yields and starch contents. However, varieties with shorter duration need to be developed (Hoang Kim *et al*., 2001b). Farmers in the Mekong Delta region need very early varieties with a crop duration of less than seven months to escape floods in the rainy season. These varieties also need to have fresh root yields of 26-30 t/ha and starch contents of about 27%. By evaluating the germplasm collection, VNCP is trying to collect and maintain the short duration character and improve other characters by crossing with high starch yielding varieties, mainly from CIAT.

Improvement of Quality and Nutritional Value of Cassava

A long-term objective is to improve the nutritional value of cassava, including low cyanogenic potential, high protein content, high vitamin A and other micronutrients for malnourished human populations (Graham and Rosser, 2000; West, 2001). The methods to achieve these objectives are to introduce new breeding materials, mainly from CIAT (Bedoya *et al*., 2001; Calle *et al.*, 2001), crossing and applying biotechnology in breeding, to multiply planting material of new varieties, and to enhance the adoption of sustainable cassava production practices. We participate in a collaborative program with Dr. Hernan Ceballos in evaluating new breeding varieties in Vietnam. It is hoped that within the next few years, the new high quality varieties will be released to farmers.

Efficient Utilization of Recombination Breeding and Biotechnology

The method of recombination breeding was most effective in developing stable high yielding varieties. The pre-requisite for this breeding program is the maintenance and screening of a large cassava germplasm collection to identify donors with desirable features, such as short duration, high dry matter content, low HCN, high protein, high yield and carotene and vitamin A content, tolerance to abiotic stresses and problem soils etc. The method of recombination breeding is being studied in Vietnam.

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