Performance of Twenty Cassava Cultivars on Marginal Peats and Peaty Clays of Guyana[1]

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ABSTRACT

A cassava trial including 20 cultivars was conducted to assess the suitability of Guyana's marginal Anira peat No. 20 and Inki clay No. 100 for this crop during a 12-mo growing period. Germplasm material was obtained from Brazil, Colombia, Mexico, Puerto Rico, and Guyana. Cultivars Tacana and Iracema (Brazil) ranked above all others on both soils, producing 28 t/ha fresh roots on the Anira peat and 24 t/ha on the Inki clay. All introduced cultivars outyielded their local counterparts. The highest yielding native cultivar, Badwoman, produced 12 and 10 t/ha of fresh roots on the Anira peat and Inki clay, respectively. Cultivar M Col 673 had the highest root dry matter content, about 40% for both soils. Edible fresh matter content (ratio of peeled to unpeeled root) averaged 0.85 and was essentially the same for all cultivars. A highly significant relationship was obtained between total plant weight and root yields on both soils (r = 0.92 and 0.94), and between harvest index and root yields (r = 0.64 and 0.81). The number of stems per cutting and stem diameter at harvest were not related to yield. However, number of edible roots per plant was highly correlated with yield (r = 0.69 and 0.54). Root thickness was also related to yield (r = 0.92 and 0.95) on both soils. Under field conditions, all cultivars stored well for 5 days before primary deterioration began.

INTRODUCTION

Priorities for determining the feasibility of planting cassava on Guyana's peats and peaty clays were discussed in a previous paper (7). These soils cover approximately one million hectares of essentially unexploited land. They lie south of the coastal clays and, unless drained, are flooded most of the year (5). Soils are extremely acid and contain low levels of plant nutrients. However, when drained and intensively managed, they can be made productive. This was demonstrated by earlier studies in

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which improved cultivars of cassava yielded up to 30 t/ha of fresh roots in 12 mo on Anira peats (7).

This paper presents the results of two experiments to evaluate the yield performance of 20 local and introduced cassava cultivars on marginal peats and peaty clays of Guyana.

MATERIALS AND METHODS

The experiments were conducted at the Enmore Sugar Estate from November 1975 through November 1976. The cultivars were arranged in a randomized block design and replicated five times. Nine of the 20 cultivars, namely, Badwoman, Brancha Butterstick, Bitter Stick, Chinese Stick, Four Month, L.H. 2, R. Singh, Twelve Month, and Uncle Mack were obtained locally. The remaining came from abroad. Cultivars Iracema, Piracununga, and Tacana were promising lines from Brazil, Del País was introduced from Puerto Rico, and the others, i.e., CMG 40, Llanera, M Col 22, M Col 673, M Mex 23, M Mex 55, and M Mex 59 were obtained from the Centro Internacional de Agricultura Tropical, Colombia.

The two soil types are locally classified as Anira peat No. 20, and Inki Clay No. 100. The Anira peat No. 20 (Anira peat hereafter) consisted of dark-reddish-brown peat from the surface to a depth of 120 cm. The surface layer (0 to 15 cm) consisted of raw to semi-decomposed peat-peaty clay. Hydrogen sulphide was present throughout the 122 cm profile. Anira peat has a high swell/shrink ratio (50% or greater) and may undergo spontaneous combusion when dry (5). Relevant soil properties are given in table 1. The soil is extremely light and porous and, at field capacity ($\frac{1}{3}$ bar), it holds 3 times its weight in water. Cation exchange capacity was 18.2 meq/100g.

The Inki Clay No. 100 had a surface matt of 1 to 20 cm of peaty clay. The upper subsoil was a soft-gray to greenish-gray clay which was underlaid by peat (5). The soil texture was comprised mainly of clay; organic matter constituted 10% (table 1).

