CIAT INITIATIVES ON CASSAVA IMPROVEMENT IN ASIA

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Introduction

After the initial successes in rice and wheat improvement by IRRI and CIMMYT, respectively, often referred to as the "Green Revolution", the Centro Internacional de Agricultura Tropical (CIAT) was established in Cali, Colombia, in 1969, mainly to conduct research on other crops that were considered of importance for Latin America. The wide range of crops initially selected was soon narrowed down to four main commodities: cassava (*Manihot esculenta* Crantz), common beans (*Phaseolus vulgaris*), rice for Latin America and beef. Thus, in 1972 the CIAT Cassava Program was established and a multidisciplinary team was assembled to conduct both basic and applied research on the crop. At about the same time, in Nigeria, the International Institute of Tropical Agriculture (IITA) was established to work on crops of major importance in Africa, among which was cassava as well as other root and tuber crops. CIAT was assigned the world mandate for basic research on the crop and to focus specifically on Latin America and Asia, while IITA would concentrate on specific problems in Africa, mainly the African Cassava Mosaic Virus and several insect problems. Being near the center of origin of the crop, CIAT has assembled the world's largest collection of cassava land-races, mainly from Colombia, Brazil, Peru, Ecuador and other countries in Latin America. Once tissue culturing techniques were fully developed, this was later expanded to include local varieties from Asia, mainly from Indonesia, Malaysia and the Philippines. This cassava germplasm collection, held in trust at CIAT headquarters in Colombia, now has more than 6,000 accessions.

CIAT in Asia

During the 1970s, cassava in Asia started to change from being an important food crop to an industrial crop. While cassava was never an important food crop in Thailand, the opening up of the European animal feed market for dry cassava chips meant that cassava became an important export crop for Thailand starting in the early 1970s. Initially this was mainly starch for food and industrial purposes, followed by the export of the dried solid waste from the starch industry as an animal feed, and later the export of dry chips and pellets for the animal feed industry in Europe. Thus, cassava production in Thailand increased from nearly nothing in the early 1970s to a major export product by the end of the decade. In 1975 the first of several groups of Thai cassava researchers arrived at CIAT for long-term training in various disciplines of cassava research. Later this also included researchers from other countries in Asia. Four one-month cassava production training courses were also held at CIAT in 1978, 1980, 1985 and 1989, for groups of cassava researchers from Asia. Altogether, 153 cassava researchers from Asia have received training in various disciplines at CIAT from 1975 to 2000.

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The first CIAT cassava scientist to be based in Asia was Dr. Romero Obordo, who was stationed at SEARCA in Los Banos, Philippines from 1977 to 1979. In 1978 a batch of 15 promising cassava varieties from Latin America arrived as stem cuttings in the Philippines. After passing through plant quarantine, these were multiplied in the Philippines and later distributed for testing in Regional Trials in Thailand, Indonesia, India and Sri Lanka. In addition, about 50,000 hybrid seeds were sent to seven countries in Asia from 1973 to 1981. With the establishment of cassava breeding programs in Thailand, Philippines, Malaysia, Indonesia and Sri lanka in the 1970s, these seeds formed the initial basis for the development of new high-yield and high-starch cassava varieties in these countries.

In 1983 Dr. Kazuo Kawano, CIAT Cassava Breeder in Colombia since 1973, was transferred to Asia and stationed at the newly established CIAT Cassava Office for Asia in Bangkok, Thailand. In 1986 he was joined by a CIAT Cassava Soil Scientist/Agronomist, Dr. Reinhardt Howeler, who had worked in the area of plant nutrition and soil management since the inception of CIAT's Cassava Program in 1972. Both CIAT scientists worked directly with colleagues in the various countries in Asia, conducting collaborative research in the area of cassava genetic improvement and agronomic practices. Initially this was focused on Thailand, Indonesia, Philippines, Malaysia, Sri Lanka, and to a lesser extent India, but in the late 1980s this collaboration expanded to include China and Vietnam. In 1998 Dr. Kawano returned to Japan, while Dr. Howeler continued to coordinate the Asian Cassava Research Network. This network was expanded in the early part of the 21st century to include Laos, Cambodia and East Timor. As part of the Asian Cassava Research Network, CIAT has organized seven Regional Cassava Workshops, starting in 1984 in Thailand and alternating every three years among the major cassava producing countries in the region. The Proceedings of these Workshop are an important historical record of the development of the cassava research programs in Asia. The last Workshop was held in Bangkok, Thailand in 2002, and the Proceedings of this Workshop will soon be published.

