

Two new cassava starch clones, Rayong 90 and OMR 36-05-24

(Dua klon kanji ubi kayu baru, Rayong 90 dan OMR 36-05-24)

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Key words: cassava, starch varieties, evaluation and selection, root yield, root starch content, morphological characteristics

Abstrak

Biji benih dan tisu kultur meristem ubi kayu telah dibawa masuk dari CIAT dalam tempoh 1983–1994, dan penilaian serta pemilihan telah dijalankan terhadap klon yang dihasilkan sehingga tahun 2000. Dari skim penilaian berperingkat, dua klon telah didapati berpotensi untuk pengeluaran kanji, kerana memberi hasil ubi dan mempunyai kandungan kanji yang sederhana tinggi. Dalam ujikaji hasil yang terakhir, klon Rayong 90 dan OMR 36-05-24 memberi hasil ubi segar (32–37 t/ha) yang lebih tinggi daripada varieti kanji biasa, Black Twig (28 t/ha) selepas 12 bulan. Walaupun hasil ubi ini bersamaan dengan hasil varieti MARDI (Perintis dan MM 92) tetapi kedua-dua klon Rayong 90 dan OMR 36-05-24 mempunyai kandungan kanji (27%) yang ketara lebih tinggi daripada Perintis, MM 92 dan Black Twig (21–25%). Klon ini mungkin dapat mempertingkatkan daya pengeluaran ladang ubi kayu yang kini semakin kurang.

Abstract

Cassava seed and meristem tissue culture introductions were made from CIAT over the period 1983–1994, and evaluation and selection was carried out on the resulting clones up to the year 2000. From the scheduled evaluation scheme, two clones were found to be promising for starch, having both reasonably high root yields and moderately high starch contents. In a final yield trial, these clones, Rayong 90 and OMR 36-05-24, produced higher fresh root yields (32–37 t/ha) than the standard starch variety, Black Twig (28 t/ha) after 12 months. Although their root yields were only equivalent to the earlier MARDI varieties (Perintis and MM 92) both Rayong 90 and OMR 36-05-24 had significantly higher starch contents (27%) than the MARDI varieties as well as Black Twig (21–25%).

These clones may help boost productivity in the current cassava farms which are declining in number.

Introduction

From a profitable industry peaking in the 1970s, the cassava (*Manihot esculenta* Crantz) starch industry has been steadily declining over the last two decades. This has largely been due to two factors: the

increasing competition for arable land, and the falling farm prices for raw cassava roots. The current situation is one of high demand for cassava starch (at 90 000 tonnes per year, growing at a mean rate of 27.8%

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annually over the period 1991–97) and practically no local supply (Tan 1998). It is a fact that Peninsular Malaysia no longer has the luxury of vast tracts of suitable land – in the range of 1 500–2 000 ha – required to keep just a single 25-tonne capacity starch factory in operation, working an 8-hour shift a day, throughout the year. Currently available land in the Peninsula is confined to problem soils, such as:

- Steep or hilly land – unsuited to mechanization; soil erosion problem
- Peat – unsuited for mechanization; drainage problem
- Bris soils – unprofitable because of high fertilizer requirements; water retention problem
- Tin-tailings – unprofitable because of high fertilizer requirements; water retention problem
- Abandoned paddy land – too clayey for good storage root development; difficult to harvest roots in the wet as well as in the dry season.

At present, the area in Peninsular Malaysia under cassava cultivation totals less than 2 000 ha a year, showing a declining trend of 7% per annum over the period 1990–98. Compared to the peak production in 1976, there has been a 90% drop in cultivated area. Many starch factories have already abandoned operations for lack of root supply. The two remaining ones in Perak operate only a few days a week.

Cassava varieties, Perintis and MM 92, released by MARDI in the past have not been successfully adopted. While cassava growers are impressed by the much higher productivity of these varieties compared to the commercial starch variety, Black Twig, the same cannot be said of the starch processors. The low starch contents of Perintis and MM 92 (20–22%) translate into having to process a larger volume of roots to recover the same amount of starch as when

Black Twig roots (which has a starch content of 24–28%) were used. Furthermore, the price of fresh roots is based on the starch content of the roots, with a RM3.85 discount for every 1% less starch than 28%.

With this past experience in mind, MARDI embarked on selecting for high-yielding clones with starch contents which are higher or at least equivalent to that of Black Twig. The result of these efforts is described in this paper.

