BREEDING AND DISSEMINATION OF NEW CASSAVA VARIETIES IN THAILAND

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ABSTRACT

The cassava breeding program in Thailand was initiated by the Department of Agriculture in 1937. Several cultivars were introduced from Malaysia and the Philippines, and later from the Virgin Islands and Colombia. However, substantial progress in breeding of high-yielding varieties was achieved only after the establishment of the Thai-CIAT breeding program in 1983. Varieties under the name of Rayong have been released from Rayong Field Crops Research Center, Department of Agriculture, since 1984; the most recent variety, called Rayong 72, was released in 1999. Earlier, Kasetsart University released Kasetsart 50 in 1992, while MKUC34-114-206 will be released soon.

Massive multiplication and distribution of new cassava varieties were undertaken by the Department of Agricultural Extension, the Cooperative Promotion Department, and the Thai Tapioca Development Institute Foundation. A recent survey revealed that more than 90% of the cassava planting area in Thailand (996,191 ha) is now planted to new cultivars. Kasetsart 50 is the most popular cultivar in that it is cultivated in about 56% of the total planting area. In addition to high yielding ability and good plant type, a successful cultivar should have a high root starch content, because the price of fresh roots is calculated according to their starch content. The average yield of these new cultivars, calculated for 1996 to 2002, was 99-135% of that of the traditional cultivar Rayong 1. The national average yield has increased steadily since 1997, from 14.80 t/ha (average for 1967-1996) to 17.53 and 17.06 t/ha in 2001 and 2002, respectively. According to a survey conducted in three starch factories, the root starch content during 1997-2001 was also significantly higher as compared to the 1982-1985 period.

INTRODUCTION

Since cassava has been one of Thailand's most important crops, comprehensive breeding has been conducted in coordination with CIAT since 1983. Several varieties have been released. Both government and private sector agencies have been involved in the massive multiplication and distribution of new varieties. New cultivars have now largely replaced the traditional cultivar, Rayong 1. Recently, the impact of three new cultivars on yield and root starch content has been observed on the national average cassava yield.

Breeding

Cassava breeding in Thailand started in 1937 with the introduction of 20 varieties from Malaysia and the Philippines. Later on, from 1963 to 1977 a total of 65 varieties were introduced from the Virgin Islands and Colombia. However, none of these introductions yielded greater than the local cultivar (Srinives and Rojanaridpiched, 1986). Rayong 1, which was the official name given to a local cultivar in 1975, was the most important cultivar in Thailand during the 1960s to 1990s. This cultivar has a moderate yield potential and root starch content, good stake germination, good plant type with very few branches,

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and wide adaptation to the Thai bio-physical environment. The success of the Thai cassava industry has been largely due to Rayong 1 cultivar. Kawano (1992) commented that Rayong 1, at that time was the world's most important cassava cultivar.

Major progress in breeding of high-yielding varieties has been achieved after the establishment of the Thai-CIAT breeding program in 1983. A number of breeders were trained at CIAT headquarters in Colombia, and several cultivars and lines as well as thousands of F_1 seeds were introduced for hybridization and selection. The following new varieties were released by Rayong Field Crops Research Center, Department of Agriculture: Rayong 3 in 1983, Rayong 60 in 1987, Rayong 90 in 1991, Rayong 5 in 1994, and Rayong 72 in 1999. In addition, Kasetsart University released Sriracha 1 and Kasetsart 50. A new promising clone MKU34-114-206 from the cross of Rayong 5 with Kasetsart 50 will be released soon. Based on data from 30 yield trials (**Table 1**), MKUC34-114-206 has 7% higher fresh root yield than Kasetsart 50, while the root starch content is slightly higher than that of Kasetsart 50.

Table 1. Fresh and dry root yield and other characters of MKUC34-114-206 as compared with recommended varieties. Data are average values from 30 yield trials during 1998-2000.

	Root yield				Root starch	
	Fresh		Dry		content	Harvest
Variety	(t/ha)	(%)	(t/ha)	(%)	(%)	index
MKUC34-114-206	35.94 a[1)]	107	13.36 a	107	25.4 a	0.63 b
Rayong 5	31.17 c	93	11.73 c	94	24.1 c	0.62 bc
Rayong 72	37.18 a	111	13.26 ab	106	23.5 d	0.69 a
Kasetsart 50	33.63 b	100	12.51 b	100	25.0 ab	0.60 d
Mean	33.13	-	12.45	-	25.0	0.61
CV (%)	15.4	-	20.0	-	6.8	8.7

[1)] Values within a column that are followed by the same letter are not significantly different by Duncan's Multiple Range test.

