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Total Dry Matter Production, Tuber Yield, and Yield Components of Six Local Cassava Cultivars in Trinidad

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Dry matter production, quantitative shoot morphology, dry matter distribution, tuber yield, and yield components of six representative cassava cultivars in Trinidad are presented. The results are discussed in relation to the yield performance of elite cassava cultivars and the yield potential of the cassava species. A cassava type on which improvement of the yield potential of the species might be based is identified.

Cassava production in the Commonwealth Caribbean is estimated at 26 × 10^3 t with an average productivity of 13.3 t/ha (7.8 tons/ha if the small but highly productive cassava in the Barbados is excluded). This level of cassava productivity is low compared with that in Brazil (14.6 t/ha), and cassava production represents only approximately 10% of the yam production of the region.

Cassava is grown in ecosystems ranging from the dry plains of Jamaica (annual rainfall 130 cm) to the very wet coastal plains of Guyana (annual rainfall 500 cm). However, despite the low productivity of Caribbean cassava, there have been reports of the existence of varieties with high yield potential (60 t/ha under experimental conditions). Similar productivity levels have been reported for elite cultivars in the CIAT cassava collection and a potential productivity level of 90 tons/ha/year has been predicted for the species by Cock (1974).

To increase Caribbean cassava production, two objectives must be achieved: (1) high productivity cultivars suitable for growth under the wide range of Caribbean ecosystems must either be identified or synthesized; and (2) cultural practices calculated to optimize yield of high performance cultivars must be developed.

In pursuance of these objectives, total dry matter yield, tuber yield, and other components of selected cultivars have been analyzed to study crop performance in cassava cultivars with contrasting growth habits. This was done prior to introduction of exotic germ plasm and regional testing of selected high performance types in different Caribbean ecosystems. Preliminary data on six representative cultivars are presented to place these cultivars in the profile of tuber yield productivity levels.

Materials and Methods

Six cultivars (*Manihot esculenta* Crantz) were grown on 30-cm-high ridges that were 90 cm apart. Stem cuttings (18 cm, 85 g) were planted 90 cm apart at an angle of 45° along the crest of the ridge and were each treated with 140 g of a standard 12:12:7 NPK fertilizer one month after planting. The experiment was established as a randomized split plot design with three replicates, as an out of season crop planted in the dry season on 10 January 1974. One week after shoot emergence selected

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Table 1. Total dry matter production and quantitative stem morphology of six cassava cultivars.[a]

	Dry matter production							
	g/plant	g/plant /week	t/ha	t/ha /week	Stem D. wt. /plant	Branch No. /plant	Stem D. wt. /branch	Node No. / branch /plant
Redstick	3189	69.3	38.3[b]	0.83	1522	29.7	51.2	40.1
Whitestick II	3036	66.0	36.4	0.79	1553	24.5	63.4	45.1
Whitestick I	2997	65.0	36.0	0.78	1698	19.2	88.4	58.8
Maracas Blackstick	1885	41.0	22.6	0.49	645	16.7	38.6	36.3
Around the World	1664	36.2	20.0	0.43	961	34.3	28.0	35.0
Pie Pip	1424	31.0	17.1	0.37	638	30.5	20.9	32.0
Mean	2366	51.4	28.4	0.62	1170	25.8	45.3	40.0
S.E.	477.7	—	—	—	242.3	6.8	—	6.0

[a]Predicted dry matter production rates reported by or calculated from different authors: 46 tons/ha/year (Cock 1974); 73 tons/ha/year calculated from de Witt (1967); and 130 tons/ha/year calculated from Loomis and Williams (1963).

[b]43 tons/ha/year.

plants in each replicate were pruned to one shoot and the single shoot condition was maintained during crop growth. After 46 weeks of growth, the crop (15 plants per cultivar) was harvested and total dry matter, dry matter distribution, parameters of shoot morphology, tuber yields, and the components of yield, tuber number, and mean tuber weight were recorded and evaluated by analysis of variance and by correlation and regression analysis.

Results and Discussion

Total Dry Matter Production

The six cassava cultivars studied could be classified into high (3000 g/plant) and low (1400–1900 g/plant) dry matter producing types (Table 1). The average rate of dry matter production of the former types (42 tons/ha/year) was similar to the production rate predicted by Cock (1974) for cassava, was 58% of the rate (73 t/ha/year) predicted by de Wit (1967) for *Solanum* potatoes, but only 32% of the 130 t/ha/year production level based on calculations of maximum photosynthetic productivity by Loomis and Williams (1963) for maize.

