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EVALUATION OF THREE CASSAVA VARIETIES FOR TUBER QUALITY AND YIELD

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ABSTRACT

Three cassava varieties were evaluated in a completely randomised design with four replications at the Gladstone Road Agricultural Centre during 2011. Plants were harvested 10 months after planting and evaluated for root and stem characteristics and tuber yield. Significant differences were seen between the three varieties for all stem and root responses. The variety 'John LaMotte' presented the highest mean yields of marketable tubers (22.9 t/ha) compared to 'Blue Mountain' (17.1 t/ha) and 'Cuban White Stick' (14.9 t/ha). Dry matter content ranged from 41.1% in 'John LaMotte' to 46.3% in 'Blue Mountain'. The variety 'John LaMotte', which exhibited the highest tuber weights, had the lowest dry matter content. Both 'Blue Mountain' and 'Cuban White Stick' had significantly lower tuber weights with higher dry matter contents than 'John LaMotte'. Dry matter content was significantly negatively correlated with storage root weight, suggesting that when the storage root weight is high, the dry matter content tends to be low. Proximate analyses of the raw pulp taken from the tubers of the three cassava varieties revealed that 'John LaMotte' contained the highest percentage ash and highest potassium content of 861.2 mg/100g. The mean values of sodium (mg/100g), were 49.9 for 'Cuban White Stick', 40.0 for 'John LaMotte' and 36.2 for 'Blue Mountain'. 'Blue Mountain' had the highest total carbohydrate content of 42.7%.

Cassava (*Manihot esculenta* Crantz)

Introduction:

The cassava (*Manihot esculenta* Crantz) is cultivated mainly in the tropic and sub-tropic regions of the world, over a wide range of environmental and soil conditions. It is very tolerant of drought and heat stress and produces well on marginal soils. It is an important dietary staple in many countries within the tropical regions of the world (Perez and Villamayor, 1984), where it provides food for more than 800 million people (FAO, 2007). As a subsistence crop, cassava is the third most important carbohydrate food source in the tropics after rice and maize, providing more than 60% of the daily calorific needs of the populations in tropical Africa and Central America (Nartey, 1978). According to Alexandratos (1995), cassava plays an important role in alleviating food problems, because it thrives and produces stable yields under conditions in which other crops fail.

Cassava is a versatile crop and can be processed into a wide range of products such as starch, flour, tapioca, beverages and cassava chips for animal feed. Cassava is also gaining prominence as an important crop for the emerging biofuel industry and, as corroborated by Ziska *et al.* (2009), is a potential carbohydrate source for ethanol production. A well planned strategy for the development and utilisation of cassava and cassava products can provide incentives for farmers, crop vendors and food processors to increase their incomes. It can also provide food security for households producing and consuming cassava and cassava products (Plucknett *et al.*, 1998).

Traditionally, cassava has been grown by farmers throughout the Bahama Islands and has been of particular importance to small farmers of the central and southeastern islands, where it is still cultivated. It is a crop that is generally grown on marginal lands with a minimum of agricultural inputs (Hillocks *et al.*, 2002). Once established, the cassava crop is given little attention, but still is able to tolerate weed competition, as well as insect pests and diseases. The potential exists for improving the productivity of cassava through better agronomic practices, superior varieties and pest and disease management.

Cassava varieties are generally distinguished from each other by their morphological characteristics which include leaf, stem and tuber colour, leaf shape and number of storage roots per plant. The plant produces all year round and can be harvested over an extended period of time. Although it is easily propagated by stem cuttings, the lack of quality planting material is a major constraint to the development of a viable cassava production system. Eze and Ugwuoke (2010) report that tuber yield of cassava is influenced by both the quality of planting material used and the agronomic practices employed. Access to high yielding cassava varieties and an improvement of the production system will result in increased economic benefits to local farmers.

Among the objectives of the root and tuber crops programme at the Gladstone Road Agricultural Centre are to identify high yielding cassava varieties, to evaluate and preserve cassava germplasm and to provide good quality planting material for local farmers. Documented information on the performance of cassava on the calcareous soils of The Bahamas, under improved agronomic practices, is lacking. Until this present study, very little effort had been made to evaluate existing varieties and new introductions for their yield potential under local conditions. Consequently, there is a need for conducting research on cassava in order to identify varieties suitable for growing on Bahamian soils. The productivity of this crop can be improved through the selection of cassava varieties most suitable for local conditions and the application of the appropriate agronomic practices.