Table 1 also indicates that Rayong 72 has the highest fresh root yield potential when compared with Rayong 5, Kasetsart 50 and MKUC34-114-206. However, Rayong 72 had the lowest root starch content among these tested varieties. MKUC34-114-205, according to its high root starch content, has the same dry root yield potential as Rayong 72.

Rayong 72 was officially released only for planting in the Northeast, but was not for the Eastern part of the country due to its low root starch content there. After 1-2 years of promotion farmers were satisfied with Rayong 72. However, cassava chipping and drying factories do not like Rayong 72 because it requires longer drying time of chips and absorbs moisture again during storage. In contract, Rayong 72 roots are well accepted by starch factories.

It is still uncertain whether the new clone, KMUC34-114-206, will be widely adopted as it exhibits heavy branching in some locations and seasons.

At present, the starch industry in Thailand has become more important than the cassava chip and pellet industry. New cassava varieties should be bred specifically for

traits demanded by the starch industry, such as high root starch content and good starch quality, such as white and clear color with high viscosity. Other agronomic characters that are important to achieve widespread farmer adoption are:

- good germination when planted in both the rainy and dry seasons
- vigorous growth and less branching
- ease of harvest
- high root yield and starch content
- long storability of planting material

The important Thai cassava varieties, Rayong 3, Rayong 60, Rayong 90, Kasetsart 50, Rayong 5, Rayong 72 and MKUC34-114-206 all originated from eight land races **(Figure 1)**, of which six from CIAT, i.e. MCol 22, MVen 270, MCol 1684, MMex 55, MVen 307, and CMC 76; one from the Virgin Islands, i.e. V43; and the Thai variety Rayong 1.