Trial sites were located 3 m below sea level. Mean annual temperature was above 26.7° C with monthly variations of less than 4°. Rainfall amounted to 293 cm and exceeded the mean by 23%. During the first 3 mo of the experiment, 152 cm or about 50% of the total rainfall was recorded. This resulted in a drop of about 20% in germination. Rainy days constituted 40% of the trial period. In 6 of the 12-month growing period there was an excess of moisture in the soil as indicated by a positive atmospheric water balance. On the contrary, sunshine hours totalled 2,333 and ranged from an average of 4.3 hr/day in December to 9.6 hr/day in August.

Trial sites were naturally flooded until early 1974 when drainage

TABLE 1.—*Selected physical and chemical properties of the 0 to 30 cm soil layer of two soils planted to cassava*

	Soil type	
	Anira peat No. 20	Inki clay No. 100
Clay, %	12	63
Silt, %	22	24
Sand, %	14	3
Organic matter content, %	52	10
Field capacity at $\frac{1}{3}$ bar, %	299	58.7
Permanent wilting percentage at 15 bars, %	230	40
Bulk density, g/cm^3	.24	.94
pH (1:2.5)	3.71	4.21
Cation exchange capacity, meq/100 g	18.2	15.5
Available nutrients[1]		
Calcium, meq/100 g	2.66	3.86
Magnesium, meq/100 g	6.26	7.58
Potassium, meq/100 g	.17	.30
Phosphorus, p/m	37.50	1.27

[1] Ca and Mg were determined using *N* KCl extract. K was determined using 0.5 *N* CH_3COOH extract; P, by the Truog method.

TABLE 2.—*Yields of fresh roots of 20 cassava cultivars at 12 months on marginal peats and peaty clays of Guyana*

Cultivars	Fresh-root yield on indicated soil	
	Anira Peat No. 20	Inki Clay No. 100
	T/ha	*T/ha*
Tacana	28.08	24.30
Iracema	27.58	23.32
Mexico 23	23.25	16.83
Piracununga	18.31	19.75
CMC 40	17.95	18.11
M Mex 59	17.35	16.17
Llanera	16.96	18.37
M Col 673	14.21	12.35
Del País	13.04	11.51
Badwoman	11.68	10.06
Twelve Month	8.65	5.59
M Mex 55	8.25	12.01
Four Month	6.79	5.01
Chinese Stick	6.46	4.35
M Col 22	6.32	9.96
Uncle Mack	5.38	8.07
Brancha Butterstick	4.66	6.39
Bitterstick	4.43	2.26
R. Singh	3.84	5.62
L. H. 2	2.92	1.89
Coefficient of variation, %	16.98	33.16
LSD (0.05)	3.46	4.86

facilities were installed. After drying, land preparation began and consisted of plowing, harrowing, and levelling. Inter-bed ditches (0.5 m × 0.5 m) were made 22 m apart and connected to main drains (1 m × 1 m).

Lime was applied as aragonite at 6.72 tons/ha 1 mo before sowing. Prior to planting, urea, triple superphosphate, and muriate of potash were broadcast at rates of 84 N, 33.5 P_2O_5, and 100.5 K_2O (kg/ha), respectively. A similar amount was banded at a 15-cm radius from the plant and 4 to 5 cm deep, 4 mo after planting.

To correct for possible minor element deficiencies a prophylactic

TABLE 3.—*Dry-root yield of 20 varieties of cassava at 12 months on marginal peats and peaty clays of Guyana*

Cultivar	Dry-root yield on indicated soil	
	Anira peat No. 20	Inki clay No. 100
	T/ha	*T/ha*
Badwoman	4.37	3.19
Bitterstick	1.68	.86
Brancha Butterstick	1.66	2.39
Chinese Stick	2.31	1.56
CMC 40	5.40	4.82
Del País	4.37	3.67
Four Month	2.60	1.85
Iracema	10.16	8.44
L.H. 2	1.03	.68
Llanera	6.85	6.47
M Col 22	2.16	3.14
M Col 673	5.92	4.87
M Mex 23	3.41	5.56
M Mex 55	2.88	3.83
M Mex 59	5.33	5.82
Piracununga	6.36	5.66
R. Singh	1.51	2.13
Tacana	9.69	8.32
Twelve Month	3.26	2.03
Uncle Mack	2.02	2.56
Coefficient of variation	17.16	32.65
LSD (0.05)	1.26	1.61

application of 45 kg/ha of fritted trace elements (B R-12) was supplied with the first fertilizer application. B R-12 contains 5.5% MnO_2, 5.4% Fe_2O_3, 11.5% ZnO, 1.0% CuO, 7.0% B_2O_3, and 0.2% MoO_3.

