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CORRELATION STUDIES ON THE PERFORMANCE OF SOME CASSAVA VARIETIES AT FIVE LOCATIONS

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Keywords: Cassava, Varietal performance, Correlation of agronomic characters among sites.

RINGKASAN

Daripada 16 jenis ubi kayu yang diuji di enam tapak terletak di lima lokasi, Black Twig, Medan dan Bangkok 1 merupakan jenis yang paling sesuai untuk suasana yang berbeza. Ketiga-tiga jenis ini mempunyai hasil ubi yang tertinggi di lima daripada enam tapak percubaan. Hasil ubi adalah paling tinggi di salah satu daripada dua tapak yang terletak di Serdang, dan paling rendah di Pontian di mana tumbesaran pokok pada amnya, kurang memuaskan. Tapak-tapak di kawasan tanah gambut (Jalan Kebun dan Pontian) menghasilkan ubi yang mempunyai isi kandungan kanji yang lebih rendah daripada ubi yang didapati dari tapak-tapak di tanah biasa yang terdapat di Serdang, Sitiawan dan Bukit Selambau.

Kajian korelasi di antara tapak-tapak menunjukkan hasil ubi dan kanji mempunyai kesanggupan berulang di tapak-tapak tanah biasa dan di tapak-tapak tanah gambut. Keadaan ini membayangkan bahawa pemilihan peringkat awal yang dapat mengenalpasti klon-klon yang berhasil tinggi bagi kawasan pengeluaran ubi kayu sekarang dan berpotensi dapat dijalankan di satu tapak tanah biasa dan satu lagi tapak tanah gambut. Ini akan menghindarkan pemilihan peringkat awal dijalankan di merata tempat, suatu amalan yang mahal. Percambahan keratan ada pertalian di antara tapak-tapak tanah biasa, tetapi tidak begitu ketara di kawasan tanah gambut. Isi kandungan kanji adalah stabil dan dapat dipilih di mana-mana tempat kerana ianya menunjukkan korelasi yang tinggi di antara semua tapak percubaan.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is one of the more important field crops cultivated in Peninsular Malaysia. It occupied an area of 12 512 hectares in 1980 (MINISTRY OF AGRICULTURE, 1981), and was utilized mostly for starch extraction. Although cassava is grown everywhere in Peninsular Malaysia, Perak has by far the largest area under the crop (over 85% of the total area) while Kedah ranks a poor second (about 5%). Indications are that future expansion of cassava cultivation on mineral soils is unlikely to be significant. Firstly, there has been a declining trend in crop area over the past five years after having peaked in 1976 at 20 913 hectares (MINISTRY OF AGRICULTURE, 1977; 1978; 1979; 1977–1980). Secondly, a substantial amount of cassava production in Perak is the result of cultivation on illegal holdings located on state land, mining and forest reserves (AW YONG and MOOI, 1973). Thirdly, a recent informal survey of cassava farmers in Perak and Kedah revealed that the vast majority of these farmers considered cassava cultivation as a part-time enterprise, a useful means of earning some additional income (CHAN, KHELIKUZAMAN, TAN, GEH and LOH, 1983). In other words, farmers have less commitment to cassava, and pay greater attention to the cultivation of more lucrative crops such as oil palm, rubber and cocoa.

It is highly probable that in future years with increasing pressure on land availability from the expansion of major crop areas, the area under cassava will remain static or shrink further. However, there exists an avenue for expansion of cassava cultivation in the large tracts of peat which occur in Peninsular Malaysia, where there will be less competition from other crops. Research to date has revealed the potential of growing cassava on drained peat (CHEW, 1977) where two major advantages stand out. One, cassava is highly tolerant of the acid conditions of peat, requiring minimal liming. Two, the loose friable structure of peat facilitates manual harvesting of cassava, a significant cost of cultivation on mineral soils.

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For the above reasons, breeding and selection efforts on cassava at MARDI aim at identifying new materials adapted to current cassava-producing areas and to potential peat locations. As an initial step, it was deemed necessary to observe the performance of some cassava varieties at sites located in these areas and at Serdang and Jalan Kebun (peat) research stations. In this manner it would be possible to determine whether correlations exist among locations with regard to important performance traits. This will in turn establish whether Serdang and Jalan Kebun stations may be used justifiably and effectively for the bulk of the initial stages of selection and short-listing of new clones.