Objective:

The objectives of this study were to evaluate three cassava varieties for their productivity on Bahamian soils, to assess the cassava stem characteristics for their suitability as planting material and to improve the capability of local farmers to select good quality cassava varieties.

Materials and Methods:

The study was carried out at the Gladstone Road Agricultural Centre, New Providence, from April 2010 to February 2011. The cassava planting material used in this study and some of their characteristics are listed in Table 1. These varieties are already a part of the production systems of local farmers. Though no nutritional studies have been done to determine the levels of hydrogen cyanide (HCN) within their edible portions, they have been designated by farmers as sweet cassava varieties, with apparently low HCN contents. To date, there have been no reports of HCN toxicity with any of the three varieties evaluated. Their origins could not be independently verified at the time of this study; the information found in Table 1 was obtained from the farmers who supplied the plant material, or identified it as such from stock plants growing at the Gladstone Road Agricultural Centre.

Table 1. Characteristics and origin of plant material used in the experiment.

VARIETY	ORIGIN	DESCRIPTION
Cuban White Stick	Cuba	Early branching, spreading
Blue Mountain	Jamaica	Early branching, spreading
John LaMotte	Unknown, well established local variety	Late branching, erect

The three cassava varieties evaluated in this experiment were established in an open field in a completely randomised design with four replications, on ridges 1.5 m apart, with a 1.0 m spacing between plants within rows. The planting material consisted of mature stem cuttings of about 20 cm in length, containing between 10 and 12 nodes and planted in a vertical position along the top of the ridges. Each plot consisted of 30 plants, with data being taken from ten plants within each plot. Tuber yield was determined from the actual area of each plot, which, according to Romani *et al.*, (1993), provides a good estimate of true yield. This is also supported by Neppl *et al.*, (2003) whose study indicated that interactions of centre row with border row were insignificant.

The usual cultural practices were observed to ensure an even stand of plants in the experimental plots. The cassava trial plots were grown under rain-fed conditions. Fertiliser was applied at a rate of 250 kg per hectare (223 lb per acre) one month after planting, then again at three months after planting. Before each application of fertiliser, the plots were weeded and cultivated. Plant characteristics (Table 2) were described according to the descriptor list for cassava genetic resources (Biodiversity International, CIAT, 2009).

Table 2. Characteristics observed of cassava plants and system of rating (after CIAT, 2009)

No.	Characteristic	Method of determination	Key
1	Colour of first fully expanded leaf	Observing and estimating	1. Light green 2. Dark green 3. Green-purple 4. Purple
2	Shape of central leaf lobe	Observing and estimating	1. Oblanceolate 2. Linear 3. Elliptic 4. Pandurate (obovate with pair of basal lobes) 5. Lanceolate 6. Other
3	Colour of unexpanded apical leaves	Observing and estimating	1. Light green 2. Dark green 3. Green-purple 4. Purple 5. Other
4	Pubescence of young leaves (newly formed in the transitional stage)	Observing and estimating	1. Sparse 2. Intermediate 3. Dense
5	Petiole colour	Observing and estimating	1. Light green 2. Dark green 3. Green-purple 4. Purple 5. Other
6	Stem colour (observed between 50-100 cm from ground level)	Observing and estimating	1. Silver green 2. Light brown or orange 3. Dark brown 4. Other
7	Storage roots per plant	Counting	
8	Storage root pulp colour (observed immediately after being cut open)	Observing and estimating	1. White or cream 2. Yellow 3. Pink 4. Other
9	Storage root surface colour	Observing and estimating	1. White 2. Cream 3. Light brown 4. Dark brown 5. Other
10	Colour of outer surface of storage root cortex	Observing and estimating	1. White or cream 2. Yellow 3. Pink 4. Purple 5. Other

The mean monthly maximum and minimum temperatures for the experimental period were 28.5°C (80.5°F) and 18.4°C (62.4°F), respectively. The total rainfall for the period was 1124 mm (44.4 in). Mean monthly sunshine duration for the period was 7.7 h. Weather data (Table 3) on sunshine duration, maximum and minimum temperatures and rainfall for the period under study were obtained from the Meteorological Department of the Commonwealth of The Bahamas.

Table 3. Weather data on rainfall, hours of sunshine and mean maximum and minimum temperatures for New Providence for the period of April 2010 to February 2011, courtesy of the Meteorological Department of The Bahamas.

