CASSAVA BREEDING AND AGRONOMY RESEARCH IN MALAYSIA DURING THE PAST 15 YEARS

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ABSTRACT

The paper reviews cassava breeding and agronomy research carried out by MARDI over the 15-year period, 1984-1999. Evaluation of seedling clones derived from sexual seeds introduced from CIAT/Colombia and the Thai-CIAT program has culminated in the release of two varieties: Perintis (in 1988), which is a very high-yielding variety, and MM 92 (in 1992), which is a six-month variety; both varieties are widely adaptable. The shortcoming of both varieties is their rather low root starch contents compared to the local commercial starch variety, Black Twig. In the pipeline are two new clones: one with potential as a table variety, having low root cyanide content and showing suitability for making oil-fried crisps, a popular snack; the other, having a higher root yield than Black Twig while having a similar starch content.

Agronomy research has given attention to: (a) reduction of production costs, (b) maximization of profits, and (c) expansion of cassava production into marginal areas. Strategies to reduce costs include the use of machines in field operations to reduce labor requirements, especially for planting and harvesting; development of a computer software package to diagnose major nutrient insufficiencies and to recommend fertilizer rates instead of using blanket fertilizer rates; decreasing the fertilizer recommendations and frequency of application when growing the early variety MM 92 on drained peat. In order to maximize profits, intercropping with sweet corn and the recycling of starch factory solid wastes as a supplementary fertilizer are advocated. With difficulties in accessing arable land for planting cassava, drained peat was found to be a potential area provided that specific agronomic practices are adopted. Likewise, planting on slopes requires the adoption of certain cultural practices, like the planting of contour grass barriers, to minimize soil erosion and sustain root yields.

INTRODUCTION

As cassava has long been used as a starch source in Malaysia (Tan and Khatijah, 2000), cassava research at the Malaysian Agricultural Research and Development Institute (MARDI) has addressed itself to cassava production technology for starch processing. This translates into selection of high-yielding varieties and reduction of production costs through appropriate agronomic practices.

This paper attempts to review the breeding and agronomy research on cassava carried out by MARDI over the last 15 years.

Production Scenario

Cassava has been grown both on small-holdings and on a plantation scale; the latter by companies who run a starch-processing factory, while the former by farmers who sell their produce to these starch factories.

The main area of cassava production has been Perak state in Peninsular Malaysia, which accounts for more than 40% of the total production area (Anon, 1996). Most of the plantings are on upland, well-drained mineral soils, with a few on tin-tailings (resultant

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from tin-mining activities). With the difficulty in accessing suitable land for growing cassava, in recent years some farmers have been forced to cultivate the crop on hilly areas, thus encountering problems of soil erosion.

Last year, the price for cassava roots (delivered to the factory) dropped from the 1998 price of RM 0.18 per kilogram (equivalent to 4.7 US cents/kg) to RM 0.13 (3.4 US cents/kg). At this price, it is anticipated that fewer farmers will replant cassava after this year's harvest. This is because it is difficult to make a profit, especially if the small-holding is located some distance from the factory, entailing transport costs of RM0.03/kg which will reduce the actual price of the roots to RM0.10/kg (2.6 US cents/kg). The last two starch factories in operation will probably face worse problems of root supply in the future, and may be forced out of the starch processing business if there are no new plantings of cassava.

BREEDING RESEARCH

The breeding and selection program for cassava at MARDI started in earnest in 1975 with the first importation of seed from CIAT, Colombia. This reliance on imported seed – hybrid and open-pollinated in origin – has been necessary, given the poor flowering characteristics of the local germplasm, and the limited research resources (staff and funding) allocated to cassava.

The main emphasis of the program has been to produce clones which were higher yielding than the commercial starch variety, Black Twig. It was not easy to select for clones with high root dry matter content in the early years because of the focus given to high root yield in the materials disseminated by CIAT at that time. The result of the breeding and selection program, which tested seedling clones in diverse environments (three on mineral soils, three on drained peat), culminated in the release of variety Perintis by MARDI in 1988. Perintis was a clone selected from a cross between CM 321-170 and MCol 1684 (Tan, 1987), and introduced in a seed batch in 1977. The outstanding features of Perintis are:

- wide adaptability to mineral soils and drained peat, as well as to climatic conditions (ranging from a distinct dry season of 2-3 months in a year, to a well-distributed rainfall pattern) (Tan, 1989)
- high root yield of 50-60 t/ha compared to Black Twig (30-35 t/ha)
- lower susceptibility to *Cercospora* brown leafspot.