MATERIALS AND METHODS

A total of 16 varieties of cassava from the germplasm collection maintained at MARDI, Serdang was planted to a series of six trials over five locations, *viz.* Serdang, Selangor (two sites); Jalan Kebun, Kelang; Sitiawan, Perak; Bukit Selambau, Kedah; and Pontian, Johore between 1979 and 1981. The 16 varieties were selected to represent a range in agronomic as well as morphological characteristics *(Table 1)* while including some of the highest yielding materials in the collection.

A Randomized Complete Block Design with four replications was used for each of the trials. Before planting, eight soil samples were collected per replicate in each trial, and mechanical and chemical analyses were carried out on samples bulked within replicates.

Each plot comprised 25 sample plants and each sample area was surrounded by two border rows. Cuttings of 20 cm length were planted horizontally at a spacing of 1 metre by 1 metre. A fertilizer rate of 480 kg/ha of a commercial formulation of 12 N:6 P_2O_5:22 K_2O:3 MgO was applied at three weeks after planting. In the case of the peat sites at Jalan Kebun and Pontian, a supplementary rate of 10 kg/ha of copper sulphate was supplied to correct inherent copper deficiencies in the soil.

Table 1. List of cassava germplasm varieties used in the six trials

Variety	Leaf lobe	Plant habit	Source and remarks
Jurai	Lanceolate	Late branching, once or twice	Local farmers' variety.
Betawi	Obovate	Unbranched	Local farmers' variety.
Green Twig	Obovate	Unbranched	Local farmers' variety.
Bangkok 1	Obovate	Unbranched	Introduced from Thailand.
El Salvadore 8/1 326/2	Obovate	Intermediate branching, 2–3 times	Introduced from Hawaii.
I.T.U. 15007 20/1B	Obovate	Intermediate branching, once or twice	Introduced from Hawaii.
Trinidad 146 52/A	Obovate	Intermediate branching, 4–5 times.	Introduced from Hawaii.
Brazil 146 56/A	Obovate	Intermediate branching, once	Introduced from Hawaii.
Kuning 2	Obovate	Early branching, 2–3 times	Local farmers' variety.
Medan	Obovate	Largely unbranched	Local farmers' variety, widely grown and edible.
C3	Obovate	Early branching, around 4 times	Open-pollinated seedling clone
Buluh	Lanceolate	Intermediate branching, 4–5 times	Local farmers' variety.
Fowlfat 146 42/A	Obovate	Intermediate branching, 4–5 times	Introduced from Hawaii.
Llanera	Lanceolate	Early branching, 4–6 times	Introduced from Hawaii.
Silon	Obovate	Intermediate branching, 2–3 times	Local farmers' variety.
Black Twig	Obovate	Unbranched	Local farmers' variety, widely grown commercially.

Rainfall data were recorded over the experimental period at each site.

Data on germination were collected at three weeks, and data on plant height, root yield, harvest index (root weight over total plant weight), total root number, commercial-sized (longer than 15 cm) root number, starch content of roots, starch yield and cyanide content of roots at harvest, 12 months after planting. Starch content was estimated by specific gravity (s.g.) measurements of root samples (NOOR AUNI and TAN, 1980) using a conversion formula of:

Starch content $Y = -90.9512 + 102.9848X$

where X = s.g. estimate.

Starch yield is the product of root yield and starch content. Cyanide content was estimated by the sodium picrate paper method, with modifications to measure colour change quantitatively using a spectrophotometer (TAN and NOOR AUNI, 1981).

Analyses of variance were computed on all measured traits for each site. To determine whether crop performance at the various sites was in anyway related, varietal means over replications of specific agronomic traits at each site were used in correlation studies. The six traits studied were those relevant to the cassava industry, *viz.* germination (log-transformed values), root yield, harvest index, starch content, starch yield and cyanide content. Correlations were run by variety over sites, separately for each trait in turn.

RESULTS

Site characteristics in terms of soil type, chemical composition of soil, and rainfall pattern are given in *Table 2*. Two sites were on peat and the rest on mineral soils, ranging in texture from sandy clay to silty loam to silty clay. The soil pH was generally low (less than 4.0) at the peat sites, and ranged from 4.25 (at Sitiawan) to 7.32 (at Bukit Selambau) for the sites located on mineral soils. Besides having a soil pH which was neutral, the K status of the soil at Bukit Selambau was also much higher than at the others.

The two sites at Serdang were considered as separate entities because of their clear difference in soil type, pH and K content *(Table 2)*. The trials at these sites were conducted in different years, hence the variation in rainfall.