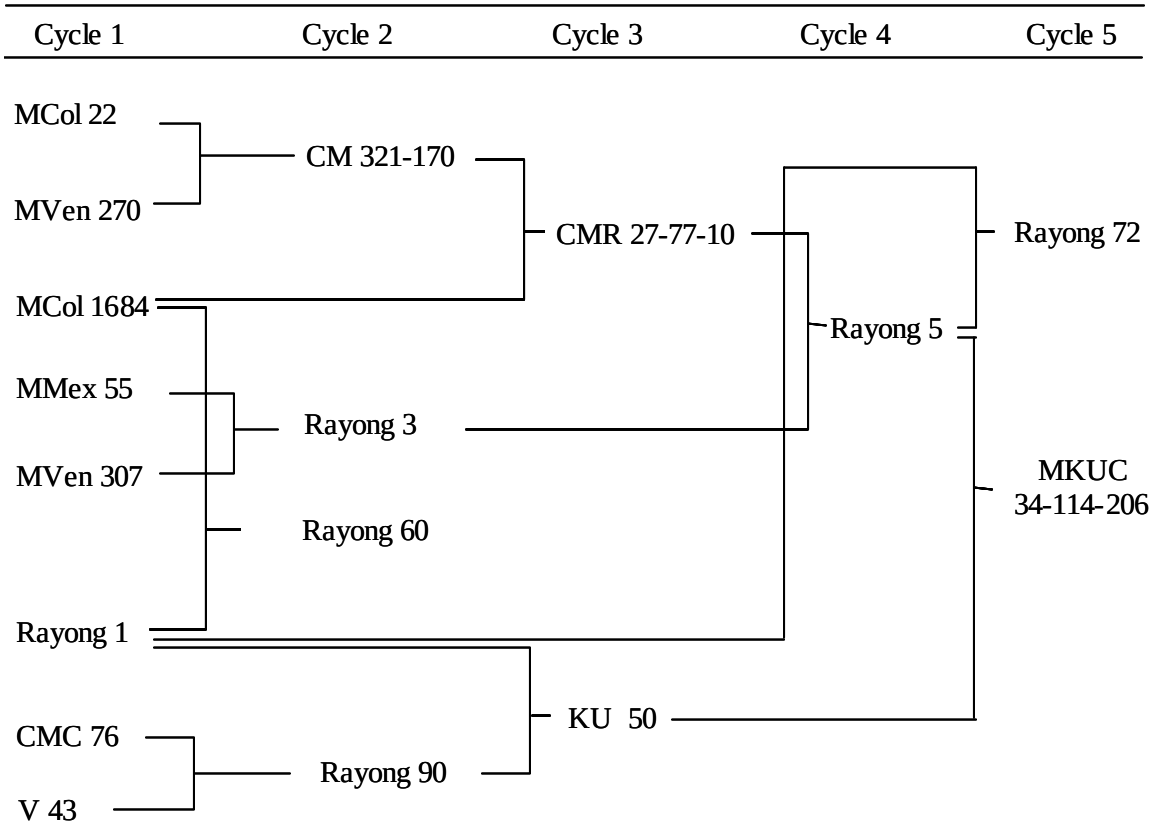

Figure 1. Pedigree of the most important Thai cassava cultivars.

Even though Rayong 1 is less important now, it was one of the parent of Rayong 60, Kasetsart 50 and Rayong 72. The new clone MKUC34-114-206 also contains genes of Rayong 1 through Kasetsart 50.

In order to breed for future varieties, it is necessary to have a new set of germplasm flow into the breeding program. Since 2000, CIAT has transferred the cassava core collection of about 600 clones of cassava to Rayong Field Crops Research Center in the form of tissue culture plantlets. This germplasm needs to be multiplied and evaluated. Any clones with good agronomic traits, high yield and root starch content should be used for crossing with local commercial cultivars.

Varietal Multiplication and Distribution

Cassava varietal multiplication and distribution has been supported financially by the Thai government through the Ministry of Agriculture and Cooperatives to the Department of Agriculture, the Department of Agricultural Extension, and the Department of Cooperative Promotion. The Thai Tapioca Development Institute Foundation, a non-profit organization, also took part in the program. It is important to summarize the major activities since 1994 by each of these institutions.

1. Department of Agricultural Extension (DOAE)

DOAE received a budget to multiply and distribute new varieties to farmers from 1994-1999. DOAE contracted the Department of Agriculture (DOA) and Kasetsart University to multiply the basic planting material of new varieties.

As such, only a part of the total number of cassava stakes required by DOAE were satisfied by DOA and KU. The rest was fullfilled by contracted farmers. From 1994 to 1999, 29,269 farmers received new varieties to plant in a total area of 37,020 hectare (**Table 2**). Planting material of Kasetsart 50 was distributed for 17,803 ha, followed by Rayong 5 and Rayong 90 with 8,548 and 7,105 ha, respectively. Rayong 60 and Rayong 3 were distributed for only 2,986 and 578 ha, respectively. Each variety was multiplied and distributed in different quantities according to farmers' own requests.

Table 2. New cassava cultivars distributed to farmers under contract by the Department of Agricultural Extension from 1994 to 1999.

	No. of	Area distributed (ha)					
Year	farmers	Rayong 3	Rayong 60	Rayong 90	Rayong 5	KU 50	Total
1994	2,548	578	2,296	2,145	-	413	5,432
1995	3,839	-	690	2,685	1,772	1,368	6,515
1996	3,622	-	-	1,500	2,470	2,428	6,398
1997	6,649	-	-	110	2,144	4,266	6,520
1998	6,348	-	-	390	1,542	4,656	6,588
1999	6,313	-	-	275	620	4,671	5,567
Total	**29,269**	**578**	**2,986**	**7,105**	**8,548**	**17,803**	**37,020**