Cuttings 15 cm long were row-planted in plots 9 × 4.6 m. Each row contained 10 experimental plants surrounded by border rows. All observations were from 20 test plants taken from two central rows. Prior to planting, cuttings were immersed in a suspension of Dithane[3] M-45 (0.04%

[3] Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of equipment or materials by the Agricultural Experiment Station of the University of Puerto Rico or an endorsement over other equipment or materials not mentioned.

A.I.) and monocrotophos (0.06% A.I.) for 0.5 h and planted inclined in furrows 8 to 10 cm deep. Plots were manually weeded as often as necessary.

Moderately severe attacks of cassava bud-worm [*Phlyctaenodes bifilalis* Hamp.) (Pyraustidae:Lepidoptera)] were observed from the third month and persisted through harvest. Sprays of Trichlorofon (Depterex) at 1 kg A.I./ha, at 3 weekly intervals were used to control this pest.

Both experiments were harvested 361 days after planting. Before harvesting, plant height (soil surface to the distal growing tip) and stem

TABLE 4.—*Useful fresh-root yield of 20 cultivars of cassava at 12 months on marginal peats and peaty clays of Guyana*

Cultivar	Useful root yield in indicated soil	
	Anira peat No. 20	Inki clay No. 100
	T/ha	*T/ha*
Badwoman	10.04	8.66
Bitterstick	3.65	1.93
Brancha Butterstick	3.92	5.47
Chinese Stick	5.49	3.72
CMC 40	15.50	15.25
Del País	11.38	9.64
Four Month	5.64	4.27
Iracema	24.21	21.13
L.H. 2	2.53	1.66
Llanera	14.71	15.67
M Col 22	5.32	8.40
M Col 673	12.30	10.54
M Mex 23	19.92	14.43
M Mex 55	7.02	9.88
M Mex 59	14.86	13.40
Piracununga	15.92	16.55
R. Singh	3.28	4.83
Tacana	24.57	20.90
Twelve Month	7.28	4.74
Uncle Mack	4.52	6.83
Coefficient of variation (%)	17.21	10.15
LSD (0.05)	3.02	3.78

diameter at the soil surface were recorded. At harvest, observations were made on number of shoots per cutting, number of roots per plant, largest root diameter, fresh root weight, and fresh weight of stems and leaves.

Laboratory analyses consisted of dry matter content determinations of unpeeled roots and edible fresh-matter content (ratio of peeled to unpeeled root). Dry and edible matter determinations were made on three 200-g subsamples of material taken from the proximal, center, and distal portions of approximately 2 kg of freshly-harvested roots/plot. Drying was made at 55 to 60 ° C for 48 h in a forced-draft oven.

A composite sample (8 kg) of freshly-harvested roots of each cultivar was allowed to remain on the field plots for storage life determinations.

RESULTS AND DISCUSSION

The cultivars obtained from Brazil outyielded all the others on the Inki clay and ranked among the best on the Anira peat (table 2). The Tacana

TABLE 5.—*Plant height, total plant yield, yield of stems and leaves, and harvest index of 20 cassava cultivars at 12 months on marginal peats and peaty clays of Guyana*