Annual rainfall amounted to around 2 000 mm at most of the sites, except at Sitiawan which was drier and at Bukit Selambau which was wetter. The number of rain-days at this latter site also reflects the higher intensity of rain per fall. The distribution of rainfall over the experimental or cropping period at each site is shown in *Figure 1*.

Root yield data of the 16 varieties at each of the six sites are presented in *Table 3*. The top five varieties for each site were picked from this table and data on their agronomic characters shown in *Table 4*. Medan, Bangkok 1 and Jurai were consistently among the top five at Serdang and

Table 2. Soil and rainfall characteristics of the six sites

Site	Soil type	pH	N (%)	P (ppm)	K (ppm)	Rainfall	
						Annual (mm)	Rain-days
Site A, Serdang	Sandy clay	5.98	0.11	7	47	2 351	167
Site B, Serdang	Silty clay	4.64	0.10	6	124	2 165	182
Sitiawan	Silty loam	4.25	0.18	16	106	1 559	100
Bukit Selambau	Silty clay	7.32	0.19	5	369	3 357	142
Jalan Kebun	Peat	3.78	1.19	11	96	2 715	180
Pontian	Peat	3.58	1.27	29	205	2 410	200

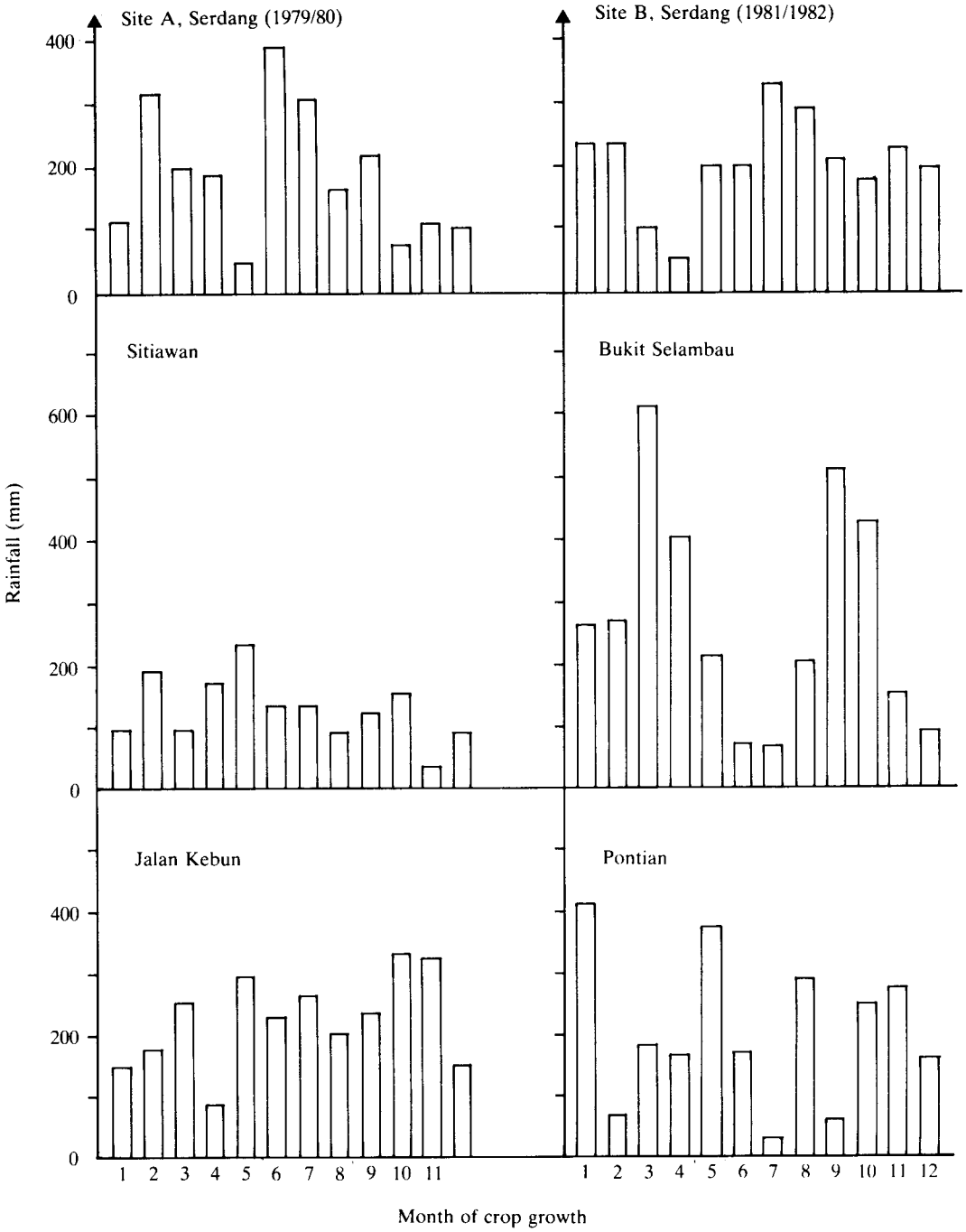

Figure 1. The distribution of rainfall over the experimental or cropping period at six sites in five locations.

Sitiawan. Three varieties featured among the top five in all sites except one, *viz.* Medan (except at Jalan Kebun), Bangkok 1 (except at Bukit Selambau) and Black Twig (except at Site A, Serdang).

Site means for the various agronomic characters including root yield are given in *Table 5.* Root and starch yields were highest at Site B, Serdang. Sitiawan, Site A at Serdang, Jalan Kebun and Bukit Selambau

Table 3. Root yield (t/ha) of 16 cassava varieties at six sites

Variety	Site A, Serdang	Site B, Serdang	Sitiawan	Bukit Selambau	Jalan Kebun	Pontian
Jurai	27.6	42.6	31.1	14.1	18.6	6.2
Betawi	26.2	26.8	21.6	25.8	19.6	9.6
Green Twig	19.8	28.6	21.3	24.8	23.4	11.2
Bangkok 1	29.8	33.6	32.6	20.4	30.7	12.8
El Salvadore 8/1 326/2	29.1	33.6	23.2	17.0	31.7	7.8
I.T.U. 15077 20/1B	19.8	27.2	19.2	13.5	20.2	7.0
Trinidad 146 52/A	13.6	17.5	14.8	13.4	18.3	5.6
Brazil 146 56/A	17.1	34.8	22.6	21.6	27.3	11.0