Materials and methods

A number of introductions comprising seed batches and meristem tissue cultures from CIAT* Headquarters in Cali, Colombia and the CIAT-Thai Programme in Rayong, Thailand were made over the period 1983–1994. The usual stepwise evaluation of the resulting cassava clones (Tan and Mohsin 1984) was carried out to shortlist promising genotypes, based mainly on fresh root yield, harvest index and root starch content, and in comparison with the local checks, Black Twig, Perintis and MM 92. In the case of seed, this scheme of selection starts with seedling selection, where single seedlings were evaluated at a wide plant spacing of 2 m x 2 m. Those showing high harvest index (root weight divided by total plant weight including root weight) as well as high fresh root yield and root starch content (estimated from the specific gravity of the roots – see Noor Auni and Tan 1980) were cloned, and advanced to unreplicated single-row trials. These comprised 10 plants per clone, tested in blocks against single rows of the check varieties: Black Twig, Perintis and MM 92. The plants were spaced at 1 m apart within the row, and the rows are 1.5 m apart. Only the middle eight plants per row were harvested, and clones were selected for root starch content, fresh root yield and harvest index which are higher than Black Twig, the commercial starch variety, and advanced into preliminary yield trials.

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In the case of meristem tissue culture introductions, the clones were subcultured and multiplied first in tissue culture and then in the field until there was enough planting material to evaluate the clones in preliminary yield trials. For both seed and tissue culture introductions, preliminary yield trials consisted of 25-plant plots (5 m x 5 m plot size with plants at 1 m x 1 m spacing) replicated twice per clone, using Black Twig, Perintis and MM 92 as checks. Only the central 9 plants per plot (3 x 3) were harvested for data collection. A randomized complete block design with two replications was used. Clones which had higher fresh root yields than Black Twig and higher than or equivalent root starch contents as Black Twig were selected.

For seedling, single-row and preliminary yield trials, harvests were carried out after 12 months. Those clones qualifying for advanced yield trials were tested and harvested after 6 and after 12 months. Advanced yield trials comprised 5 m x 9 m plots, allowing half of the plot (central nine plants) to be harvested at 6 months and leaving another nine surrounded by a border row all round for harvest at 12 months. The same three checks were used. A randomized complete block design with four replications was used. At the six-month harvest, clones were selected if they outperformed the early variety MM 92.

The five best selections from different introduced batches were combined in a single final yield trial planted on drained peat in 2000 at the MARDI station in Pontian. Three check varieties were included, namely, MM 92, Perintis and Black Twig. A randomized complete block design was adopted with four replications. Plot size was 13 m x 7 m. With a planting distance of 1 m x 1 m, this amounted to 91 plants per plot. As in the advanced yield trial, each plot was divided in half to allow for harvests at 6 and 12 months after planting. Only the central 25 plants were harvested each time. Data on plant establishment were collected at one month

after planting. At each harvest, data were collected on total fresh root yield, harvest index and starch content.

The usual agronomic and fertilizer practices for cassava on drained peat (Tan and Chan 1992, 1994) were adopted in all the above trials, i.e. throughout the evaluation and selection process.

Results and discussion

None of the clones originating from the seed and tissue culture introductions produced early yields like MM 92. Results are presented only on the performance of the two final selections in relation to the three checks in single-row, preliminary and advanced yield trials (*Table 1*). These clones are Rayong 90, introduced in the form of a meristem tissue culture, and OMR 36-05-24 which was a seed introduction. The high yields of Rayong 90 and OMR 36-05-24 were already apparent in the single-row trials. Rayong 90's high starch content was also evident at this stage. In the subsequent replicated trials (preliminary and advanced yield trials), although these two clones did not outyield Perintis and MM 92 convincingly, they had significantly higher starch contents. While their root yields were at a level similar to Black Twig's, Rayong 90 and OMR 36-05-24 had generally higher or equivalent starch contents.

Results from the final yield trial testing promising clones against the local checks, MM 92, Perintis and Black Twig, are presented in *Table 2*. Excluding the checks, the two highest yielding clones after 12 months were Rayong 90 and OMR 36-05-24. However, it may be seen that both these clones are not particularly outstanding in root yield at 6 months after planting as compared to early variety MM 92. This is in keeping with the results of the advanced yield trial (*Table 1*).

