Characteristics of Indigenous and Introduced Cultivars of Cassava in Guyana

A. H. Wahab[1]

A yield trial was conducted for 12 months to assess the performance of 12 varieties of cassava on Guyana's agriculturally poor but extensive peats and peaty soils. On the peats, the four high yielding varieties, M. Mexico 59, M. Mexico 23, Del Pais, and M. Colombia 673 gave fresh yields of 30.5, 19.3, 19.3, and 18.2 t/ha, respectively. On the peaty clays, high yielding varieties were M. Mexico 59, Uncle Mack, Del Pais, and M. Mexico 23 with yields of 23.1, 22.1, 20.0, and 17.6 t/ha, respectively. The lowest yielding varieties on both soils were Chinese stick (7.6 t/ha on the peats and 9.0 t/ha on the peaty clay) and Bitterstick, which produced 11.7 t/ha on the peats and 9.0 t/ha on the peaty clay.

Plant height and shooting and branching patterns were not related to yield, but harvest index was correlated with yield on both soils. Useful matter (ratio of peeled/unpeeled root) was not significantly different between varieties on both soils.

Immediately to the south of Guyana's Coastal plain lie approximately one million hectares of undrained peats, peaty clays, and muck soil. Many of the peat swamps and marshes are used to provide water for irrigation and for domestic and industrial uses. Native vegetation on these soils consists mostly of swamp forest, but freshwater marsh is found in some places. The peat is locally called "pegasse" and when it merges with the clays it is referred to as "pegassy clay".

Peat or muck soils are marginal for conventional agriculture, however viable cultivation of these marginal peaty soils could be of value to Guyana's expansionist agricultural program. Cassava appears to be a promising crop for these marginal soils as it is: (1) adapted to poor soils; (2) relatively resistant to weeds and insect pests; (3) best suited to light soils for root production; and (4) is not season-bound. Additionally, efforts are underway to transform cassava from a traditional back yard crop to one of agroindustrial importance.

The performance of 12 indigenous and introduced cultivars of cassava was evaluated on these drained peats and peaty clays.

Materials and Methods

Soils

Field trials were conducted on two soil types (pH 3–4), locally classified as Anira peat No. 20, and Inki Clay No. 100 (Steele and Ramdin 1975). The Anira peat consists of dark reddish brown peat from the surface (0–15 cm) and varies from raw to semidecomposed peat-peaty clay. Hydrogen sulfide is present from 0 to 122 cm. This peat has a high swell/shrink ratio (50% or greater) and may be ignited when dry (Mahadeo 1975). Inki clay consists of a surface matt of 1–20 cm of peaty clay. The upper subsoil is a soft gray to greenish gray clay that is underlined by peat (Mahadeo 1975).

Trials were conducted south of Enmore Sugar Estate from April 1975 to April 1976. The two areas were naturally inundated until early 1974 when the necessary drainage facilities were installed. Following drainage, the areas were cleared of weeds, underlying logs, and timber. Land preparation consisted of ploughing and rotovation. In-field drains (12 m apart, 0.5 m deep) were excavated and connected to a drainage canal. Soils were sampled at 0–15 cm and 15–30 cm for determination of physicochemical properties. Samples were taken at planting and following harvest (12 months later) to monitor soil chemical characteristics.

Varieties and Experimental Design

A total of 12 varieties were used. Of these, seven (Brancha butterstick, Bitterstick, Chinese stick, Four month, R. Singh, Twelve month, and Uncle Mack) were believed to be indigenous to Guyana, one (Del Pais) was introduced from Puerto Rico, and the others (Llanera, M. Colombia 673, M. Mexico 23, and M. Mexico 59) were promising varieties from CIAT's collection. Planting material for eight varieties was obtained from 6 to 9 month

[1]Guyana Sugar Corporation Limited, Georgetown, Guyana.

Table 1. Physicochemical characteristics at the time of planting of the two soils used to compare the 12 cassava cultivars.