Cassava Breeding and the Release of New Varieties in Asia

Cassava was first introduced into Asia from Latin America, its center of origin, in the 16th and 17th century. In Latin America the crop has been grown for at least 4000 years, while in Asia the crop is relatively new, having been grown for only about 300 years. Thus, the genetic variability of the crop in Asia is much narrower than in Latin America, probably limited to no more than 500-600 local varieties, mainly found in Indonesia and India. These had either been introduced from elsewhere over the years, or evolved by open pollination and farmer selection of promising seedlings. This narrow genetic base was of particular concern in Thailand where in the late 1980s about 1 million hectares were planted to a single variety, Rayong 1. Attempts to improve this variety by crossing with other local varieties were not very successful due to the lack of genetic variability within the available germplasm. This changed in the early 1980s with the establishment of the CIAT Cassava Office in Asia and the introduction of large numbers of F1 hybrid seeds from the CIAT-Colombia cassava breeding program. Since then, nearly half a million seeds have been introduced into various Asian cassava

breeding programs, each seed with their own genetic make-up. This has greatly widened the genetic base of cassava in Asia, and markedly speeded up the progress made in cassava breeding in the region. These hybrid seeds were planted and evaluated; after passing through several stages of clonal propagation and selection, some of these were released as promising new varieties. However, in most cases these promising new lines were further crossed with better-adapted local varieties to produce more F_1 seeds for further selection. Over the years Thailand has produced thousands of seeds from local varieties crossed with Latin American germplasm, which were evaluated and tested in numerous on-station and on-farm trials. This eventually led to the release of 11 new high-yielding and high starch varieties. Moreover, the Thai-CIAT breeding program, located at Rayong Field Crops Research Center (RFCRC), also contributed over 100,000 F_1 hybrid seeds to other Asian cassava breeding programs, especially to Indonesia, Philippines, Vietnam and China. Some of these were eventually selected and released as new varieties. **Table 1** shows the pedigree and the main features of the "CIAT-related" varieties that have now been released in six countries in Asia. In addition, national breeding programs, especially in India and Indonesia, have released a large number of new varieties selected from their own local varieties, or produced through crossing or mutation breeding of indigenous cassava varieties.

Table 1. CIAT-related[1)] cassava varieties that have been released in Asia and their most important characteristics.

Country	Variety name	Year of release	Clonal code or pedigree	Location of hybridization	Main features
Cambodia	Malaysia	-[2)]	KM 94 = Kasetsart 50	KU	High yield, high starch
China	Nanzhi 188	1987	CM321-188	CIAT	high yield
	Nanzhi 199	1987	MPan 19	CIAT	high yield, high starch
	GR 891	1998	MCol 2215	CIAT	high yield, high starch
	GR 911	1998	MBra 35 x CM 523-7	CIAT	high yield
	SC 5	2002	ZM 9057	CATAS	high yield
	SC 6	2002	OMR 33-10-4	RFCRC	high starch
	SC 7	2005	ZM 8639	CATAS	high yield
	SC 8	2005	CMR38-120-10	RFCRC	high yield
Indonesia	Malang 1	1992	CM1015-19 x CM849-1	CIAT	high yield, bitter
	Malang 2	1992	CM922-2 x CM507-37	CIAT	high yield, sweet
	UJ 3 = Thai	2000	Rayong 60	RFCRC	high yield, early bulking
	UJ 5 = Kasetsart	2000	Kasetsart 50	KU	high yield, high DM
Malaysia	Perintis	1988	CM321-170 x MCol 1684	CIAT	very high yield, low starch
	MM 92	1992	CM1362-6 x CM586-1	CIAT	early high yield, low starch
	Sri Kanji 1	2003	Rayong 90	RFCRC	high yield, rel. high starch
	Sri Kanji 2	2003	OMR36-05-24	RFCRC	high yield, rel. high starch
	Sri Pontian	2003	SM1542-19	CIAT	edible, for snack food
Philippines	VC-1	1986	CM323-52	CIAT	high yield
	VC-2	1988	CMC 40	Brazil	high yield, edible

Table 1 (continued)

Country	Variety name	Year of release	Clonal code or pedigree	Location of hybridization	Main features
	VC-3	1990	CM3590-1	CIAT	dual purpose
	VC-4	1990	CM4014-3	CIAT	high yield, dual purpose
	VC-5	1990	MCol 1684	Colombia	high yield, bitter
	PSB Cv-11	1995	CM3419-2A	CIAT	dual purpose
	PSB Cv-12	1995	SM972-20	CIAT	dual purpose
	PSB Cv-15	1999	CM3422-1	CIAT	dual purpose
	PSB Cv-19	2000	SM808-1	CIAT	mite resistant
Thailand	Rayong 3	1983	MMex 55 x MVen 307	CIAT	high starch
	Rayong 2	1984	MCol 113 x MCol 22	CIAT	for snack food
	Rayong 60	1987	MCol 1684 x Rayong 1	RFCRC	high early yield
	Sriracha 1	1991	MCol 113 x MCol 22 x Rayong 1	KU	high DM
	Rayong 90	1991	CMC 76 x V 43=CMR21-1	RFCRC	high DM, rel. high yield
	Kasetsart 50	1992	R 1 x R 90=MKUC28-77-3	KU	high yield, high DM
	Rayong 5	1994	CMR27-77-10 x R 3=OMR25-105-112	RFCRC	rel. high yield, high DM
	Rayong 72	1999	R1 x R5	RFCRC	high yield, high starch
	Huay Bong 60	2003	R5 x Kasetsart 50	KU	high yield, drought tol.
	Rayong 7	2005	CMR35-64-1	RFCRC	high yield, high starch
	Rayong 9	2005	CMR35-48-196	RFCRC	good for ethanol production
Vietnam	KM 60	1993	Rayong 60	RFCRC	high early yield
	KM 94	1995	Kasetsart 50	KU	high yield, high starch
	SM937-26	1995	SM937-26	CIAT	high yield, high starch
	KM 95	1995	OMR33-17-15	RFCRC	high yield; dual purpose
	KM 95-3	1998	SM1157-3	RFCRC	high yield; dual purpose
	KM 98-7	1998	SM17-17-12	RFCRC	High yield
	KM 98-1	1999	R1 x R5	RFCRC	high yield; dual purpose
	KM 98-5	2005	Rayong 90 x KM 98-1	IAS	High yield, dual purpose, short duration
	KM 140	2005	KM 36 x KM 98-1	IAS	High yield, dual purpose, short duration