Source: *Department of Agricultural Extension.*

2. The Thai Tapioca Development Institute Foundation (TTDI)

TTDI is a non-profit foundation which was established in 1993 with an initial trust fund of US$ 24 million from the government. The main objective is to increase the productivity of cassava farmers, develop new cassava products and to develop new markets for cassava products. TTDI owns 260 ha of land in Huay Bong subdistrict in Nakhon Ratchasima province. During 1993-1994, Rayong 60, Rayong 90, Sriracha 1, Kasetsart 50 and Rayong 5 were planted at this Center for yield comparisions in large plots. It was found that Kasetsart 50 had high root yield, root starch content, and vigorous stems, suitable for efficient multiplication. Therefore, the TTDI committee decided to massively multiply Kasetsart 50 for the farmers in 1995-1998. Fifteen million stakes of Kasetsart 50 were distributed to 18,807 farmers, each of which received 1,500 long stems, enough for planting 0.8 ha **(Table 3)**. Before receiving stakes of new varieties farmers were required to attend a training course on how to increase cassava productivity. Since there was a high demand for planting material of new cultivars, after the harvest of these new cultivars, farmers had to give planting material free of charge to their neighbors. TTDI conducted several other activities, such as farm visits by TTDI's staff, and a cassava yield competition among recipient farmers. Several farmers participating in this project obtained cassava yields of 30-35 t/ha.

Table 3. Distribution of Kasetsart 50 to farmers by TTDI from 1995 to 1998.

Year	No. of farmers	No. of stakes distributed	Area planted (ha)
1995	1,301	1,825,500	1,040
1996	7,089	6,233,501	5,671
1997	7,031	4,806,825	5,624
1998	3,386	2,228,080	2,708
Total	**18,807**	**15,093,906**	**15,043**

Source: *Thai Tapioca Development Institute Foundation (TTDI).*

3. Cooperative Promotion Department (CPD)

More recently, CPD also received a budget for the multiplication and distribution of new cassava varieties to members of agricultural cooperatives. CPD received stakes of new varieties from DOA and also contracted farmers to multiply these. From 1999 to 2001, 11,297 ha of new varieties were planted by members of agricultural cooperatives, of which 8,638 ha were planted with Kasetsart 50, 5,250 ha with Rayong 72, 1,613 ha with Rayong 5, and 1,046 ha with Rayong 90 (**Table 4)**. Unfortunately, in the area planted with Rayong 72 problems arose as cassava chip factories refused to buy Rayong 72 roots because of the longer time required for drying, and cassava chips of this cultivar reabsorbing moisture during storage. Meanwhile, cassava starch factories did buy Rayong 72 roots. In mid 2002, TTDI held a meeting with cassava chip, pellet and starch factory owners and breeders and concluded that any promotion of Rayong 72 should be done in the vicinity of starch factories and only with advanced contracts by the factory.

Table 4. New cassava cultivars distributed to farmers by the Cooperative Promotion Department from 1999 to 2001.

	Area distributed (ha)				
Year	Rayong 5	Rayong 90	Kasetsart 50	Rayong 72	Total
1999	640	149	3,428	-	4,217
2000	491	350	3,474	-	4,315
2001	482	547	1,736	5,250	2,765
Total	**1,613**	**1,046**	**8,638**	**5,250**	**11,297**

Source: *Cooperative Promotion Department.*

4. Kasetsart University (KU)

Kasetsart University also multiplied and distributed 1 million stems of Kasetsart 50 to 800 farmers in 1999, which was enough for planting 500 ha.

In summary, the total area of new cassava cultivars, multiplied and distributed by DOAE, TTDI, CPD and KU from 1994 to 2001, is shown in **Table 5**. Kasetsart 50 was the most popular cultivar planted in an area of 41,984 ha; this was followed by Rayong 5 and Rayong 90 planted in 10,161 and 8,151 ha, respectively, while Rayong 3 was planted only in 578 ha and Rayong 60 in 2,986 ha. The future acceptance of Rayong 72, the most recently recommended cultivar, is still not clear.

Table 5. Total area planted with new cassava cultivars that were multiplied and distributed by DOAE, TTDI, CPD, and KU from 1994 to 2001.

Cultivars	Area promoted (ha)
Kasetsart 50	41,984
Rayong 5	10,161
Rayong 90	8,151
Rayong 72	5,250
Rayong 60	2,986
Rayong 3	578
Total	**69,110**

Varietal Adoption

Rayong 3 has a high root starch content and a root yield similar to that of Rayong 1. This cultivar is characterized by a very small and highly branched plant type as compared to Rayong 1, which makes this variety unsuitable for growing in poor soils. Since the release of Rayong 3 in 1983, considerable efforts were made to multiply and promote this cultivar. As such, in 1992 it was estimated that Rayong 3 was planted in 108,000 ha or about 7.30% of the total cassava growing area (Klakhaeng *et al*., 1995).