	Anira peat No. 20	Inki clay No. 100
Field capacity of plow layer (%)	299	59
Bulk density (g/cm³)		
0–15 cm	0.2	0.9
15–30 cm	0.2	0.9
pH		
0–15 cm	3.7	4.2
15–30 cm	3.6	4.1
Total soluble salts (ppm)		
0–15 cm	861	647
15–30 cm	932	830
Cation exchange capacity (meq/100 g)		
0–15 cm	18.2	15.5
15–30 cm	22.3	16.8
Al (meq/100 g)[a]		
0–15 cm	7.4	8.6
15–30 cm	7.4	8.1
Ca (meq/100 g)		
0–15 cm	4.4	3.0
15–30 cm	3.6	2.6
Mg (meq/100 g)		
0–15 cm	5.3	3.4
15–30 cm	8.0	5.4
K (meq/100 g)		
0–15 cm	0.5	0.3
15–30 cm	0.4	0.3
P (ppm) Truog		
0–15 cm	37.5	1.5
15–30 cm	15.3	0.8
N (%)		
0–15 cm	1.5	0.5
15–30 cm	1.4	0.4
Organic matter (%)		
0–15 cm	31.4	8.1
15–30 cm	33.5	7.1

[a]Ca, Mg, and Al were determined using *N* KCl extract, K was determined using 0.5*N* CH_3COOH extract.

old plants. These plants were established in the field nursery from two-node stem cuttings following CIAT's rapid multiplication method. Planting material of the remaining four varieties (Bitterstick, Chinese stick, R. Singh, and Twelve month) were obtained from 12 to 15 month old plants made available by the Central Agricultural Station, Mon Repos. A completely randomized 5 replicate trial was used. Plots (9.1 × 4.6 m, 0.004 ha) were planted in 5 rows of 10 plants each. All observations were made on 15–20 test plants taken from two central rows. Rows 1 and 5 were buffer rows. Where insufficient planting material was available the planting density (11955 plants/ha) was kept constant by planting other varieties in the buffer rows.

Planting, Soil Amelioration, and Subsequent Management

Planting material (15 cm long) was machine cut, immersed in a suspension of Dithane-M-45 (0.04% a.i.) and monocrotophos (0.06% a.i.) for 0.5 h, and planted inclined in furrows 8–10 cm deep. Both trial sites were planted in late April 1975 within 2 days of each other, just prior to the long rainy season.

Lime was applied in the form of 6.7 t/ha of aragonite 1 month after sowing. Fertilizers were applied at rates of 198 kg N (urea), 67 kg P_2O_5, and 134 kg K_2O/ha. One-half of the fertilizer was applied with the lime, one-quarter 3 months, and the balance 5 months after planting. Each application was banded circularly 15 cm away from the plant and incorporated 4–5 cm. To correct apparent copper and zinc deficiencies, 14 kg $CuSo_4$ and 12 kg $ZnSO_4$/ha were applied at 5 months as well as a prophylactic dose of 22 kg/ha of fritted trace elements.

Plots were manually weeded 1, 4, and 9 months after planting. Serious outbreaks of hornworm (*Erynnis ello*) were observed at both sites following heavy and continuous showers in September, October, November, and December. After the crop became infested for a second time, fortnightly applications of monocrotophos (0.5 liter a.i./ha) were made, resulting in effective control. Moderately severe attacks of shoot fly (*Silba pendula*) were observed from the ninth month and persisted through harvest. Trichlorfon (Dipterex) at 1 kg a.i./ha at 3-week intervals controlled this pest.

Results

Soil Properties

Some physicochemical characteristics of the two soils are presented in Table 1. Both soils were extremely acidic, and pH was not ameliorated following lime application. Water holding capacity of the Anira peat (300%) greatly exceeded that of the Inki clay (58%). Conversely, bulk densities of the Anira peat

Table 2. Germination and plant height data for cassava variety trials.[a]

	Anira peat No. 20		Inki clay No. 100	
Variety	Germination at 60 days %)	Plant height at harvest cm)	Germination at 60 days %)	Plant height at harvest (cm)
Brancha butterstick	96.0[ns]	170.0[e]	94.8[ns]	198.0[e]
M. Mexico 23	98.4	139.0[c]	97.6	163.0[abcd]
Bitterstick	92.4	216.0[g]	96.4	201.0[e]
Chinese stick	95.6	153.0[d]	98.0	183.0[de]
Del Pais	98.8	154.0[d]	98.4	168.0[abcd]
Four month	97.6	124.0[b]	99.6	165.0[abcd]
Llanera	91.6	120.0[ab]	94.4	162.0[abc]
M. Colombia 673	94.8	154.0[d]	98.8	148.0[a]
M. Mexico 59	93.2	167.0[e]	94.0	181.0[cde]
R. Singh	88.8	115.0[a]	92.0	169.0[bcd]
Twelve month	90.0	180.0[f]	92.4	205.0[f]
Uncle Mack	98.8	136.0[c]	98.4	158.0[ab]
Grand mean	95.0	152.2	96.0	178.6
S.E.	—	1.83	—	6.37
C.V. (%)	—	2.7	—	8.0

[a]Values followed by the same letter do not differ significantly ($p = 0.05$), ns = no significant difference within column.