Cultivar	Anira Peat No. 20				Inki Clay No. 100			
	Plant height	Total plant weight	Stems and leaves	Harvest index	Plant height	Total plant weight	Stems and leaves	Harvest index
	M	*T/ha*	*T/ha*		*M*	*T/ha*	*T/ha*	
Badwoman	1.22	22.66	10.99	0.51	1.20	19.91	7.26	0.62
Bitter Stick	1.62	26.26	21.83	.17	1.80	14.84	12.57	.16
Brancha Butterstick	1.31	13.24	8.58	.34	1.45	12.90	6.41	.51
Chinese Stick	1.32	18.20	11.74	.34	1.36	16.50	10.14	.25
CMC 40	1.60	27.28	9.33	.66	1.62	29.87	11.76	.61
Del País	1.35	24.86	11.79	.52	1.51	22.79	11.27	.50
Four Month	1.14	18.28	11.49	.38	1.27	12.92	7.90	.39
Iracema	1.74	44.70	17.12	.62	1.48	36.42	13.11	.63
L.H. 2	1.43	10.16	7.24	.29	1.47	6.80	4.91	.31
Llanera	1.45	29.45	12.49	.58	1.40	29.22	10.85	.62
M Col 22	.69	9.23	2.91	.69	.75	14.25	4.28	.68
M Col 673	1.51	26.71	12.51	.53	1.50	24.23	11.87	.50
M Mex 23	1.51	37.61	14.36	.62	1.50	29.88	13.05	.58
M Mex 55	.72	12.36	4.10	.67	.70	17.46	5.44	.68
M Mex 59	1.06	27.17	9.82	.64	1.26	26.75	10.58	.62
Piracununga	1.00	24.62	6.31	.75	1.04	24.50	4.85	.79
R. Singh	.80	7.25	3.41	.54	1.16	9.66	4.03	.59
Tacana	1.79	41.96	13.88	.67	1.60	35.21	10.91	.69
Twelve Month	1.47	19.26	10.61	.45	1.38	14.62	9.02	.38
Uncle Mack	1.05	11.06	5.68	.41	1.11	13.17	5.10	.59
Coefficient of Variation (%)	8.13	14.56	40.61	11.90	16.16	29.17	33.76	9.34
LSD (0.05)	.18	5.45	6.93	.10	.27	7.58	5.21	.08

cultivar produced 28.08 t/ha of fresh roots on the Anira peat, and 24.30 t/ha on the Inki clay, outyielding the poorest performer, L.H. 2, by 10- and 13-fold, respectively. Viewed collectively, the introductions yielded 300% more fresh roots than the local cultivars. Cultivars M Mex 23 and M Mex 59 ranked among the seven best yielders on both soils. This finding supports previous results (7). Among local cultivars, Badwoman yielded highest on both soils, producing 11.68 and 10.06 t/ha of roots on

the Anira peat and the Inki clay, respectively. In general, there was a tendency among cultivars to yield lower (11.60 t/ha) on the Inki clay than when grown on the Anira peat (12.31 t/ha).

This suggests the possibility of immediate yield increase by varietal screening. Noting that there were only two cultivars that exceeded 20 t/ha out of a germplasm collection of 20, it appears necessary to start a selection program with a very wide variability of germplasm.

DRY MATTER CONTENT

Dry-root yields are presented in table 3. Dry matter varied between 30 and 42% on the Anira peat and ranged from 27 to 39% on the Inki clay.