Despite its remarkable root yield, Perintis did not find favor with the starch processors because of its low starch content (20-22%) compared to Black Twig (24-28%). This poorer conversion rate meant that a larger volume of roots had to be processed to produce an equivalent amount of starch. Moreover, the factory root price is discounted by RM 3.85 per tonne for every 1% lower starch content than the "standard" 28%. This poses a disincentive to farmers to grow Perintis.

In 1992, MM 92 was released by MARDI. MM 92 is a progeny of the cross CM1362-6 x CM586-1 introduced in a seed batch in 1982. Its outstanding qualities are:

- wide adaptability to mineral soils and drained peat
- early harvestability, producing a root yield of 30-35 t/ha after six months (which is comparable to the yield of Black Twig at 12 months)
- flexibility in harvest (can be delayed till 12 months) to take advantage of prevailing market prices for roots.

Unfortunately, MM92 went the way of Perintis because of its low root starch content (20% or lower).

Fortunately, after 1990 seed introductions from CIAT/Colombia and the Thai-CIAT program increasingly included materials with high root dry matter content. This made it possible to select for higher starch-containing clones in tandem with high or moderate root yields. Evaluation trials have succeeded in identifying two clones of promise which were introduced in 1991 and 1992. Due to a management decision in MARDI to discontinue research on cassava in 1995, no further seed introductions have been carried out since then. Work on cassava breeding and selection has wound down with the objective of finishing the last stages of evaluation and selection of the existing introduced materials.

As it became clear that growing cassava for starch may not be the only way to exploit the crop, attention has shifted to the selection of clones with lower levels of cyanogen in the roots, making them suitable as table varieties or for processing into food products. Main forms of processed cassava foods are *kerepek* (oil-fried crisps) and *keropok* (variously flavored puffed crackers). Both are popular traditional snacks. Currently, farmers grow two or three varieties of cassava for making *kerepek*, i.e.. Medan, Ubi Kuning and Ubi Putih. The root yields of these clones tend to be low to moderate (**Table 1**). One clone, SM1562-19, introduced in a seed batch from CIAT/ Colombia in 1992, has a low root cyanogen content and has shown in a preliminary test good acceptability by a *kerepek* processor. The clone is currently being multiplied for wider testing for this form of utilization.

Table 1. Root yields of farmer varieties for making *kerepek* compared with root yields of SM 1562-19 and other high yielding starch varieties at 6 and 12 months after planting.

	Fresh root yield (t/ha)	
Variety/Clone	6-months	12-months
Medan*	3.4	18.1
Ubi Putih*	18.8	25.6
Ubi Kuning*	15.1	27.7
SM 1562-19	**23.6**	**36.8**
Black Twig	11.4	38.1
Perintis	23.1	50.8
MM 92	29.6	45.7

*Not in same trial

Another clone, CM6149-30, introduced in a seed batch in 1991 has shown promise as a starch variety, having high root yields and a starch content equivalent to that of Black Twig (**Table 2**). It is currently under final evaluation, and if its good agronomic performance is confirmed, it will be released as a new variety soon.

Table 2. Performance of CM 6149-30 in comparison with other clones and check varieties at the Pontian Peat Station, Johor, Malaysia, in 1995-1997.