(0.24) were about one-fourth those of the Inki clay (0.94). The total soluble salts were low in both soils at planting, but had increased slightly at harvest within the 15–30 cm Anira peat layer and throughout the 0–30 cm soil depth in the Inki clay.

There were a greater number of exchangeable sites on the Anira peat than there were on the Inki clay. Exchangeable aluminum was fairly high for both soil types. Phosphorus levels were low in both soils and remained unchanged at harvest. Anira peat plots contained very high total nitrogen throughout the 0–30 cm soil depth, whereas nitrogen within the Inki clays was lower but adequate for plant growth. Potassium levels in both soils were adequate and showed an increase at harvest.

As would be expected, organic matter was much higher in the Anira peat than on the Inki clay. Ratios of C/N were optimal for the peats at the time of planting and became less favourable following cultivation. This situation was somewhat reversed in the clays where a more favourable C/N ratio was obtained following cultivation.

Germination and Growth Characteristics

Data on germination and plant height at harvest are presented in Table 2. Indigenous varieties germinated faster than the introduced ones; however, at 60 days all varieties germinated equally well on both soils. Plant heights were not significantly different between soils up to 70 days. Thereafter, all plants on the Inki clay grew taller than on the Anira Peat. On both soils Bitterstick and Twelve month grew tallest and were the most vigorous. Throughout the trial, varietal differences in plant height were statistically significant. Except for Del Pais, all the other introduced varieties produced one main stem per cutting on both soil types. Most of the local variety produced two main stems on one or both soils.

Distances from the soil surface to the first branching point on the main stem varied significantly among varieties. There was a tendency for early branching in the varieties Four month, Llanera, and M. Colombia 673. All varieties had at least two branches attached to the main shoot and several indigenous varieties produced three. Stem diameter at the first branch differed significantly among varieties on both soils. Indigenous varieties had the thinnest stems on both soils; plants on the Inki clay had larger stem diameters than those grown on the Anira peat.

Fresh Root Yields

Fresh weight data are presented in Table 3. Root yields were significantly different between

Table 3. Yields (fresh roots, t/ha) of 12 cassava varieties (11955 plants/ha) at 12 months on two agriculturally poor soils in Guyana.[a]

Variety	Anira peat No. 20	Inki clay No. 100
M. Mexico 59	30.5[e]	23.1[f]
M. Mexico 23	19.3[d]	17.6[cdef]
Del Pais	19.3[cd]	20.0[def]
M. Colombia 673	18.2[bcd]	16.5[bcde]
Twelve month	16.4[bcd]	12.4[abcd]
Llanera	15.3[bcd]	16.9[bcdef]
Uncle Mack	15.2[bcd]	22.1[ef]
Brancha butterstick	14.2[abcd]	15.3[bcd]
R. Singh	13.0[abcd]	14.7[bcd]
Four month	12.1[abc]	17.4[bcdef]
Bitterstick	11.7[ab]	11.1[abc]
Chinese stick	7.6[a]	9.0[ab]
Grand mean	16.1	16.3
S.E.	2.2	2.0
C.V. (%)	29.5	26.8

[a]Values followed by the same letter do not differ significantly (p = 0.05).

varieties on both soil types. There was a wider spread (7.6–30.5 t/ha) in root fresh matter on the Anira peat than there was on the Inki clay (9.0–23.1 t/ha). Three of the five introduced varieties yielded worse and five of the seven indigenous varieties better on the Inki clay than on the Anira peat. Chinese stick yielded lowest on both soils. M. Mexico 59 produced significantly higher yields (30.5 t/ha) than all the other varieties grown on the Anira peat. It also ranked highest (23.1 t/ha) on the Inki clay but was not significantly better than Uncle Mack, which produced 22.1 t/ha. Except for Four month, M. Mexico 23, M. Colombia 673, Twelve month, and Uncle Mack all the other varieties ranked similarly on both soils. Uncle Mack rose from seventh place (15.2 t/ha) on the Anira peat to second on the Inki clay.

Dry Matter, Total and Useful Yield, Harvest Index, and Root Density

Values for some of these parameters are shown in Table 4. Root dry matter was significantly different between varieties in both soil types. Values ranged from 29 to 37% for the Anira peat and from 28 to 42% for the Inki clay. Highest producers of dry matter were M. Mexico 59 (9.0 t/ha) and Uncle Mack (7.6 t/ha). These varieties produced almost four times as much dry matter as Chinese stick. Total fresh matter production was significantly different between varieties irrespective of soil type. However, there was a greater concentration of fresh matter in the shoots, stems, and leaves of plants on the Anira peat. Total fresh matter ranged from 19 to 41 t/ha for the Anira peat and 24 to 39 t/ha on the Inki clay. Again, M. Mexico 59 produced the highest amount of total fresh matter on the Anira peat, whereas Del Pais was the highest on Inki clay.