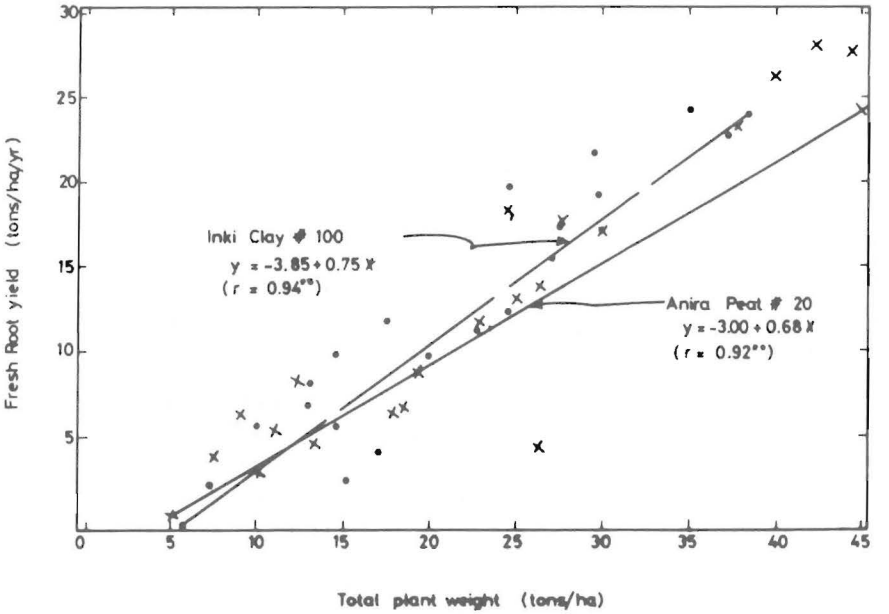

FIG. 1.—Relationship between total plant weight and fresh-root yield of cassava grown on marginal peats and peaty clays in Guyana.

Irrespective of soil type, M Col 673 contained the least amount of moisture. This is in accord with a previous trial in which this variety was compared with 11 others. On the Anira peat, dry-root yields ranged from 1.03 to 10.16 t/ha, whereas, on the Inki clay, root dry matter varied from 0.68 to 8.44 t/ha (7). As in the fresh-root data, the introduced cultivars significantly outyielded their local counterparts.

EDIBLE ROOT CONTENT

Edible fresh-root content (table 4) indicates that irrespective of cultivar and soil, the peeled- to unpeeled-root ratio was essentially the same, an

average of 0.85 for all cultivars. Viewed differently, the outer and inner peel of the root constitutes about 15% of its fresh weight. As in the case of fresh root weights, the Brazilian cultivars Tacana and Iracema out-yielded the others in terms of edible yield on both soils.

The data presented in tables 2, 3, and 4 demonstrate that, despite their apparent unsuitability for conventional agriculture, Guyana's marginal peats and peaty clay soils can be made rather productive when properly managed. Considering that the present national production of cassava is estimated at 7 to 10 tons/ha and the high yields obtained in these

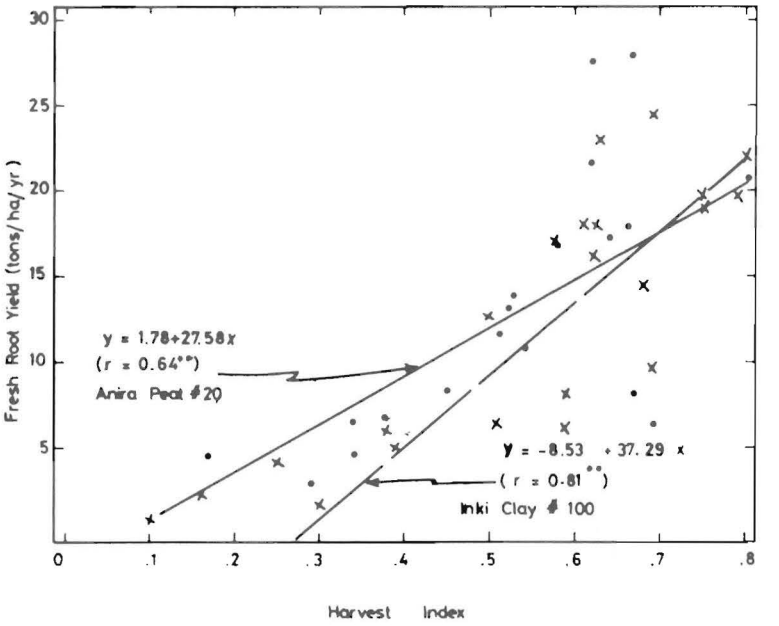

FIG. 2.—Relationship between harvest index and fresh-root yield of cassava grown on marginal peats and peaty clays in Guyana.

experiments, it is important that these soils be further studied with the aim of increasing their productivity. Also, it has been shown that a yield increase can be achieved immediately if these soils are planted with suitable cassava cultivars.