Clone	Fresh root yield (t/ha)		Harvest index		Starch content (%)		Starch yield (t/ha)	
	6-mo	12-mo	6-mo	12-mo	6-mo	12-mo	6-mo	12-mo
Rayong 3	12.3	13.5	0.72	0.68	27.2	22.8	3.35	3.18
Rayong 60	17.0	23.4	0.63	0.64	27.0	22.8	4.56	5.42
CMR 28-67-76	18.2	19.8	0.66	0.61	27.3	24.1	4.96	4.78
MKUC28-77-3	18.0	22.6	0.65	0.64	28.1	23.4	4.98	5.39
CM 6149-23	15.3	27.0	0.60	0.60	27.5	21.6	4.20	5.91
CM 6149-30	**22.3**	**37.6**	**0.58**	**0.63**	**24.5**	**23.0**	**5.44**	**8.74**
CM 6149-54	18.3	30.5	0.59	0.62	26.9	23.8	4.95	7.26
CM 6149-55	13.6	17.0	0.59	0.58	26.8	23.0	3.64	3.86
CM 6885-75	13.7	23.0	0.60	0.61	27.2	24.1	4.08	5.58
CM 7752-4	13.5	19.0	0.58	0.57	27.8	24.7	3.78	4.69
CM 8061-2	15.0	21.4	0.59	0.68	25.2	21.7	3.94	4.55
Checks								
Black Twig	19.0	28.2	0.57	0.58	25.6	23.0	4.68	6.70
Perintis	23.1	35.5	0.67	0.74	22.6	19.2	5.32	6.90
MM92	25.4	32.0	0.72	0.69	22.7	16.7	5.86	5.38
LSD (p=0.05)	3.9	5.5	0.04	0.03	1.9	1.2	1.03	1.25

AGRONOMY RESEARCH

Agronomy research on cassava in MARDI has given attention to three main areas:

- reduction of production costs
- maximization of profits
- expansion of production into marginal areas.

Reduction of Production Costs

1. Mechanization in field production

One of the main production costs is labor, which has become expensive because of a shortage arising from competing demand from the manufacturing and construction sectors. To counter this problem, research has investigated the mechanization of field production operations, especially for planting and harvesting – two of the operations most demanding of labor (**Table 3**). Most jobs can be mechanized, except:

- the collection of healthy stems from a crop to be harvested for use as planting materials for the next crop
- bundling cuttings
- destumping the stems from the roots after they have been dug out from the ground

Machine packages can be assembled to suit the location, terrain and scale of planting (Sukra and Tan, 1994). Savings in labor requirements for each operation are given in **Table 3**.

Table 3. Estimated labor required per day for a 400-ha cassava farm on mineral soils.

Field operation	Labor (men/day)	
	Mechanized	Manual
Primary tillage	(2)	(2)*
Secondary tillage	(2)	(2)*
Stem harvesting	4	4
Gathering and stacking stems	8, (2)	15
Stem cutting	2	15
Bundling cuttings	2	2
Transporting cuttings and fertilizers	1, (1)	1, (1)
Planting and fertilizer application	3, (1)	32 + 21
Pre-emergence herbicide spraying	(1)	6
Weeding at 2 months	(1)	56
Post-emergence herbicide spraying	(1)	22
Tops and weed cover destruction	(1)	-
Digging roots	(3)	100
Destumping roots	16	16
Gathering roots and transport	12, (10)	10, (6)
Clearing stems from field	-	8
Total	**73**	**317**

*contract job, using tractors
Figures in parentheses represent number of tractor drivers
Source: *Sukra and Tan, 1994.*

2. Fertilizer recommendations using DRIS

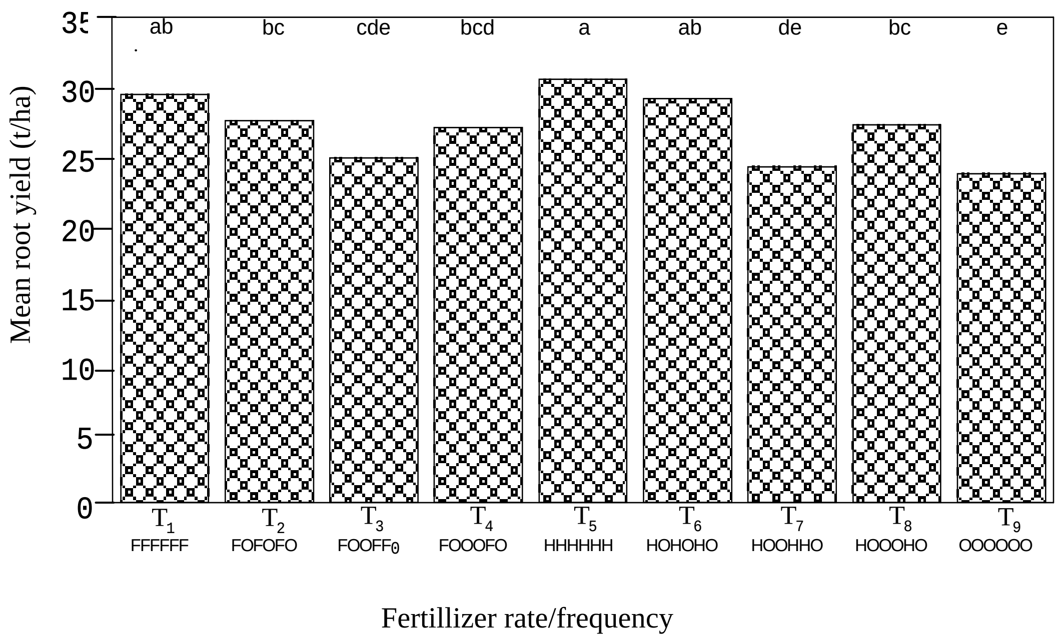
In the past, fertilizer recommendations for cassava have been blanket in nature:

60 kg N, 30 kg P_2O_5, 160 kg K_2O per ha on mineral soils (Chan *et al*., 1983)
250 kg N, 30 kg P_2O_5, 160 kg K_2O per ha on drained peat (Tan and Chan, 1989)

In order to save on costs and to maximize profits, a computer program based on DRIS (Diagnosis and Recommendation Integrated System (Sumner, 1986) was developed for diagnosis of nutrient insufficiencies and for formulating fertilizer recommendations, using data from long-term fertility trials. These trials had tested different levels of N, P and K (and lime in the case of peat), and had been carried out on mineral soils (Chan, 1980) and on drained peat (Tan and Chan, 1989). By collecting leaf samples at around 3 months after planting, and analyzing certain major nutrients, it was possible through inputting these values into the computer program to correct any nutrient insufficiencies in the standing crop to optimize yield performance (Chan, 1992).

3. Fertilizer practices with early variety MM 92

It was found that for variety MM 92 planted on drained peat it was not necessary to apply fertilizers every season to consecutive crops. It was possible to sustain root yields by supplying half the rate of fertilizers formerly recommended for cassava (i.e. 125 kg N, 15 P_2O_5 and 80 K_2O/ha) on peat to every alternate crop (T_6 in **Figure 1**). This practice produced average root yields over six crops which were not significantly different from applying the full fertilizer rate to every crop (T_1 in **Figure 1**).



F=full rate (250:30:160) H=half rate (125:15:80) O=no fertilizer

Note: Bars bearing the same letter are not significantly different from one another according to LSD test (p=0.05)

Figure 1. Mean fresh root yields (over 6 crops) of cv. MM 92 planted on drained peat using different rates of fertilizers and frequency of application at the Pontian Peat Station, Johor, Malaysia, from 1991 to 1995.
Source: *Adapted from Tan, 1995.*

Maximization of Profits

1. Intercropping cassava with short-term crops

It is possible to increase farm income by intercropping cassava with sweet corn, either by planting a single row of corn between cassava in square planting at 0.9x0.9 m, or by adopting the double-row planting system with two rows of corn as shown in **Figure 2**. Groundnut was found not to be suitable as an intercrop because of its susceptibility to shade (**Table 4**). These practices are well suited to small farmers growing cassava on peat by manual means.

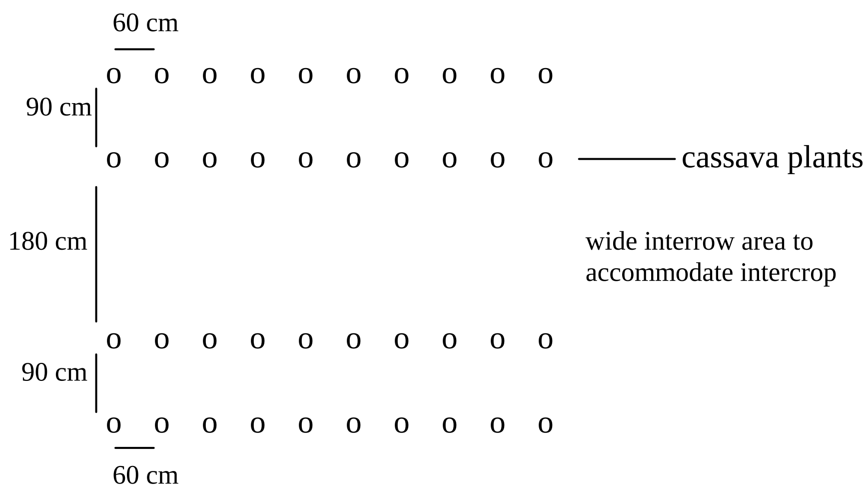


Figure 2. Layout for double-row planting (gives same cassava population as normal square planting at 0.9 x 0.9 m).

