Yield performance of introduced cassava clones in an Ultisol in Puerto Rico[1,2]

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ABSTRACT

In 2000, cassava production in Puerto Rico was almost 750,000 kg with an annual farm value of $386,000. During the same year more than 6,800,000 kg of cassava tubers were imported. Studies with new introductions of cassava clones are necessary to increase production, reduce costs and meet local demand. Seven cassava introductions and one local cultivar were evaluated in 1997 and 1998 at Corozal for yield and hydrogen cyanide (HCN) concentration. Clones CM 3380, CM 3311, SG 804 and SM 494 produced the highest number of marketable roots. Clones CM 3311, CM 3380 and SG 804 produced the highest root marketable weight in 1997, averaging 37,905 kg/ha. In 1998, clones CM 3311 and CM 3380 were the best yielders, averaging 28,713 kg/ha of marketable roots. In both years clone SG 804 had a significantly higher concentration of HCN, which averaged 121 mg/kg, whereas the rest of the clones had values of HCN below 63 mg/kg.

Key words: cassava, yield, HCN concentration

RESUMEN

Rendimiento de clones introducidos de yuca en un Ultisol en Puerto Rico

En el año 2000 la producción de yuca en Puerto Rico fue de 750,000 kg con un valor en la finca de $386,000. El mismo año se importaron 6,800,000 kg de yuca a la isla. Es necesaio que se realicen estudios encaminados a evaluar nuevas introducciones de yuca para aumentar la producción y satisfacer la demanda local. Siete introducciones de yuca y un cultivar local fueron evaluados para rendimiento y concentración de cianuro (HCN) en Corozal en 1997 y 1998. Los clones CM 3380, CM 3311, SG 804 y SM 494 produjeron el mayor número de raíces mercadeables. En 1997 los clones CM 3311, CM 3380 y SG 804 produjeron las raíces mercadeables con mayor peso, promediando 37,905 kg/ha. En 1998, los clones CM 3311 y CM 3380 obtuvieron los mayores rendimientos, promediando 28,713 kg/ha de raíces mercadeables. En ambos años el clon SG 804 obtuvo una concentración de

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HCN significativamente más alta (121 mg/kg) mientras que en los demás clones la concentración de HCN fue menor de 63 mg/kg.

INTRODUCTION

Cassava is one of the most important energy sources in the diet of large segments of the population in the tropics. National worldwide average yields vary widely, from 1,780 kg/ha in Sudan to more than 27,300 kg/ha in Barbados (FAO, 2000). Much cassava is grown without irrigation in tropical areas with a pronounced dry period, and often in soils of low fertility (Howeler, 1996). In 1999-2000, cassava production in Puerto Rico was almost 750,000 kg with an annual farm value of $386,000 (Departamento de Agricultura, 2000) whereas average yield was 2,454 kg/ha (FAO, 2000). During the same year more than 6,800,000 kg of cassava tubers was imported (Puerto Rico Planning Board, 2000). Therefore, an incentive exists to increase production to meet local demand and perhaps export to other markets in the Caribbean Basin.

In 1980, Ramírez et al. (1983) tested 10 promising cassava cultivars which ranged in yield from 8,435 kg/ha to 29,442 kg/ha. From 1980 to 1983, Badillo-Feliciano (1984) evaluated 12 local and introduced clones of cassava in an Oxisol. The highest yield (39,921 kg/ha) was attained by cultivar IAC-Mantequeira (PI 12902). To our knowledge, since then studies to evaluate yield potential of new cassava introductions have not been conducted in Puerto Rico or elsewhere in the Caribbean. The objective of the study was to evaluate seven cassava introductions and one local cultivar in Puerto Rico for yield and HCN content.

MATERIALS AND METHODS

Field experiments were established 13 March 1997 and 25 March 1998 at the Corozal Agricultural Experiment Substation of the University of Puerto Rico (latitude 18°20'N, longitude 66°31'W, altitude 185 m) in the highland agricultural zone of Puerto Rico. The Corozal soil is a well-drained Ultisol (clayey, mixed, isohyperthermic Aquic Haplohumults) with a pH of 5.1, 15% slope, bulk density of 1.4 g/cm^3, and 2.28% organic carbon in the first 14 cm of soil. The 27-year mean annual rainfall is 1,863 mm and Class A pan evaporation is 1,391 mm. Table 1 shows total monthly rainfall, evaporation and mean maximum and minimum temperatures during the experimental period.