PLANT CHARACTERISTICS

Plant height, total plant fresh weight, weight of stems and leaves, and harvest index are summarized in table 5. Each of these agronomic characteristics differed significantly between cultivars on both soils. Irrespective of soil type, M Col 22 and M Mex 55 were the smallest

cultivars, measuring less than 1 m. Also, these cultivars were among the lowest producers of stems and leaves but yielded relatively high fresh-root weight. Hence, they were characterized by a high harvest index. This situation can be contrasted with other cultivars (Bitter Stick and Chinese Stick) that were among the tallest and highest producers of stems and leaves but which produced relatively low fresh-root weight and thus had a low harvesting index. On the other hand, cultivars such as Iracema, M Mex 23, and Tacana grew vigorously, produced large quantities of stems

TABLE 6.—*Number of shoots arising from a stem cutting, stem diameter, number of edible roots per plant, and maximum root diameter at 12 months of 20 cultivars of cassava on marginal peats and peaty clays of Guyana*

Cultivars	Anira Peat No. 20				Inki Clay No. 100			
	Shoots per plant	Stem diameter	Edible roots per plant	Maximum root diameter	Shoots per plant	Stem diameter	Edible roots per plant	Maximum root diameter
	No	*Cm*	*No*	*Cm*	*No*	*Cm*	*No*	*Cm*
Badwoman	2.07	1.55	3.98	5.05	2.46	1.73	4.12	4.59
Bitterstick	1.58	2.09	4.36	3.97	1.62	2.16	2.91	3.14
Brancha Butterstick	1.50	1.73	2.55	4.03	1.53	1.80	2.78	3.75
Chinese Stick	1.47	2.14	3.45	3.96	2.14	2.07	4.08	3.38
CMC 40	2.00	1.91	4.06	7.23	2.10	1.98	4.35	7.15
Del País	1.61	1.87	5.34	5.57	1.84	2.16	9.20	5.17
Four Month	1.91	1.88	4.22	4.15	2.13	1.88	5.37	3.96
Iracema	3.22	1.99	5.81	7.24	3.45	1.86	5.73	6.37
L.H. 2	1.57	1.72	2.60	3.55	1.68	1.74	1.55	3.02
Llanera	1.17	2.27	3.99	3.96	1.47	2.02	5.41	7.31
M Col 22	1.75	1.71	4.23	4.66	1.62	1.67	4.70	4.60
M Col 673	1.45	2.23	3.88	4.77	1.70	2.10	3.99	5.50
M Mex 23	1.48	2.23	3.47	6.27	1.37	2.35	5.06	5.41
M Mex 55	1.28	1.81	3.73	4.76	1.35	1.80	3.89	5.36
M Mex 59	1.56	2.17	3.97	5.37	1.73	2.11	3.83	5.56
Piracununga	1.98	1.62	5.28	7.51	2.24	1.67	5.51	6.57
R. Singh	1.72	1.53	3.38	3.63	1.91	1.64	3.40	3.71
Tacana	1.97	2.30	6.56	7.87	2.02	2.14	6.20	7.16
Twelve Month	1.95	2.13	4.57	4.17	1.88	2.03	3.09	3.54
Uncle Mack	1.90	1.66	2.70	4.41	2.39	1.74	4.70	4.21
Grand Mean	1.76	1.97	4.11	5.22	1.93	1.93	4.49	4.97
Standard Error	.41	.10	.69	.38	.46	.48	.74	1.03
Coefficient of Variation (%)	28.41	6.40	17.27	8.81	37.30	39.37	26.07	20.12
L.S.D. (0.05)	.83	1.30	1.40	.07	.91	.96	1.47	2.05

and leaves and, consequently, higher root yields. In addition, they were characterized by a high harvest index. These results show that high total plant weight and harvest index are very important in obtaining high yields. Indeed, there is a highly significant relation between total plant weight and root yield (fig. 1, $r = 0.92$ and 0.94) for the Anira peat and Inki Clay, respectively; and between harvest-index and root-fresh yield

TABLE 7.—*Days to onset of primary and secondary root deterioration of 20 cassava cultivars grown on Anira peat No. 20 and Inki clay No. 100 in Guyana, and stored under field conditions* [1]