Month	Total rainfall (**mm/**inches)	Mean monthly radiation (h)	Mean maximum temperature (°C/°F)	Mean minimum temperature (°C/°F)
April 2010	**85.3**/3.4	**9.0**	**30.9**/87.6	**17.1**/62.8
May 2010	**75.4**/3.0	**10.3**	**32.9**/91.2	**21.5**/70.7
June 2010	**72.4**/2.8	**9.4**	**35.2**/95.4	**23.0**/73.4
July 2010	**191.3**/7.7	**8.9**	**34.9**/94.8	**23.9**/75.0
August 2010	**203.7**/8.0	**8.4**	**35.4**/95.7	**23.0**/73.4
September 2010	**191.3**/7.5	**8.5**	**35.1**/95.2	**23.3**/73.9
October 2010	**194.1**/7.6	**7.1**	**32.2**/90.0	**20.5**/68.9
November 2010	**47.2**/1.9	**7.7**	**30.5**/86.9	**16.0**/60.8
December 2010	**45.2**/1.8	**6.8**	**23.6**/71.8	**16.1**/61.0
January 2011	**13.5**/0.5	**6.8**	**24.7**/76.4	**17.4**/63.4
February 2011	**4.6**/0.2	**9.2**	**26.8**/80.6	**18.9**/66.0

Note: Monthly mean values have been rounded up to the nearest tenth

After 10 months of growth, the plots were harvested and the storage roots counted, weighed and measured. Data was taken from ten randomly selected plants from each plot. The following parameters were measured: total tuber yield per plant (kg), total number of tubers per plant, tuber length (cm), marketable tuber weights (kg) and number of marketable tubers. Also evaluated were the following stem characteristics: plant height (cm), number of nodes, stem diameter (cm), length of internodes (cm) and number of primary branches. Plant height was measured from the base of the plant to the highest shoot.

Samples of the harvested tubers for each of the three cassava varieties were submitted to the Food Safety and Technology Laboratories of the Department of Marine Resources for analyses. The raw cassava pulp was processed, then analysed for biochemical and mineral composition and the values expressed on a dry matter basis. Quality characteristics measured included, moisture, dry matter, crude fat, ash, sodium, potassium and total salt.

Methods Used in Analysis of Cassava (Based on A.O.A.C., 1995):

Moisture/Dry Matter - Tubers were peeled, wiped and chopped into small pieces. Triplicate 2g samples were accurately weighed into pre-labelled, pre-weighed dishes and were dried at 130°C to constant weight. Dried samples/dishes were weighed. Moisture content (%) was calculated. Dry matter (%) was calculated by 100 – Moisture content (%).

Other Analyses - Samples were peeled, wiped, chopped and dried in oven. The dried samples were subsequently powdered in a high-speed blender and used for the remainder of the tests.

Ash - Triplicate prepared samples were weighed into pre-weighed, porcelain crucibles. The samples were transferred to a muffle furnace and ashed at 550°C for 8 hours. The crucibles were allowed to cool in desiccators and then weighed. Percentage ash content was calculated.

Fat - Fat determination carried out by the acid hydrolysis method. 8g samples were weighed in triplicate and digested in acid. The digests were transferred to Monjonnier flasks where the fat was extracted with ethers. The ether extract was transferred into previously dried and weighed flasks and the ethers evaporated and the remaining fat dried and weighed and the % fat calculated.

Salt - Determination using the Volhard method where sample was treated with $AgNO_3$, wet ashed and the excess $AgNO_3$ back titrated with KSCN using $FeNH_4(SO_4)_2$ as indicator.

Sodium and Potassium - Aqueous solutions of ashed samples were aspirated directly into a Cole-Parmer Model 2655-00 flame analyzer. Intensity was compared against a prepared standard curve.

Statistical Analyses:

All experimental results were analysed using Instat+™ and ASSISTAT. Instat is an interactive statistical package, copyright © 2006, Statistical Services Centre, University of Reading, UK. All rights reserved. ASSISTAT, Version 7.6 beta (2011), website – http://www.assistat.com, by Fransisco de Assis Santos e Silva, Federal University of Campina-Grande City, Campina Grande, Brazil.