The cassava clones tested in this study (CM 3064-4, CM 3311-3, CM 3380-7, CM 4484-2, SG 804-5, SM 494-2, CM 523-7) are introduced selections developed by the 'Centro Internacional de Agricultura Tropical' (CIAT) at Cali, Colombia. The local cultivar Serrallés was used as a control.

TABLE 1.—*Average maximum and minimum air temperature, total rainfall, and class A pan evaporation during the experimental period at Corozal, Puerto Rico.*

Month	Temperatures (°C)		Rainfall (mm)	Pan evaporation (mm)
	Maximum	Minimum		
1997-1998				
March	29.5	17.1	7.9	81.5
April	30.6	17.6	26.7	141.0
May	32.9	19.4	127.5	177.3
June	33.1	21.0	26.4	173.2
July	32.7	21.3	114.0	158.0
August	32.7	21.5	119.9	151.4
September	32.3	21.4	191.3	128.3
October	31.5	20.9	85.1	111.2
November	29.2	18.9	69.6	83.6
December	32.0	19.0	2.5	123.4
January	30.1	18.5	171.4	104.1
February	29.7	18.0	177.3	104.6
March[1]	30.3	17.0	84.1	130.0
Average	31.3	19.3	92.6	128.3
1998-1999				
March[2]	30.3	18.8	55.6	26.2
April	29.9	19.3	150.6	112.3
May	31.6	19.9	158.0	117.3
June	32.4	21.1	143.5	136.1
July	32.5	21.4	98.0	150.9
August	32.6	21.6	162.0	138.7
September	32.5	21.3	258.6	126.2
October	32.0	20.9	321.8	120.6
November	30.0	19.9	262.4	100.6
December	27.8	19.5	436.9	89.9
January	28.2	17.9	82.5	98.3
Average	30.9	20.1	193.6	110.6

[1]Average of first four days of the month.
[2]Average of last 27 days of the month.

In both experiments, the planting material consisted of mature stem cuttings containing four to five nodes planted vertically in raised beds. The experimental design consisted of a randomized complete block design with five replications. Each replication contained eight plots representing different clones. Each plot consisted of four rows 1.2 m apart with plants spaced 0.90 m apart within the row for a total of 20 plants per treatment per replicate. Yield data were recorded only from

the six inner plants from each plot. The crop was fertilized at a rate of 1,000 kg/ha of 15-2.2-12.4-3% (N-P-K-Mg), which was equally divided and applied at one and four months after planting. Supplemental overhead irrigation was applied as needed. Weed and insect control followed the recommendations of the University of Puerto Rico Agricultural Experiment Station (1997). Harvesting was 4 March 1998 and 20 January 1999, respectively, for each experiment. Damaged or deformed roots were classified as non-marketable. At each harvest, representative marketable roots from each variety were washed free of soil, and potential hydrogen cyanide (PHCN) was determined by the alkaline picrate method (CIAT, 1985).

Analysis of variance was made using the ANOVA procedure of the SAS program package (SAS Institute, 1990). Means among clones for all measurements were separated by Fisher's protected Least Significant Difference (LSD) at the 0.05 probability level.

RESULTS AND DISCUSSION

Year had a significant ($P \leq 0.01$) effect on most of the variables that were studied. This was probably attributable to differences in rainfall. Average monthly rainfall during the 1998-99 experiment was 110% higher than in 1997-98 (Table 1) and 25% higher than the 27-yr average for the site. Over 60% of the total rain received in 1998-1999 fell during the months of September to December. On 21 September 1998, hurricane Georges hit the island of Puerto Rico bringing heavy rains and sustained winds of 177 km/h. In view of these differences in climatic conditions, experimental data are presented separately for each year.

Clone CM 3380 produced the highest number of marketable roots in both years. However, this trait was not significantly different from that obtained in clones SG 804, CM 3311, SM 494 and CM 523 in 1997 and from clone CM 3311 in 1998 (Table 2). It is noteworthy that in 1998 the number of marketable roots declined between 14% and 55% in all clones except CM 3380. The number of marketable roots in the latter declined by only 7% (Table 2). A smaller number of marketable roots in 1998 was the result of root damage from excess soil water brought about by heavy rains that year.

Clones CM 3064 and SM 494 produced the highest number of non-marketable roots in 1997, averaging 66,861 roots per hectare. In 1998, clone CM 3064 produced a significantly higher number of non-marketable roots (Table 2).