Kuning 2	23.1	29.1	20.9	20.0	22.2	6.6
Medan	32.5	35.8	30.3	23.4	21.5	11.0
C3	30.4	32.2	33.2	23.3	11.1	6.9
Buluh	10.5	14.5	9.8	14.1	16.0	8.8
Fowlfat 146 42/A	9.1	16.5	7.2	14.3	12.4	4.0
Llanera	17.3	18.1	8.6	2.4	7.5	4.0
Silon	11.1	25.5	18.3	12.5	16.6	6.4
Black Twig	12.8	38.0	25.6	24.0	31.2	10.0
L.S.D. (P=0.05)	6.1	5.7	4.4	8.0	7.5	5.6

gave comparable mean yields. The lowest yields were obtained at Pontian where the plants were much shorter (indicating low vigour) than elsewhere. Although mean total root number at Pontian was not significantly smaller than at Site A, Serdang, the low yields may be traced to the considerably fewer commercial-sized roots. In other words, root size was substantially reduced at Pontian, again an indication of poor vigour. Starch content appeared to be lower at the peat sites (around 21.5%) than at the sites located on mineral soils (23% and above).

In *Tables 6a* to *6c* are the correlation coefficients among sites for the traits root yield, harvest index, starch content, starch yield and cyanide content. Significant correlations were obtained for root yield among the sites at Serdang and Sitiawan. Strangely enough, a stronger correlation existed between root yields at Bukit Selambau and at Pontian than elsewhere although Bukit Selambau yields associate well with yields at Sitiawan, and to a lesser degree with yields at Serdang (Site B) and at Jalan Kebun.

For harvest index, significant correlations were revealed among the Serdang sites and Sitiawan, and between all the other sites and Jalan Kebun. Starch content was highly correlated among all the different sites. The situation with starch yield is somewhat similar to the pattern of associations for root yield.

Highly significant correlations were found among all the sites on mineral soils for germination. The peat sites on the other hand had no relationship with any other site or with one another. Cyanide content at Site B, Serdang was associated with those at Sitiawan, Jalan Kebun and Bukit Selambau, while the content at Sitiawan related to those at Bukit Selambau, Jalan Kebun and Pontian.