2. Recycling of starch factory solid wastes

Starch factories produce solid wastes, amounting to 40 kg (dried form) for every tonne of roots processed (Ti and Chua, 1972). These wastes can constitute a serious pollutant if dumped indiscriminately into waterways. They still contain a fair amount of nutrients (**Table 5**).

A two-season trial on drained peat showed that chemical fertilizer costs may be reduced by supplementing the use of 1 t of starch factory wastes per ha of cassava (**Table 6**), resulting in savings of RM 195 or US$ 51 per ha (Tan *et al*., 1997).

Expansion of Cassava Cultivation into Marginal Areas

1. Exploitation of peat land

Difficulties in getting land to grow cassava because of its lower value compared to other short-term crops such as fruits and vegetables have led to investigating the use of drained peat as an alternative. Cassava shows good adaptability to peat, as long as it is adequately (but not over-) drained and cleared. An efficient drainage system is required to quickly remove water from the field following heavy rain, as studies have shown that cassava roots will rot and yields will decline drastically with four days or more of standing flood water (Tan, 1998). A package of agronomic practices has been developed for successful cultivation of cassava on drained peat (Tan, 1993b).

Table 4. Costs and returns of production per hectare in monocropping and intercropping cassava with groundnut and sweet corn using two planting arrangements in Jalan Kebun Peat Station, Selangor, Malaysia.

	Monocropped cassava	Intercropped cassava			
		Square		Double-row	
		GN	SC	GN	SC
Production costs (US$/ha)	415	535	548	535	491
Yields					
-cassava (t/ha)	30-35	30	30	30	35
-groundnut (kg/ha)		672		791	
-sweet corn (cobs/ha)			36,000		24,500
Gross returns (US$/ha)					
-cassava	632-737	632	632	632	737
-groundnut		170		200	
-sweet corn			1 040		710
Net returns (US$/ha)	217-322	267	1 124	297	956

Note: GN=groundnut; SC=sweet corn; monocropped cassava planted in square arrangement.
Source: *Tan, 1988.*

Table 5. Nutrient composition of dried cassava starch factory solid wastes.

Nutrient	Concentration
Total N	1.34 %
P_2O_5	1.28%
K_2O	7.72%
Ca	3.12%
Mg	11.30%
Mn	20.90 ppm
Fe	2.30 ppm
Zn	0.52 ppm
B	0.48 ppm
S	21.90 ppm

Source: *Kwong Yik Lee Tapioca Sdn.Bhd.,Chemor, Perak, 1992.(peronal. communication)*

Table 6. Fresh root yield, root starch content and starch yield from treatments receiving various combinations of chemical fertilizers and starch factory solid wastes at the Pontian Peat Station, Johor, Malaysia, in 1994/95..

Treatment	Chemical fertilizers (kg/ha)	Starch wastes (t/ha)	Fresh root yield (t/ha)	Starch content (%)	Starch yield (t/ha)
M1W0	50:30:40	0	24.0a	24.5b	5.96b
M1W1	50:30:40	0.5	26.1a	24.1b	6.36ab
M1W2	**50:30:40**	**1.0**	**26.6a**	**25.3ab**	**6.79ab**
M1W3	50:30:40	1.5	25.2a	23.9b	6.08ab
M2W0	100:30:80	0	27.6a	26.4a	7.30a
M2W1	100:30:80	0.5	26.3a	24.2b	6.45ab
M2W2	100:30:80	1.0	27.4a	23.8b	6.55ab
M2W3	100:30:80	1.5	25.6a	25.4ab	6.53ab

Mean values within the same column with the same letter are not significantly different from one another according to the new Duncan's multiple range test (p=0.05)
Source: *Tan et al., 1997.*

Evaluation and selection of clones adapted to drained peat has shown that root yields obtained are comparable to yields from mineral soils, but that root starch contents tend to be lower because of higher root moisture content (**Table 7**).