Results:

The three cassava varieties were evaluated for their morphological characteristics (Table 4) and tuber yield on the calcareous soils of The Bahamas. Stand establishment was very good for the experimental plots. There were no visible signs of harmful pests or diseases on the leaf, stem or root parts during the period of this experiment. There was some loss of foliage during the cooler months from November 2010 to February 2011, but this had no adverse effect on tuber yields. Indeed, there is a reduction in the rate of leaf production and root dry weight at temperatures lower that 17ºC (Alves, 2002), but other researchers (Irikura *et al.*, 1979) have found that the same cassava variety yields well over a wide range of temperatures, indicating that the effect of natural selection is highly significant on varietal adaptation.

These varieties were distinguished from each other on the basis of their leaf, stem and tuber characteristics. A wide range of variation was encountered in the characteristics of the three cassava varieties in this study. The cassava variety ‘Blue Mountain’ had a dark brown storage root surface colour with a white flesh and pink cortex. The variety ‘Cuban White Stick’ displayed a white fleshed tuber with a tan storage root surface and pink cortex. ‘John LaMotte’ was characterised as a white fleshed tuber with a dark brown storage root surface colour and a cream coloured root cortex.

Table 4. Characteristics observed of three cassava varieties after 10 months of cultivation.

PLANT DATA	**VARIETY**		
	Blue Mountain	**Cuban White Stick**	**John LaMotte**
Colour of first fully expanded leaf	green-purple	green-purple	dark green
Shape of central leaf lobe	elliptic	oblanceolate	linear
Colour of unexpanded apical leaves	green-purple	green-purple	green-purple
Pubescence of young leaves (newly formed in the transitional stage)	sparse	dense	dense
Petiole colour	green-red	green-purple	green-purple
Stem colour (observed between 50-100 cm from ground level)	dark brown	silver	light brown
Storage roots per plant	8	3	7
Storage root pulp colour (observed immediately after being cut open)	white	white	white
Storage root surface colour	dark brown	tan	dark brown
Colour of outer surface of storage root cortex	pink	pink	cream

Each of the three roots (Plate 1) displayed a different type of attachment of the main roots to the base of the stem. The roots of ‘Blue Mountain’ were sessile, or attached directly to the stem with little or no peduncle. The variety ‘Cuban White Stick’ was pedunculate, having long root peduncles joining the root to the stem, while ‘John LaMotte’ was a mixture of sessile and pedunculate, with both types of stem to root attachment. The texture of the root epidermis in both ‘Blue Mountain’ and ‘John LaMotte’ were rough, while ‘Cuban White Stick’ exhibited a smooth texture.

a b c

Plate 1. Freshly harvested roots of three cassava varieties: (a) ‘Blue Mountain’ smaller, more uniformly sized tubers (sessile), (b) ‘Cuban White Stick’, less tubers, larger and more uniform in size (pedunculate), (c) ‘John LaMotte’ displayed more variation in tuber sizes (mixed).

The analysis of variance test performed revealed significant differences between the three varieties for all root yield responses measured. Analysis of the data (Table 5) showed a statistical significance of 1% level of confidence for the root measurements.

Table 5. Analysis of variance (ANOVA) for total tuber weights, total number of tubers, tuber length, marketable weights and number of marketable tubers among three cassava varieties. Standard error is for each treatment mean. Error mean square has 119 df. *, ** and *** denote statistical significance at 5, 1 and 0.1% level of confidence, respectively. NS indicates differences between means not significant.

		--------------------------------------*Significance levels*--				
Source	df	Total tuber weights/plant (kg)	Total number of tubers/plant	Tuber length (cm)	Marketable weights/plant (kg)	Number of marketable tubers/plant
Varieties	2	**	**	**	**	**
Error	117					
Std. Err		**0.1**	**0.3**	**1.2**	**0.1**	**0.2**

Root yields were determined by the length, weight and number of storage tubers produced per plant. The roots were separated into marketable and unmarketable tubers, depending upon size and weight. Table 6 displays the mean root yield responses for the three cassava varieties. Total tuber yield of the varieties ranged from 3.43 kg per plant for ‘John LaMotte’ to 2.24 kg per plant for ‘Cuban White Stick’. Of the three cassava varieties, ‘John LaMotte’ also had the highest number of marketable tubers per plant and the highest marketable weights per plant. ‘Cuban White Stick’ produced the longest tubers of all three cassava varieties and had the highest weight per tuber, though this variety had far less tubers per plant.

Table 6. Mean values of root yield responses assessed 10 months after planting three cassava varieties.