DISCUSSION

Black Twig is the predominant cassava variety planted in Perak, and also in Peninsular Malaysia. Its wide adaptability to a range of ecological conditions is borne out by the results of this present series of trials where it emerged among the top five in every site except one at Serdang. Medan, an edible variety widely grown as a backyard crop (although not in any commercial scale

Table 4. Agronomic characters of top five varieties of cassava at each of six sites

Site	Variety	Germination (%)	Plant height (cm)	Harvest index	Total root no.	Commercial root no.	Starch content (%)	Starch yield (t/ha)	Cyanide content (μg/mg)
Site A, Serdang	Medan	81.4	520	0.39	236	104	26.7	8.6	190
	C3	96.6	410	0.39	266	113	26.1	8.0	200
	Bangkok 1	98.2	481	0.35	345	95	24.6	7.4	347
	El Salvadore 8/1 326/2	94.7	421	0.44	177	93	25.0	7.3	85
	Jurai	95.4	513	0.37	205	108	25.2	7.0	155
	L.S.D. (P=0.05)	–	58	0.05	50	24	1.9	1.6	N.S.
Site B, Serdang	Jurai	96.0	461	0.50	229	146	24.7	10.5	182
	Black Twig	99.2	444	0.48	220	138	26.7	10.2	130
	Brazil 146 56/A	94.4	430	0.44	253	129	27.2	9.5	146
	Medan	98.0	471	0.45	259	154	26.3	9.4	86
	Bangkok 1	99.0	462	0.42	350	140	23.2	7.8	147
	L.S.D. (P=0.05)	–	51	0.07	52	33	1.8	1.6	N.S.
Sitiawan	Medan	92.9	315	0.57	280	162	24.3	7.4	80
	Bangkok 1	89.6	310	0.55	271	197	21.9	7.2	67
	C3	95.6	268	0.57	263	183	21.2	7.0	126
	Jurai	95.1	341	0.54	257	177	22.0	6.8	92
	Black Twig	92.1	357	0.45	179	102	24.2	6.2	44
	L.S.D. (P=0.05)	–	48	0.06	52	35	1.3	1.1	42
Bukit Selambau	Betawi	100.0	289	0.55	191	101	25.1	6.4	70
	Black Twig	99.5	333	0.55	132	64	24.9	6.0	66
	Green Twig	96.3	294	0.60	134	76	23.6	5.9	59
	Medan	93.9	307	0.57	183	99	25.0	5.8	22
	C3	100.0	244	0.58	180	92	23.9	5.6	70
	L.S.D. (P=0.05)	–	61	0.07	51	26	1.7	2.0	47
Jalan Kebun	El Salvadore 8/1 326/2	91.0	290	0.66	193	100	22.5	7.1	3
	Black Twig	95.8	327	0.53	190	102	20.8	6.5	8
	Brazil 146 56/A	97.8	355	0.47	223	92	21.6	6.0	34
	Bangkok 1	99.6	340	0.56	331	112	18.5	5.6	18
	Green Twig	97.4	346	0.49	154	73	19.2	4.6	56
	L.S.D. (P=0.05)	–	44	0.06	64	35	1.8	1.7	30
Pontian	Brazil 146 56/A	95.1	160	0.62	141	30	22.8	2.6	82
	Medan	98.5	170	0.64	141	38	21.6	2.4	106
	Bangkok 1	96.5	180	0.70	152	36	17.4	2.3	66
	Green Twig	99.2	168	0.59	103	25	18.8	2.1	130
	Black Twig	93.9	162	0.60	92	21	19.6	2.0	112
	L.S.D. (P=0.05)	–	37	0.08	76	19	2.0	1.2	N.S.

Table 5. Site means for important agronomic traits of 16 cassava varieties

Character	Site A, Serdang	Site B, Serdang	Sitiawan	Bukit Selambau	Jalan Kebun	Pontian	L.S.D. (P=0.05) over sites
Germination (%)	87.2	87.7	86.4	96.0	92.2	94.2	N.S.
Plant height (cm)	451	411	312	286	336	164	111
Root yield (t/ha)	20.6	28.7	21.9	18.6	20.5	8.4	16.4
Harvest index	0.29	0.40	0.45	0.51	0.46	0.57	0.19
Total root no.	189	218	190	139	193	110	N.S.
Commercial root no.	73	111	111	67	78	24	67
Starch content (%)	25.3	25.5	23.2	24.9	21.8	21.5	3.1
Starch yield (t/ha)	5.2	7.3	5.0	4.6	4.4	1.8	4.1
Cyanide content (μg/mg)	176	120	67	47	24	100	112

Table 6a. Correlation coefficients by variety among root yields and among harvest indices over the six sites (df=14)