It must, however, be stated that mechanization is not possible on drained peat with existing machines and field equipment because of the low bearing capacity of peat and the abundance of wood debris and tree stumps in newly cleared peat land.

2. *Control of soil erosion*

As cassava cultivation is forced into more hilly terrain due to lack of suitable arable land, it is essential that the problem of soil erosion be addressed. Various tillage and crop management combinations have been tested for their efficacy in reducing soil erosion. It was found that on a moderate slope of 5.5-10.5%, the most practical method – which was least detrimental to root yield (15% reduction compared to control) and caused an acceptable level of soil loss – was by leaving strips of natural grass to grow between cassava planted in double rows (**Table 8**).

CONCLUDING REMARKS

Although research on cassava production by MARDI has slowed down considerably, work still continues on the use of cassava in processing, e.g. modification of starches and their utilization. In drafting a recent proposal for a National R&D Program for Root Crops, the task force delegated the job decided that cassava is the cheapest source of starch compared to other root crops in

Malaysia. It proposed research on cassava be continued (not necessarily by MARDI alone), giving emphasis to certain specific areas. Furthermore, MARDI has moved on to providing feasibility studies (soil suitability assessment as well as financial analyses) and consultancy services to those parties interested in embarking on growing cassava for starch or processed food products, and who are able to gain access to farmland of a commensurate size. Such consultancies also provide MARDI with the opportunity to put into practice all the agronomic recommendations she has formulated over the years, to test out their effectiveness on a large enough scale, and to overcome day-to-day practical problems, while building up more expertise in the management of cassava plantations. Probably, some fine-tuning will be required before the package of production technologies on offer will be completely applicable and economically successful.

Table 7. Average performance of cassava clones on three mineral and three drained peat soils (1986-1989).

Clone	Fresh root yield (t/ha)		Starch content (%)[1]	
	Mineral soils[1]	Drained peat[2]	Mineral soils	Drained peat
CM 305-8	36.9	27.2	23.4	21.5
CM 378-17	33.4	26.6	26.5	23.0
CM 621-7	37.4	38.0	23.9	21.5
CM 621-22	36.6	30.6	23.7	21.4
CM 621-42	40.0	29.3	25.0	22.8
CM 845-13	29.2	24.8	28.5	24.8
CM 942-28	37.2	30.6	24.7	22.7
CM 982-2	29.4	34.4	25.6	23.9
MMex 1-20	29.7	29.0	26.2	24.6
17/A	36.9	33.7	25.6	23.3
CM 462-6	39.8	30.6	22.5	17.5
Black Twig	34.6	33.4	25.8	23.9
Red Twig	27.8	24.6	26.6	24.2
C 5	33.4	26.9	24.6	22.6
Perintis	48.4	45.9	23.3	19.7

1) Bukit Tangga, Kedah; Kluang, Johor; and Serdang, Selangor.
2) Jalan Kebun, Selangor; Pontian, Johor; and Teluk Intan, Perak.
Source: *Tan, 1993a.*

Table 8. Cassava yield and cumulative soil loss as affected by various tillage and crop management practices when planted on 6-10% slope at MARDI, Serdang, Malaysia in 1989-1991.

Treatment	Mean root yield (t/ha)[1)]	Cumulative soil loss (t/ha)		
		1st season	2nd season	Mean
High tillage	26.8bc	4.56	24.80	14.68
Normal tillage (control)	32.7a	4.49	21.45	12.97
No fertilizer	24.2c	2.73	14.12	8.42
Reduced tillage	26.2b	5.18	26.63	15.90
Zero tillage	21.2d	2.13	14.82	8.48
Subsoiling	27.6b	3.26	14.70	8.98
Grass barriers	27.8b	3.11	7.17	5.14
Groundnut intercrop	27.7b	3.98	10.43	7.20
Citronella intercrop	27.5b	4.22	13.80	9.01

[1)]over two seasons

Note: Values in the same column bearing the same letter are not significantly different from one another according to the new Duncan multiple range test (p=0.05)

Source: *Chan et al., 1994.*

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