Rayong 60 was released in 1987. It gave higher yield but had a similar root starch content as Rayong 1. This low root starch content resulted in a lower root price in the rainy season.

Later on, Rayong 90, Rayong 5, and Kasetsart 50 were released. Both root yield and root starch content of these varieties were higher than Rayong 1, and the adoption by farmers of these new varieties was faster. In 1992, the area planted to Rayong 1 was 92.7% of the total planting area; this decreased to 79 and 70.1% in 1994 and 1995, respectively (Rojanaridpiched *et al*., 1995). It was predicted that the area planted to Rayong 5 and Kasetsart 50 was likely to increase dramatically in the future, while Rayong 90 would increase at a slower rate due to its poor germination when stems had been stored for more than three weeks.

Recently, the Office of Agricultural Economics surveyed the extent of adoption of cassava varieties in 1996, 1998, 1999, and 2002. As expected, the area planted to Rayong 1 had decreased very rapidly, from 60.0% of total planting area in 1996 to only 0.06% in 2002, as shown in **Table 6.** The survey conducted in 2002 indicate that the area planted to Rayong 1 all over the country was only 557 ha, which may be too low due to sampling errors as this variety in 1999 was still grown in about 146,297 ha, or 12.70% of the total cassava area.

Table 6. Planted area of the main cassava cultivars in Thailand from 1996 to 2002.

	Crop year							
	1996		1998		1999		2002	
Cultivars	ha	%	ha	%	ha	%	ha	%
Rayong 1	765,245	60.65	202,483	18.91	146,297	12.70	557	0.06
Rayong 3	78,725	6.24	42,248	3.94	27,004	2.34	5,016	0.50
Rayong 5	32,413	2.57	113,832	10.63	125,823	10.92	181,758	18.25
Rayong 60	255,255	20.23	260,546	24.33	216,898	18.83	77,427	7.77
Rayong 90	71,543	5.67	119,697	11.17	220,926	19.18	78,818	7.91
Kasetsart 50	53,486	4.24	328,889	30.71	410,853	3.67	564,521	56.67
Others	5,164	0.40	3,305	0.31	4,125	0.36	88,094	8.84
Total	**1,261,831**	**100**	**1,071,000**	**100**	**1,151,926**	**100**	**996,191**	**100**

Source: *Office of Agricultural Economics.*

Kasetsart 50 was the most popular variety, occupying 56.6% of the total cassava planting area, followed by Rayong 5 and Rayong 90 with 18.25 and 7.91%, respectively. The area under Rayong 3 had decreased dramatically, from 78,725 ha in 1996 to only 5,016 ha in 2002, whereas that of Rayong 60 had slowly decreased from 255,255 ha in 1996 to 77,427 in 2002.

Even though the role of Rayong 1 in the cassava industry of Thailand had ended by the end of the 20th Century, nonetheless, the most popular variety Kasetsart 50, was the

F_1 hybrid of Rayong 1 and Rayong 90. Half of Rayong 1's genes are still present in Kasetsart 50.

Yield and Starch Content

The area planted to the local variety Rayong 1 has been decreasing steadily since the late 1980s to less than 60% of total area in 1996. **Table 7** shows that during the 30 year period from 1967 to 1996 the average cassava yield in Thailand was 14.48 t/ha. This average yield was used as a benchmark to indicate changes over time in the national average yield. Since then these yields have steadily increased. The national average yield reached 15.49 t/ha in 1999, 16.85 t/ha in 2000, and 17.53 t/ha in 2001.

Table 7. Planting area, production and yield of cassava in Thailand up to 2002.

Year	Planting area ('000 ha)	Production ('000 tonnes)	Yield (t/ha)	Yield (%)
1967-1996	1,022	14,425	14.48	100
1997	1,265	18,084	14.70	101
1998	1,071	15,591	14.92	103
1999	1,152	16,507	15.49	107
2000	1,184	19,064	16.85	116
2001	1,106	18,396	17.53	119
2002	988	16,868	17.06	117

Source: *Office of Agricultural Economics.*

The yield of different cultivars grown in farmers' fields was surveyed by the Office of Agricultural Economics from 1996 to 2002. **Table 8** shows that on average the yield of Rayong 1 was 13.29 t/ha, while those of Rayong 5, Rayong 90 and Kasetsart 50 were above 17 t/ha, which is about 30% higher than Rayong 1. The yield of Rayong 60 was 14.83 t/ha, or about 12% higher than Rayong 1.