As compared to 1997, the average total number of roots was 13% lower in 1998 (Table 2). However, it is noteworthy that even though some clones had a decline in the total number of roots of over 20% in

TABLE 2.—*Number (no./ha) and weight (kg/ha) of marketable and non-marketable roots, and root HCN concentration (mg/kg) of eight cassava clones grown at Corozal, Puerto Rico.*

	Number of roots			Weight of roots			
Clone	Market-able	Non-mar-ketable	Total	Market-able	Non-mar-ketable	Total	HCN
1997							
CM 3380	81298	49317	130615	37209	4029	41238	42.5
SG 804	75081	27498	102579	34405	2866	37271	114.3
CM 3311	74005	23792	97797	42101	2926	45027	51.0
SM 494	73288	62886	136174	25298	5183	30481	53.0
CM 523	62767	37660	100427	26464	3219	29683	39.5
CM 3064	55743	70837	126580	19488	5129	24617	31.0
Serrallés	54697	26003	80700	19586	2639	22225	36.5
CM 4484	53800	42741	96541	20029	4979	25008	39.0
Average	66335	42592	108927	28072	3871	31943	50.8
LSD (0.05)	22788	21028	24255	9710	1802	9341	27.4
1998							
CM 3380	75918	37361	113279	28634	3640	32274	61.0
SG 804	33476	48121	81597	12057	4435	16492	127.7
CM 3311	62468	34671	97139	28792	3799	32591	53.0
SM 494	52007	53202	105209	17778	3972	21750	58.1
CM 523	42143	55294	97437	13842	4367	18209	63.1
CM 3064	29889	88471	118360	6800	6420	13220	35.0
Serrallés	24808	45132	69940	8246	3948	12194	19.5
CM 4484	46029	32579	78608	16379	2827	19206	26.0
Average	45842	49354	95196	16566	4176	20742	55.4
LSD (0.05)	23078	22778	8626	8216	1933	8626	35.3

1998 (e.g., clones SG 804 and SM 494), clone CM 3311 showed a reduction of less than one percent. Cassava is drought tolerant (El Sharkawy and Cock, 1984; Ekanayake et al., 1996) but extremely susceptible to excess water (Connor et al., 1981). In view of the wet conditions encountered in 1998 and the small decline in total root production by clone CM 3311, it is recommended that this clone be studied for waterlogging tolerance.

Clones CM 3311, CM 3380 and SG 804 produced the highest marketable root weight in 1997 averaging 37,905 kg/ha. In 1998, clones CM 3311 and CM 3380 were the best yielders averaging 28,713 kg/ha of marketable roots. The latter two clones outyielded local cultivar Serrallés by an average of 20,069 kg/ha of marketable roots in 1997 and 20,467 kg/ha in 1998 (Table 2). In 1997, clones SM 494, CM 3064, CM

4484 and CM 3380 produced significantly higher non-marketable root weight whereas clone CM 3064 did so in 1998 (Table 2).

Average total root weight was 35% lower in 1998 than in 1997. The decline in total root weight could have been caused by less production of roots (Table 2), a reduction in leaf area brought about by leaf abscission during the hurricane, and root rotting as a result of excess soil water. The latter prompted the authors to harvest plants two months earlier than in the 1997 experiment. Clones CM 3064 and SG 804, and cultivar Serrallés had the highest decline in total root weight.

In both years clone SG 804 had a significantly higher concentration of HCN, which averaged 121 mg/kg. There was no significant difference in HCN concentration among the rest of the clones in 1997 and little in 1998 (Table 2). In India, the HCN concentration of local cultivars ranges from 35 to 50 mg/kg (Manrique, 1996). In Puerto Rico, the mean HCN concentration of high yielding cultivars has been reported to range from 0 to 50 mg/kg (Ramírez et al., 1983; Badillo-Feliciano, 1984).

The yield data obtained in this study suggest that clones CM 3311 and CM 3380 may have the best potential for cassava production in Puerto Rico. Marketable root yields from clones used in this study were between 15% and 104% higher than those obtained from the highest-yielding clones used in previous studies in Puerto Rico (Table 2 and Badillo-Feliciano and Lugo-López, 1975; Ramírez et al., 1983; Badillo-Feliciano, 1984). A panel conducted an informal sensory evaluation of cooked samples of the eight cassava clones used in this study. Clones SM 494 and CM 3380 received the highest ratings in terms of tuber appearance after cooking, texture, flavor, and fiber content (data not shown). It is recommended that a formal evaluation be conducted by a food technologist to assess the potential acceptability of these newly introduced clones.

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