Variety	**Total tuber weights/plant (kg)**	**Total number of tubers/plant**	**Tuber length (cm)**	**Marketable weights/plant (kg)**	**Number of marketable tubers/plant**
Blue Mountain	2.56b	7.78a	25.85c	2.21b	5.03b
Cuban White Stick	2.24b	3.30b	40.46a	2.14b	2.55c
John LaMotte	3.43a	7.55a	32.58b	3.22a	6.15a

The t-test at a level of 5% probability was applied. Means with different letters differ significantly.

The growth performance of the stem characteristics were analysed (Table 7), showing significant responses to the yield parameters among the three cassava varieties. Plant height, number of nodes, stem diameter and number of primary branches were significant at the 1% level of confidence, while internode length was significant at the 5% level.

Table 7. Analysis of variance (ANOVA) for plant height, number of nodes, stem diameter, length of internodes and number of primary branches. Standard error is for each treatment mean. Error mean square has 119 df. *, ** and *** denote statistical significance at 5, 1 and 0.1% level of confidence, respectively. NS indicates differences between means not significant.

		---------------------------------------*Significance levels*---				
Source	df	Plant height (cm)	Number of nodes/plant	Stem diameter (cm)	Internode length (cm)	Number of primary branches/plant
Varieties	2	**	**	**	*	**
Error	117					
Std. Err		**3.2**	**2.4**	**0.1**	**0.1**	**0.1**

The mean values for the stem characteristics measured are displayed in Table 8. The number of nodes per plant was highest in the shortest cassava variety, 'Blue Mountain', while the tallest cassava variety, 'Cuban White Stick', recorded the least number of nodes. The taller varieties 'Cuban White Stick' and 'John LaMotte' had a lower number of primary branches than the shorter cassava variety 'Blue Mountain'. Stem diameter for these two varieties were also significantly thicker than 'Blue Mountain' which displayed an early branching pattern.

Table 8. Mean values of stem yield responses assessed 10 months after planting three cassava varieties.

Variety	Plant height (cm)	Number of nodes/plant	Stem diameter (cm)	Internode length (cm)	Number of primary branches/plant
Blue Mountain	206.0b	66.18a	3.22b	4.24a	3.53a
Cuban White Stick	241.0a	41.20b	3.81a	4.31a	1.73b
John LaMotte	234.1a	62.28a	3.75a	3.64b	2.28b

The t-test at a level of 5% probability was applied. Means with different letters differ significantly.

Table 9 presents a summary of measurements for the proximate analyses of the raw pulp taken from freshly harvested roots of the three cassava varieties evaluated. Dry matter content ranged from 41.1% in 'John LaMotte' to 46.3% in 'Blue Mountain'. The mean values of sodium (mg/100g), were 49.9 for 'Cuban White Stick', 40.0 for 'John LaMotte' and 36.2 for 'Blue Mountain'. The values for potassium (mg/100g) were 861.2 for 'John LaMotte', 758.6 for 'Cuban White Stick' and 730.3 for 'Blue Mountain'. The ash content varied from 0.98% for 'Cuban White Stick' to a high of 1.15% for 'John LaMotte'.

Table 9. Proximate analyses of the raw pulp taken from the tubers of three cassava varieties.

VARIETY	ASH %	MOISTURE %	SODIUM (MG/100G)	POTASSIUM (MG/100G)	DRY MATTER %	FAT (CRUDE) %	SALT %
Blue Mountain	1.07	53.7	36.2	730.3	46.3	0.30	0.16
Cuban White Stick	0.98	55.8	49.9	758.6	45.2	0.45	0.07
John LaMotte	1.15	58.9	40.0	861.2	41.1	0.15	0.10

As the protein content of the three cassava varieties was not analysed in this experiment, it was determined from published values. The literature shows a tremendous variation in the protein content of cassava (Nassar and Dorea, 1982; Buitrago, 1990; Ceballos *et al.*, 2006; Nassar and Sousa, 2007; Rojas *et al.*, 2007; Sankaran *et al.*, 2008; Sarkiyayi and Agar, 2010). From these various sources, a reasonable estimate of the crude protein content for cassava was calculated to be around 2.2%. This value was used to calculate the total carbohydrate content of the three cassava varieties, by difference, using the formula (FAO, 2003):

100 - (weight in grams [protein + fat + water + ash + alcohol] in 100 g of cassava).

The alcohol content was assumed to be negligible, as there was not expected to be any chemical conversion of sugars within the freshly harvested raw pulp. The estimated total carbohydrate contents are shown in Table 10. These values are well below those reported by Ziska *et al.* (2009), whose study showed total carbohydrate concentrations of cassava to be about 55%, but are superior to those of Adepoju and Nwangwu (2010), whose research estimated cassava carbohydrate content to be 32.6%.