Table 8. Average yield of various cassava cultivars grown in farmers fields in 1996 -2002.

Cultivars	Yield (t/ha) 1996	1998	1999	2002	**Average**	**%**
Rayong 1	12.29	13.64	14.33	12.92	**13.29**	**100**
Rayong 3	14.84	11.79	12.25	13.55	**13.11**	**99**
Rayong 5	17.55	18.11	19.11	16.94	**17.93**	**135**
Rayong 60	16.28	14.68	13.74	14.61	**14.83**	**112**
Rayong 90	18.10	14.84	17.66	19.11	**17.43**	**131**
Kasetsart 50	22.02	15.26	16.77	17.63	**17.92**	**135**
Others	14.45	11.66	12.34	14.23	**13.17**	**99**
Total	**14.15**	**14.92**	**15.49**	**16.38**	**15.23**	**115**

Source: *Office of Agricultural Economics.*

The root starch content is very important since the price of fresh roots is calculated according to their starch content. **Table 9** shows survey results of the monthly starch content of cassava roots delivered to three starch factories in Nakhon Ratchasima. The data for 1982-1985, are for the average root starch content of Rayong 1. It is clear that during April-July the average root starch content was the lowest. It increased slowly after August and the highest starch contents were found in January-February.

Table 9. The starch content of cassava roots surveyed at three starch factories for different years and months of the year.

Month	Reference[1)] 1982-1985	Siam Quality Starch Chaiyaphum 1997-2001	Sanguan Wongse Nakhon Ratchasima 1999-2001	Corn Products Co. Nakhon Ratchasima 2001-2002
January	28.02	28.80	27.49	31.77
February	28.18	28.49	27.34	30.73
March	26.35	27.45	24.97	27.46
April	22.63	25.27	21.92	25.16
May	19.74	24.25	20.73	24.73
June	19.64	25.13	23.71	26.13
July	21.98	24.96	24.66	28.42
August	23.56	26.79	24.90	27.11
September	24.15	27.34	25.29	22.84
October	25.54	27.36	26.17	25.85
November	25.56	28.28	26.73	26.86
December	26.52	28.97	27.08	29.34
Average	**24.32**	**26.92**	**25.08**	**27.20**

[1)] *Data from Chaya, 1987.*

After the new cultivars had replaced Rayong 1, new data of root starch content were obtained from three starch factories in 1997-2002. One factory was Siam Quality Starch in Chaiyaphum, which collected data from 1997-2001; the second factory was Sanguan Wongse, the biggest starch factory in Thailand located in Nakhon Ratchasima, which collected data from 1999-2001; and the third was Corn Products Co., also located in Nakhon Ratchasima, which collected data from 2001-2002.

It was found that during the period of low starch contents during the early rainy season in May and June of 1982-1986 the root starch content was below 20%; the more recent data from three factories show that during the same two months the root starch contents were much higher than 20%. During most months the starch content during the 1997-2002 period was higher. However, for the peak period of January and February, the difference was narrower. Averaged over 12 months, the starch content from 1982-1985 was 24.32%, compared with 25.08-27.20% for the 1997-2002 period.

Future Direction

In order to achieve higher yields and more sustainable production, the government's policy concerning cassava production in Thailand should be as follows:

1. Replacing Rayong 60 and others (such as Sriracha 1 and various unnamed breeding lines) by higher yielding varieties such as Kasetsart 50, Rayong 5 and Rayong 90.
2. Giving more incentives to farmers by stabilizing the price of cassava roots. Zoning of cassava planting areas is important. Local utilization of cassava roots as for fuel-ethanol production is very promising in Thailand. Further research on new products made from cassava is also needed.
3. Soil conservation to maintain soil fertility is necessary for sustainable production. Farmer participatory research on soil conservation was a successful project. Further extension of the project on soil conservation should be continued.
4. New germplasm for higher root yield and starch content should be introduced and utilized in the breeding program, in order to develop still higher yielding varieties.

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