Quantitative Shoot Morphology

Numbers of leaves produced over the crop growth period, as assessed by total node numbers, were high (975–1231) in all cultivars except Maracas Blackstick (607). Percentage leaf fall was similar (52.5–59.9%) in all cultivars leading to proportionality between total leaf number and the number of leaves (289–585) retained at final harvest. Cultivars could, however, be separated into three groups on the basis of leaf area. Thus, there were high (Redstick and Whitestick II, 7.1–7.9 dm^2), intermediate (Whitestick I and Pie Pip, 4.5–5.3 dm^2), and low (Maracas Blackstick and Around the World, 2.6–2.7 dm^2) leaf area cultivars. Low leaf areas were due to low leaf number (289) and low average area leaf (46.2 cm^2) in Maracas Blackstick and Around the World, respectively. The high dry matter producing types Redstick, Whitestick I and II as well as the low dry matter type Maracas Blackstick were broad leaf cultivars with leaves containing 3–9 elliptically shaped leaf lobes with length/breadth ratios of 3–4. Around the World and Pie Pip were fine leaf cultivars with leaf lobes having length/breadth ratios of 12–15.

There were no obvious relationships between stem length, branch length, and internode length and total dry matter production. The cultivar separation into three high (1522–1698 g/plant) and three low (645–961 g/plant) yielding types on the basis of stem dry weight (Table 1) was similar to the total dry matter separation, indicating a measure of proportionality between stem dry weight and total dry weight. However, both in the high and low yielding groups, there were cultivars with lower branch numbers per plant (Whitestick I, 19.2 and Maracas Blackstick, 16.7) than the remaining cultivars (24.5–34.3), leading to heavier stem dry weight per branch in these

Table 2. Distribution of dry matter in six cassava cultivars.

	Dry matter distribution (% TDM)					
	Stem	Petiole	Lamina	Tuber	Thick root	Planting stick
Redstick	47.0	1.79	8.80	34.3	0.70	7.23
Whitestick II	48.3	2.19	8.50	35.6	0.67	4.68
Whitestick I	56.1	1.88	6.88	29.4	0.84	4.85
Maracas Blackstick	34.7	1.62	5.67	52.5	0.61	4.79
Around the World	57.6	1.46	8.36	25.0	1.10	6.50
Pie Pip	44.4	1.48	9.80	36.4	1.10	6.78
Mean	48.1	1.70	8.00	35.6	0.84	5.80

cultivars (88.4 and 38.6, respectively) when compared with the other two in the yield group. Whitestick I also had higher node number per branch (58.8) than the remaining cultivars (32.0–45.1). Apart from Whitestick I, the relatively small differences between values for node numbers per branch in the different cultivars (Table 1) suggested that leaf number could be increased in the cultivars studied by increasing branch number, especially as percentage leaf fall values were also constant.

Interrelationships

There were significant correlation coefficients between node number ($r = 0.64$), leaf number ($r = 0.56$), leaf area ($r = 0.69$), and total dry weight over all cultivars. For individual cultivars, correlation coefficients between node number and total dry weight were high ($r = 0.84$–0.90) in all cultivars except Whitestick I and II ($r = 0.59$ and 0.69, respectively). The leaf number correlation coefficients were also high in all cultivars except in Whitestick II and for leaf area, correlation coefficients were significant for all cultivars except Pie Pip. Total number of leaves produced was important for total dry matter production. In individual cultivars, leaf number is directly proportional to leaf area, and dry matter production is a function of photosynthesis of the leaf surface. Over the six cultivars, the low dry matter production of the fine leaf varieties (e.g. Around the World) despite their high leaf production may be explained by low leaf area (and hence low total photosynthesis). However, flowering, profuse branching, and a high percentage of recently produced young leaves at harvest may also be responsible for the low dry matter production of Pie Pip.

Distribution of Dry Matter

The distribution of dry matter between the tubers and other organs of the plants was also calculated. Dry matter distribution to tubers (harvest index) was low (25.0–36.4%) in all cultivars except Maracas Blackstick (52.5%) and there was correspondingly high dry matter distribution to stems in these cultivars (44.4–57.6%) and low distribution (34.7%) in Maracas Blackstick. However, even in this cultivar, harvest index was relatively low compared with values of up to 70% reported for the species (CIAT 1974).

On the basis of dry matter production and distribution patterns, the six cultivars studied might be classified as follows: (1) high dry matter production/low harvest index types — Redstick, Whitestick I, and Whitestick II; (2) low dry matter production/high harvest index type — Maracas Blackstick; and (3) low dry matter production/low harvest index types — Around the World, and Pie Pip.

Cultivar Yields and Yield Components

Tuber yields (Table 2) were low compared with those of elite cassava cultivars (CIAT 1974). However, four of the six cultivars studied were comparatively high yielding (29.5–31.9 t/ha) and the remaining two were low yielding (14.3 and 16.6 t/ha). The higher yielding cultivars had lower yield variability (C.V. 34–39%) than the low yielding cultivars (41–69%) confirming earlier work by Haynes and Wholey (1971), Lowe and Wilson (1975b), and Wilson (1975), which suggested that high yield variability was one of the contributing factors to low yield in tropical root crops. Thus, if the highest yield per plant recorded (4183 g) were consistently maintained over the experiment the yield productivity of

Table 3. Tuber yield of six cassava cultivars.