[1)] Having germplasm from CIAT in one or both parents

[2)] Introduced from Vietnam in the eastern provinces and from Thailand in the west, but never officially released

Adoption of New Cassava Varieties and their Economic Impact in Asia

Table 2 shows the total area under cassava according to FAO data and local estimates, as well as the area under newly released varieties in each country as estimated from surveys or local information. In Thailand, Vietnam and Cambodia most of the cassava area is now planted with new varieties, practically all containing some source of CIAT germplasm. In India, on the other hand, the new varieties that were adopted in Tamil Nadu and Andhra Pradesh, do not contain any CIAT germplasm. In Indonesia several new varieties have been released but they are not yet widely adopted except for UJ 3 and UJ 5 in Lampung province of Sumatra island. The Thai variety KU 50, released by Kasetsart University in 1992, is now grown under different names (KU 50, KM 94, UJ 5 or Kasetsart, and Malaysia) in about 887,000 ha in Thailand, Vietnam, Indonesia and Cambodia, corresponding to 25% of the whole cassava area in Asia. This is probably the most widely grown and most successful cassava variety in the world.

The adoption by farmers of this and other new varieties in Asia, coupled with improved cultural practices has had a profound impact on cassava yields and farmers' income. According to FAO data, cassava yields in Asia increased at an annual rate of 3.1% from 1996 to 2004, as compared to 1.8% in Latin America and 0.7% in Africa. The average cassava yield in Asia in 2004 was 17.16 t/ha *vs.* 12.88 and 8.85 t/ha in Latin America and Africa, respectively. **Table 3** shows that the increases in cassava yields in Asia over the past decade, on average 4.23 t/ha, resulted in an annual increase in farmers' gross income equivalent to 386 million US dollars. Due to the development of new varieties and their widespread adoption by farmers, in combination with improved fertilization, erosion control and other agronomic practices, the livilihood and income of cassava farmers in Asia has markedly increased during the past decade.

Table 2. Total area under cassava and area under improved varieties in various countries in Asia in 2004.

	Area under cassava (ha)		Area under new varieties		Area under "CIAT-related" varieties	
Country	FAO	Local estimate	(ha)	(%)	(ha)	(%)
Cambodia	22,500	25,000	~17,000[1)]	~68	~17,000	~68
China	240,115	<373,000	~36,000[2)]	~10	~12,000	~3
India	270,000		~102,500[3)]	~40	0	0
Indonesia	1,285,718		~100,000[4)]	~8	~100,000	~8
Malaysia	38,000	3,970	<5			
Philippines	180,000		~18,000[5)]	~10	~9,000	~5
Thailand	1,050,000		1,000,000	95	1,000,000	95
Vietnam	370,500		250,000[6)]	67	250,000	67
Others	51,270					
Total	**3,508,103**		**~1,523,505**	**43**	**~1,388,000**	**40**

[1)] mainly KU 50 in Kampong Cham, Battambang and Kampong Speu provinces; Ung Sopheap, personal information, 2006
[2)] about 1/3 are CIAT-related varieties
[3)] none are CIAT-related; personal information S. Ramanathan, Sept. 2005
[4)] mainly UJ 5 in Lampung; personal information J. Wargiono, Feb. 2004
[5)] about 1/2 are CIAT-related varieties
[6)] mainly KM 94 = KU 50; Kim *et al.;* 2005 and personal information Tran Ngoc Ngoan, 2005.

Table 3. Estimation of the annual increase in gross income due to higher cassava yields resulting from the adoption of new cassava varieties and improved practices, in China, Thailand and Vietnam, as well as in Asia as a whole.

Country	Total cassava area (ha)[1)]	Cassava yield (t/ha)[1)] 1994	2004	Yield increase (t/ha)	Cassava fresh root price ($/tonne)	Increased gross income due to higher yields (mil. US$)
China	250,767	15.22	16.81	1.59	27	10.8
Thailand	1,057,341	13.81	20.28	6.47	26	177.9[2)]
Vietnam	383,600	8.44	14.53	6.09	26	60.7
Asia total	**3,510,532**	**12.93**	**17.16**	**4.23**	**26**	**386.1**

[1)] Data from FAOSTAT for 2004.
[2)] In addition, farmers also benefited from higher prices due to higher starch content.