Cultivars	Anira Peat No. 20		Inki Clay No. 100	
	Deterioration		Deterioration	
	Primary	Secondary	Primary	Secondary
Badwoman	6	8	6	8
Bitter Stick	5	7	6	8
Brancha Butterstick	6	8	6	9
Chinese Stick	8	8	7	10
CMC 40	6	7	5	7
Del País	6	8	7	9
Four Month	6	7	6	8
Iracema	6	9	6	8
L.H. 2	5	7	6	8
Llanera	6	9	7	9
M Col 22	5	7	6	8
M Col 673	5	7	6	8
M Mex 23	6	8	6	9
M Mex 55	6	8	6	9
M Mex 59	6	9	7	10
Piracununga	5	7	6	9
R. Singh	6	8	5	8
Tacana	6	8	6	9
Twelve Month	5	7	5	8
Uncle Mack	6	8	6	9
Grand Mean	5.7	7.8	6.1	8.6

[1] Primary deterioration was considered to have started with the appearance of fine blue-black streaks in the root vascular tissue. Secondary deterioration was considered to have occurred when root tissues became soft.

(fig. 2, $r = 0.64$ and 0.81) for these two soils. Similar results have been reported by The Centro Internacional de Agricultura Tropical, Colombia (2).

On the average, all cultivars produced more than one stem per planted cutting irrespective of soil type (table 6). However, there was no significant relationship between number of stems per plant and root yield. This is in disagreement with earlier work by Chew in Malaya (4). Stem

diameter differed significantly among cultivars on both soils, but was not related to root yield. Highest yielding cultivars produced significantly more and thicker roots than their lower yielding counterparts. Furthermore, number of root tubers per plant was significantly correlated with yield (r = 0.69 on Anira peat and 0.95 on Inki clay). Implicit in these findings is that both root number and root bulkiness are important components for high yield.

POSTHARVEST SHELF LIFE

Quality of freshly-harvested root was good for all 20 varieties. Thereafter, at least 5 days had elapsed before primary deterioration or evidence of vascular streaking occurred (table 7). On both soils, at least 8 days had elapsed before 60% of the cultivars had begun to show cellular disintegration (secondary deterioration). Root deterioration was slower on the Inki clay than on the other soil type. Storage life appeared to be independent of cultivar.

These studies show that roots free of mechanical injury can tolerate several days in the field before being taken to processing plants. However, where delays are inevitable, the time lapse between harvest and processing should not exceed 48 h.

RESUMEN

Veinte cultivares de yuca de procedencia local e introducciones se evaluaron durante un período de crecimiento de 12 meses. Esta prueba se realizó para determinar si los suelos marginales de Guyana, tipos turba Anira #20 e Inki arcilloso #100 eran adecuados para dicha cosecha. Se obtuvo material de propagación de Brasil, Colombia, México, Puerto Rico y Guyana. Los cultivares Tacana e Iracema, ambos del Brasil, fueron los de más altos rendimientos con 28 t/ha de raíces en el suelo Anira y 24 t/ha en el suelo Inki. La mayoría de las introducciones superaron a los cultivares locales. El cultivar nativo de mayor rendimiento fue Badwoman con 12 y 10 t/ha en los suelos Anira e Inki, respectivamente. El cultivar M Col 673 fue el de contenido más elevado en materia seca: 40% en ambos suelos. La cantidad de materia fresca media utilizable fue de 0.85, básicamente similar en todos los casos. La relación entre el peso total de la planta y el rendimiento de raíces comestibles fue altamente significativa en ambos suelos (r = 0.92 y 0.94). También fue igualmente significativa la relación entre el índice de cosecha y el rendimiento de raíces (r = 0.64 y 0.81). Se comprobó que el número de tallos provenientes de un cangre (esqueje) y el diámetro del tallo al cosechar no están relacionados con el rendimiento. Sin embargo, la correlación entre el número de raíces comestibles por planta y el rendimiento fue altamente significativa (r = 0.69 y 0.54). También fue significativa la relación entre el grosor de la raíz y el rendimiento (r = 0.92 y 0.95) en ambos suelos. Bajo condiciones de campo, todos los cultivares se conservaron bien por 5 días antes de que comenzaran a deteriorarse.

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