	Tuber yield			Tuber No.		Mean tuber wt.	
	t/ha	g/plant	CV(%)	No./plant	CV(%)	g/plant	CV(%)
Redstick	31.2	2600	39	7.1	25	409	55
Whitestick II	31.9	2660	34	4.8	25	591	45
Whitestick I	27.9	2327	38	7.1	39	340	41
Maracas Blackstick	29.5	2467	36	6.1	39	430	37
Around the World	14.3	1191	69	4.2	46	272	56
Pie Pip	16.6	1383	41	3.4	41	452	44
Mean	25.2	2105	37	5.4	33	416	50

the crop would have been 57.8 t/ha or 65 t/ha/year.

Tuber numbers per plant (3.4–7.1) (Table 3) were very low compared with data previously recorded for other cassava varieties (10–12 tubers per plant). Mean tuber weights (272–591 g/plant) were however greater than those recorded by Enyi (1972) (253–297) and Williams (1974) (229–381). It appears that low tuber number was the more important contributing component to the low tuber yield in the cassava cultivars studied.

Variabilities in yield components were greater for mean tuber weight than for tuber number, and mean tuber weight was the more important immediate source of yield variation in all cultivars except Maracas Blackstick. Variabilities in each component contributed significantly and independently to yield variability and together accounted for 76–97% of the total variation in tuber yield.

If it is assumed that the major source of yield variation is the competition pressure that develops in the crop community in the course of the crop growth cycle, and that yield variability leads to reduced yield, then individual mean tuber weight values reflected pressure from this source to a greater extent than tuber number. It is concluded, therefore, that despite the low tuber number values recorded for the varieties studied, tuber number variability did not originate principally from competition pressure in the crop community. It is however difficult to determine from results of the current experiments whether low tuber number was a genetic characteristic of the cultivars or was a reflection of the environment in which the crop was cultivated, e.g. dry conditions during early growth. Nevertheless, the importance of mean tuber weight as a major source of yield variability is in agreement with data previously published for sweet potato and yam. Williams (1974) also concluded that tuber size was the major component of yield in cassava.

Interrelationships between Yield Components and Yield

There were significant negative correlation coefficients between tuber number and mean tuber weight in the two high yielding cultivars (Redstick, Whitestick II) and also in the low yielding cultivar, Pie Pip, at the $p = 5\%$ level. This level of yield component compensation was less than that recorded for sweet potato by Lowe and Wilson (1975a) and the regressions of tuber number on mean tuber weight accounted for 25–30% of the yield variation. However, the significant negative regression of tuber number on mean tuber weight for the four high yielding cultivars suggested that mean tuber weight/tuber number ratios might be cultivar characteristics. Since no such correlation could be demonstrated for the two low yielding cultivars, it is suggested either that the high yielding cultivars might be representatives of a distinct line with yield component compensation at the genetic level, or that there was not sufficient competition pressure in the population of the low yielding cultivars to develop strong compensatory relationships between the components of tuber yield. Yield component compensation partially overcame the effects of low tuber number on yield in Whitestick II and Pie Pip within the high and low yield level groups, respectively. Similar compensatory relationships did not result in raising the yield level of the high yielding cultivars to that recorded in elite representatives of the species (60 t/ha).

Significant correlation coefficients between either yield component and yield suggested that cultivars might be classified according to the contribution of yield components to yield as follows: (1) tuber number/tuber weight types in which both components were significantly correlated with yield — Around the World; (2) tuber weight types in which tuber weight was significantly correlated with yield — Whitestick I, Whitestick II, Redstick, and Pie Pip; and (3) tuber number type where tuber number was significantly correlated with yield — Maracas Blackstick.

Leaf Production

The significant correlations demonstrated between parameters of leaf production — node number, leaf number, and leaf area — and total dry weight were also established between these parameters and tuber yield, indicating that leaf production and leaf abscission were important determinants both of total dry matter production and tuber yield. Correlation coefficients were, however, higher with total dry matter than with tuber yield. Similar correlations between leaf number, node number, and cassava yield have also been demonstrated by others. Variation in node number and leaf number within the six cultivars studied explained more than 50% of the variability in tuber yield except in Whitestick I and II (40–48%). When all cultivars were considered together leaf number and node number accounted for less than 25% of the tuber yield variability. Thus, although high leaf production and leaf retention were important for high yield within individual cultivars, it would appear that high yield was not necessarily correlated with high rates of leaf production. The yield performance of Maracas Blackstick demonstrated that high yields could be achieved with a low leaf production cultivar provided that high harvest indices are realized.

Harvest Index

Although there were no significant correlations between tuber yield and harvest index in the four high yielding cultivars, such correlations were significant both for the low-yielding cultivars ($p = 0.05$ and 0.10) and for all cultivars ($p = 0.001$). The former correlation was interpreted to mean that plant to plant variation in harvest indices may have been partly responsible for the high yield variability in low yielding cultivars (Table 3). The latter correlation indicated that harvest indices might be used as a means of assessing the yield potential of a collection of cultivars grown under similar conditions as was previously suggested at CIAT (CIAT 1974).

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