Although Rayong 90 outyielded OMR 36-05-24 at 12 months, the latter has a much better plant habit than the former (*Plates 1 and 2*). Rayong 90 has many sprawling branches that may hinder both crop

Table 1. Performance of clones Rayong 90 and OMR 36-05-24 compared to varieties Black Twig, Perintis and MM 92 at various stages of testing

Stage of testing	No. of replications/no. plants per plot	Location/soil type	Year	Clone/variety	Fresh root yield	Harvest index	Starch content (%)
Single-row trial	Unreplicated/ 8 plants	Jalan Kebun/ drained peat	1994/95	Rayong 90	50.8 kg	0.65	27.5
				Black Twig	47.2 kg	0.63	22.3
				Perintis	55.4 kg	0.77	20.3
				MM 92	51.0 kg	0.77	14.1
			1995/96	OMR 36-05-24	45.6 kg	0.67	na
				Black Twig	12.0 kg	0.26	
Preliminary yield trial	2 replications/ 25 plants	Pontian/drained peat	1995/96	Perintis	25.2 kg	0.71	
				MM 92	18.6 kg	0.54	
				Mean (10)*			
				Rayong 90	48.1 t/ha ab	0.56c	25.3a
				Black Twig	46.7 t/ha ab	0.42d	23.6ab
			1996/97	Perintis	59.4 t/ha a	0.75a	20.7bc
				MM 92	29.7 t/ha c	0.65b	19.8c
				Mean (10)*	42.5 t/ha	0.62	22.7
				OMR 36-05-24	43.6 t/ha a	0.67a	23.7a
				Black Twig	31.7 t/ha a	0.56a	25.2a
Advanced yield trial (6 months)	4 replications/ 25 plants	Pontian/drained peat	1996–98 (2 seasons)	Perintis	48.1 t/ha a	0.69a	22.5b
				MM 92	42.8 t/ha a	0.66a	19.7c
				Mean (17)*	30.8 t/ha	0.62	23.3
				Rayong 90	18.1 t/ha a	0.40bc	24.1a
				Black Twig	39.6 t/ha a	0.31c	22.8ab
				Perintis	26.2 t/ha a	0.47ab	20.3c
				MM 92	32.4 t/ha a	0.55a	20.8bc
				Mean (10)*	24.9 t/ha	0.44	22.6

(cont.)

Table 1. (cont.)

Stage of testing	No. of replications/no. plants per plot	Location/soil type	Year	Clone/variety	Fresh root yield	Harvest index	Starch content (%)
Advanced yield trial (12 months)	4 replications/ 25 plants	Pontian/drained peat	1997–99 (2 seasons)	OMR 36-05-24	19.1 t/ha b	na	23.2a
				Black Twig	21.0 t/ha b		23.1a
				Perintis	28.5 t/ha a		20.2b
				MM 92	24.4 t/ha ab		18.7b
				Mean (17)*	16.2 t/ha		22.9
			1996–98 (2 seasons)	Rayong 90	35.0 t/ha b	0.56a	26.1a
				Black Twig	26.0 t/ha b	0.43b	23.2b
				Perintis	39.7 t/ha a	0.54a	21.0b
				MM 92	44.8 t/ha a	0.62a	18.0c
				Mean (10)*	31.9 t/ha	0.52	22.2
			1997–99 (2 seasons)	OMR 36-05-24	29.0 t/ha b	na	23.9a
				Black Twig	30.2 t/ha b		22.4a
				Perintis	39.6 t/ha a		18.9b
				MM 92	35.8 t/ha ab		17.1c
				Mean (17)*	24.7 t/ha		23.1

*Number in brackets refers to number of entries in the yield trial

Note: For the preliminary and advanced yield trials, values in the same column bearing the same letter are not significantly different from one another according to the new Duncan multiple range test ($p = 0.01$)
na = not available

Table 2. Performance of clones with potential as starch varieties and local checks MM 92, Perintis and Black Twig (yield trial on drained peat, MARDI Pontian Station)

Clone/Variety	Establishment rate (%)	Fresh root yield (t/ha)		Harvest index		Starch content (%)		Starch yield (t/ha)	
		6 months	12 months	6 months	12 months	6 months	12 months	6 months	12 months
Rayong 90	98.0a	18.1bc	37.6ab	0.38bcd	0.48cd	22.7ab	26.7a	4.13b	10.05a
CM 7719-7	97.2a	18.0bc	28.8bcd	0.42bc	0.50cd	22.4bc	24.0c	4.06b	6.90cd
SM 1565-7	98.4a	17.0c	22.4d	0.41bcd	0.43de	23.9a	25.4b	4.10b	5.67d
OMR 36-05-24	98.1a	16.2cd	32.2abc	0.34cd	0.51bc	21.8bcd	26.9a	3.56bc	8.66abc
CMR 36-18-23	99.4a	14.2cd	30.4bcd	0.31d	0.45cd	22.4bc	26.6a	3.20bc	8.09abc
CHECKS:									
MM 92	99.7a	28.2a	36.4abc	0.54a	0.57ab	20.7de	20.9e	5.84a	7.64bcd
Perintis	95.9a	24.0ab	40.9a	0.46ab	0.59a	19.8e	22.8d	4.74ab	9.36ab
Black Twig	97.0a	10.0d	28.0cd	0.20e	0.37e	21.1cd	25.2b	2.12c	7.07bcd

Values in the same column bearing the same letter are not significantly different from one another according to the new Duncan multiple range test ($p = 0.01$)

management as well as root harvest. Nevertheless, the fresh root yield of OMR 36-05-24 was not significantly different from the three check varieties. Rayong 90's yield was significantly higher than that of Black Twig by 34%.