Useful root fresh matter content averaged 85% and did not vary significantly between varieties on either soil. Consequently, those varieties that had produced highest fresh root yields, e.g. M. Mexico 59, Del Pais, and Uncle Mack, also produced highest amounts of useful fresh matter.

Harvest index values were significantly different between varieties in either soil type. Values were consistently higher for any one variety grown on the Anira peat versus that same variety grown on the other soil.

Root densities were essentially the same (1.094) on the Anira peat. However, values were significantly different between varieties on the Inki clay. On this soil, Four Month and Brancha butterstick produced roots having lowest (1.066) and highest (1.160) densities.

Number of root tubers per plant differed significantly between varieties on both soils. Also, root proliferation in the Inki clay exceeded that in the Anira peat, for each variety. Root tubers per plant ranged from 5 to 9 for the Anira peat, and 7 to 15 for the Inki clay.

Weights of tubers from plants grown in the Anira peat were consistently higher than for plants grown on the Inki clay. Average weight per root tuber per plant ranged from 155 to 352 g for the Anira peat and 84 to 223 g for the Inki clay.

Root tuber length differed significantly between varieties on each soil. Longest root lengths were exhibited by Brancha butterstick measuring 44 cm on the Anira peat and 54 cm on the Inki clay. Shortest root tuber length was also significantly different between varieties and on each soil type. Chinese stick produced the shortest roots irrespective of the soil. Observations on length of the median root indicated that 50% or more of the root tubers of Brancha butterstick measured 22 cm on the Anira peat and 29 cm on the Inki clay. Corresponding values for M. Mexico 59 were 26

Table 4. Results of variety trials on Anira peat No. 20 and Inki clay No. 100 after 12 months.

Variety	Anira peat No. 20: Equivalent root yield (t/ha) fresh matter	Equivalent total plant fresh weight (t/ha)	Equivalent yield (t/ha) of useful fresh matter	Inki clay No. 100: Equivalent root yield (t/ha) fresh matter	Equivalent total plant fresh weight (t/ha)	Equivalent yield (t/ha) of useful fresh matter
Brancha butterstick	14.2[abcd]	21.7[ab]	12.1[abc]	15.3[bcd]	30.6[abc]	12.8[bcd]
M. Mexico 23	19.3[d]	27.3[abcd]	16.6[bc]	17.6[cdef]	27.9[ab]	15.1[cdef]
Bitterstick	11.7[ab]	25.1[abcd]	10.4[ab]	11.1[ab]	32.9[abcd]	9.2[ab]
Chinese stick	7.6[a]	22.6[abc]	6.7[a]	9.0	26.8[a]	7.7[a]
Del Pais	19.3[cd]	30.5[cd]	16.8[c]	20.0[def]	38.7[d]	17.2[def]
Four month	12.1[abc]	22.5[a]	10.6[abc]	17.4[bcdef]	33.6[abcd]	15.0[cdef]
Llanera	15.3[bcd]	19.3[a]	13.0[bc]	16.9[bcdef]	29.5[abc]	14.6[cdef]
M. Colombia 673	18.2[bcd]	28.9[bcd]	15.8[bc]	16.5[bcde]	29.4[abc]	14.1[bcde]
M. Mexico 59	30.5[e]	41.4[e]	24.8[d]	23.1[f]	36.1[cd]	19.3[f]
R. Singh	13.0[abcd]	19.1[a]	10.5[abc]	14.7[abcd]	27.6[ab]	12.5[abcd]
Twelve month	16.4[bcd]	31.1[d]	14.0[bc]	12.4[abc]	30.4[abc]	10.7[abc]
Uncle Mack	15.2[bcd]	22.6[abc]	12.7[abc]	22.1[ef]	35.4[bcd]	18.5[ef]
Grand mean	16.1	26.0	13.7	16.3	31.6	13.9
S.E.	2.2	3.6	1.9	2.0	3.4	0.16
C.V. (%)	29.5	21.8	30.8	26.8	17.0	25.0

[a]Values followed by the same letter do not differ significantly ($p = 0.05$).

cm for the Anira peat and 19 cm for the Inki clay.

Maximum root diameter measurements indicated that root thickness differed significantly between varieties on either soil type. On both soils, root diameter of Brancha butterstick was lowest, whereas M. Mexico 59 produced roots of highest maximum diameter.