Root yield / Harvest index	Site A, Serdang	Site B, Serdang	Sitiawan	Bukit Selambau	Jalan Kebun	Pontian
Site A, Serdang		0.69**	0.86**	0.36	0.59*	0.36
Site B, Serdang	0.64**		0.78**	0.64**	0.80**	0.45
Sitiawan	0.79**	0.88**		0.39	0.62**	0.53*
Bukit Selambau	0.42	0.55*	0.66**		0.68**	0.40
Jalan Kebun	0.25	0.60*	0.48	0.55*		0.52*
Pontian	0.37	0.50*	0.61**	0.77**	0.71**	

Table 6b. Correlation coefficients by variety among starch contents and among starch yields over the six sites (df=14)

Starch content / Starch yield	Site A, Serdang	Site B, Serdang	Sitiawan	Bukit Selambau	Jalan Kebun	Pontian
Site A, Serdang		0.54*	0.73**	0.34	0.18	0.25
Site B, Serdang	0.62**		0.86**	0.53*	0.56*	0.41
Sitiawan	0.58**	0.87**		0.69**	0.48	0.58**
Bukit Selambau	0.54*	0.84**	0.86**		0.56*	0.77**
Jalan Kebun	0.75**	0.80**	0.67**	0.70**		0.64**
Pontian	0.58**	0.64**	0.53*	0.54*	0.76**	

Table 6c. Correlation coefficients by variety among germination percentages and among cyanide contents over the six sites (df=14)

Germination / Cyanide content	Site A, Serdang	Site B, Serdang	Sitiawan	Bukit Selambau	Jalan Kebun	Pontian
Site A, Serdang		0.40	0.46	0.36	0.30	0.13
Site B, Serdang	0.70**		0.69**	0.60*	0.68**	0.46
Sitiawan	0.70**	0.89**		0.48*	0.59**	0.55*
Bukit Selambau	0.80**	0.84**	0.95**		0.44	0.17
Jalan Kebun	0.05	−0.14	−0.14	−0.03		0.45
Pontian	0.43	0.42	0.21	0.21	0.01	

comparable to Black Twig), is also shown to be widely adapted (within the top four varieties in five out of the six sites) *(Table 3)*. Bangkok 1 is also a high-yielding variety adapted to five of the six sites.

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ABSTRACT

Of the 16 cassava varieties tested in six sites at five locations, Black Twig, Medan and Bangkok were shown to be highly adaptable, each emerging among the five topyielding varieties in five out of six sites. Yields were highest at one of the two sites at Serdang, and lowest at Pontian where crop growth was generally inferior. The peat sites, Jalan Kebun and Pontian, produced roots with relatively lower starch contents than roots on the mineral soil sites at Serdang, Sitiawan and Bukit Selambau.

Correlation studies among the sites revealed strong repeatability of yield (fresh root and starch) among mineral soil sites and among peat sites. It appears, therefore, that initial stages of selection and short-listing of highyielding clones destined for current and potential cassava production areas may be confined to one site located on mineral soils and another on peat. This would preclude the expensive practice of preliminary evaluation of clones over a wide range of environments. Germination was also related among the sites on mineral soils, but not at all on the peat sites. It would appear that high starch content may be selected for at any location since it is highly correlated among all the sites tested: an indication of its highly repeatable performance.

REFERENCES

AW YONG, K.K. and MOOI, S.W. (1973). *Cultivation and production of tapioca in Perak*. Department of Agriculture, Ministry of Agriculture and Fisheries, Malaysia.

CHAN, S.K., KHELIKUZAMAN, M.H., TAN, S.L., GEH, S.L. and LO, N.P. (1983). Cassava in Peninsular Malaysia: with particular reference to production techniques. *MARDI Special Rep. No. PTM–02–83*, 97 pp.

CHEW, W.Y. (1977). Assessment of cassava as an industrial crop on Malaysia peat. *MARDI Rep. No. 57.*

MINISTRY OF AGRICULTURE (1977–1981). *Miscellaneous crop acreages 1976–1980.* Statistics & Planning Division, Ministry of Agriculture, Malaysia.

NOOR AUNI, H. and TAN, S.L. (1980). Perbandingan di antara cara-cara menentukan kandungan kanji di dalam ubi kayu (*Manihot esculenta* Crantz). *Teknol. Pert., MARDI* **1**, 30–34.

TAN, S.L. and NOOR AUNI, H. (1981). Spectrophotometric quantification of Guignard's sodium picrate test. *MARDI Res. Bull.* **9**, 35–41.

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