Unlike MM 92 and Perintis, Rayong 90 and OMR 36-05-24 have better potential in replacing Black Twig as commercial starch varieties because of their acceptable fresh root yield, and – more important – their higher root starch contents. Despite not outyielding MM 92 and Perintis, these clones will be preferred by starch processors because they give a better starch extraction rate, i.e. the volume of roots processed will be less to produce the same amount of starch. Experience in Thailand has shown that starch factory owners dictate the varieties planted by farmers, and that they strongly prefer new varieties which have high starch contents, even if these varieties have a lower root yield (Limsila et al. 1998).

In terms of plant establishment from cuttings, no significant differences were shown between the two new clones and the local checks, all of which were at an acceptably high level of more than 95%. Both Rayong 90 and OMR 36-05-24 had poorer harvest indices at 12 months compared to MM 92 and Perintis, reflecting their more vigorous top growth and larger plant type. Nevertheless, these harvest indices were significantly higher than that of Black Twig, indicating an improvement in partitioning ability towards economic yield.

Further notes on Rayong 90 and OMR 36-05-24

Rayong 90 came from a batch of meristem cultures introduced in 1991 from the CIAT-Thai Programme, Thailand. This is a hybrid variety, resulting from a cross between CMC 76 x V 43. It was released as a starch variety in Thailand in 1991, where it is reported to have high dry matter content (reflective of starch content) and relatively high root yield (Limsila et al. 1998).



Plant 1. Plant habit of Rayong 90 – Many low and sprawling branches



Plate 2. Plant habit of OMR 36-05-24 – Mostly unbranched; sometimes late or early branching

OMR 36-05-24 originates from a set of seeds introduced in 1994, also from the CIAT-Thai Programme. It is from a batch of open-pollinated seeds collected from the maternal parent clone CM 6125-117.

Both clones adapt very well to drained peat. Based on previous studies testing cassava clones on both mineral soils and drained peat (Tan 1985, 1989), it may be expected that they would perform just as well on mineral soils.

The morphological characteristics of Rayong 90 and OMR 36-05-24 are presented in in *Plates 1–4*.

Conclusion

Rayong 90 and OMR 36-05-24 have potential as starch varieties because their root starch contents are significantly higher than that of Black Twig, the current commercial starch variety, and certainly much more so than the two varieties previously developed by MARDI, viz. MM 92 and Perintis. The failure of these two MARDI varieties to gain a foothold on the cassava starch industry has been due mainly to their disappointing starch content. As starch varieties that can replace Black Twig, Rayong 90 and OMR 36-05-24 may be able to pull the cassava industry out of the current doldrums.

While there is a severe land limitation in Peninsular Malaysia, use of these new clones in existing cassava farms will increase starch productivity per unit land area. As for expansion in cultivated area: the

New cassava starch clones



- A. Shoots and leaves –
Young shoot colour: green with a tinge of light brown
Yellowish green petioles
Narrow obovate lobes



- B. Mature stems –
Light brown in colour



- C. Root –
Conical root shape
Brown skin colour
Fairly smooth skin
Pale brown under skin
White flesh colour

Plate 3. Morphological characteristics of Rayong 90



A. Shoots and leaves –
Young shoot colour: light brown
Yellowish green petioles
Obovate lobes



B. Mature stems –
Orangy brown to reddish
brown with silvery patches



C. Root –
Cylindrical root shape
Dark brown skin colour
Rough skin
Pale brown under skin
White flesh colour

Plate 4. Morphological characteristics of OMR 36-05-24

north-eastern part of Sabah (near Paitan and Bengkoka) and the central area in the interior of Sabah (Keningau and Sook plains) may be the last frontier for cassava starch production. In these areas, totalling some 122 000 ha, the rainfall is insufficient for optimum oil palm production (Fung 2001). Rayong 90 having been developed in Thailand (where 3–4 months of dry season occur annually) will be able to tolerate a lower rainfall regime, and will probably have less heavy top growth than it does on peat.

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