An examination of rooting depth pattern showed that the maximum depth of root penetration on the Anira peat was 15 cm, whereas with the exception of Llanera, R. Singh, and Twelve month all other varieties on the Inki clay penetrated to a maximum depth of 30 cm.

Postharvest Storage Life

On both soils, with the exception of M. Colombia 673 all varieties stored for at least 5 days before vascular streaking was noticed (Table 5). M. Mexico 59 harvested from the Anira peat stored longer (10 days) than all other varieties. However, this variety when harvested from the Inki clay showed vascular streaking at 5 days. Secondary deterioration of roots occurred at 10 and 11 days on the Anira peat and Inki clay, respectively. Storage lives were not consistent for a given variety harvested from both soils.

Discussion

Total rainfall experienced (331 cm) during the trial period exceeded the 105 year average (210 cm) for Enmore Estate by 58% and can be described as adverse for Guyana conditions. Rain fell 62% of the trial days, and on 34 days (10%) precipitation exceeded 2.5 cm. Months of lowest rainfall (15 cm or less) were August through September 1975 and March 1976; and heavy rains fell from November through February (156 cm). In other words, during germination and stand establishment, and presumably during maximum root bulking, the crop experienced excessive moisture. Also, during the trial period, bright sunshine averaged just 6.5 h/day, which considered separately might have been detrimental to yield.

Soil properties at planting and following harvest indicated high buffering capacities in both soils. This is consistent with the percentage of base saturation observed for the Anira peat

Table 5. Time (days) to onset of primary[a] and secondary[b] root deterioration of 12 cassava cultivars stored under ambient conditions.[c]

Variety	Anira peat No. 20		Inki clay No. 100	
	Primary deterioration	Secondary deterioration	Primary deterioration	Secondary deterioration
M. Mexico 59	10	11	6	10
Brancha butterstick	7	8	8	11
Chinese stick	7	12	6	10
Twelve month	7	10	9	11
M. Mexico 23	5	12	5	8
Bitterstick	5	11	6	8
Del Pais	5	11	6	10
Llanera	5	11	7	11
R. Singh	5	11	8	11
Four month	5	9	6	10
Uncle Mack	5	8	9	12
M. Colombia 673	4	5	5	10
Grand mean	5.7	10	6.8	11

[a]Primary deterioration was considered to have started with the appearance of fine blue-black streaks in the root vascular tissue.

[b]Secondary deterioration was considered to have occurred when the root tissues became soft.

[c]Storage conditions: Anira peat 7.15–83 °F, R.H. 78.3%; Inki clay 74.4–84.5 °F, R.H. 83%.

(50%) and Inki clay (40%). Indeed, the addition of lime (6.72 t/ha) did not ameliorate soil pH. Further, available phosphorus levels were low and decreased at harvest. This is probably due to the high fixation of this nutrient, which occurs at low pH values.

Yield figures indicated that despite the unfavourable climatic conditions that prevailed, the agriculturally poor peats and peaty clays produced average yields of 16 t/ha. Recalling the serious outbreaks of hornworm and shoot fly that were experienced, it is possible that these pests coupled with the unfavourable climate depressed yields. M. Mexico 59 yielded significantly higher (30.5 t/ha) than all other varieties on the Anira peat and also ranked highest on the Inki clay (23.1 t/ha). Further, all five of the introduced varieties ranked between first and seventh on the two soils.

At harvest, the tubers in the Inki clay plot were generally more numerous but thinner than those on the Anira peat plots. This was probably due to inadequate soil potassium in the former soil. The enhanced yields of Uncle Mack (22 t/ha) on the Inki clay suggests that this variety is better suited to this soil.

An NPK program found to be best for cassava on peat soils in West Malaysia (Chew 1970) was adopted for these trials. Yields of five varieties grown under the same climatic conditions and on unfertilized and unlimed plots on the Inki clay averaged 5.3 t/ha fresh roots in 12 months. Hence, the benefits derived from lime and fertilizers are unquestionable and may be further enhanced when optimum quantities of N, P, and K for these particular soils are determined. Neither plant height nor branching pattern appeared to have any relation to yield. Partitioning of total fresh matter diverted into the roots (harvest index) was greater on the Anira peat than on the Inki clay. It is plausible that due to low K in the Inki clay, shoot growth increased at the expense of root fresh matter accumulation. Correlation coefficients (r) for fresh yields against harvest index were significant ($p = 0.05$) for both soils and were 0.64 for the Anira peat and 0.85 for the Inki clay. Useful fresh and dry matter yields were also significantly correlated with fresh root yields on both soils ($r = 1.00, 0.99, 0.96, 0.90$).

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