Table 10. Estimated total carbohydrate content of three cassava varieties

VARIETY	TOTAL CARBOHYDRATE %
Blue Mountain	42.7
Cuban White Stick	40.6
John LaMotte	37.6

Discussion:

Differences in cassava tuber yield are determined by several factors, such as number of tubers, tuber length and tuber weight. Ntawuruhunga and Dixon (2010) concluded that storage root number, storage root size and storage root diameter were the main yield components contributing to yield enhancement in cassava. The highest tuber yield per plant was recorded by 'John LaMotte', (3.43 kg) followed by 'Blue Mountain' (2.56 kg), while 'Cuban White Stick' was the lowest at 2.24 kg. It should be noted that although the highest number of tubers was observed in the variety 'Blue Mountain' it had a significantly lower weight of marketable roots per plant than 'John LaMotte'. This lower tuber weight per plant in the variety 'Blue Mountain' could be a result of competition between the roots during root filling. This data supports the determination by Hayford (2009), whose research showed that a negative correlation existed between number of tubers per plant and tuber mean weight of cassava.

The cassava variety 'John LaMotte' presented the highest mean yields of marketable tubers per hectare (Fig. 1) at 22.9 t/ha compared to 'Blue Mountain' at 17.1 t/ha and 'Cuban White Stick' at 14.9 t/ha. According to FAOSTAT estimates, the average yield in 2009 for cassava growing regions of the world was 12.6 t/ha, which is well below the results obtained by this study, under experimental conditions. These results demonstrate that under improved agronomic practices, increases in tuber yields can be obtained from cassava.

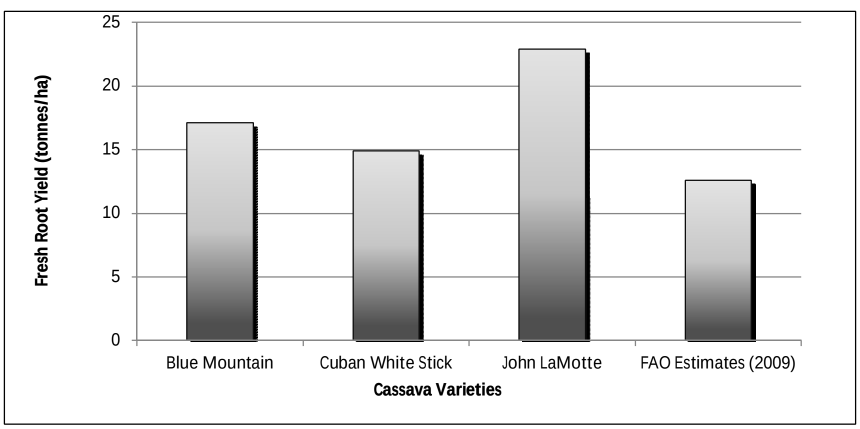

Fig. 1. Average fresh root yields of three cassava varieties evaluated at the Gladstone Road Agricultural Centre during 2011. FAO yield estimates for the cassava growing regions of the world in 2009 are found in the column at far right.

The cassava variety 'Cuban White Stick' produced a small number of large tubers which were uniform in size. It might be a more efficient plant in accumulating carbohydrates in storage roots. The roots were well formed, smooth and without surface defects. The ease of harvest and uniformly sized tubers of this variety might make it attractive to farmers and consumers alike.

A correlation has been established between length of internodes and yield by Sankaran *et al.* (2008), who discovered an inverse relationship between internode length and yield. Their findings support the results of this experiment, where the cassava variety with the shortest internode length, 'John LaMotte', gave the highest yields. The variety 'Cuban White Stick', on the other hand, had the longest internode length with the least number of nodes and the lowest tuber yields. This is similar to results of Ntui *et al.*, whose study showed that cassava varieties that produced longer internode lengths and longer stems had fewer tubers per plant. The larger number of primary branches found in the shortest variety 'Blue Mountain' makes up for the height advantage of the other two varieties. It is expected that 'Blue Mountain' will result in a larger number of stem cuttings suitable for propagation than 'Cuban White Stick' or 'John LaMotte', due to its growth habit which generates a larger number of primary branches.

Dry matter content of cassava is affected by a number of factors such as age of plant, season, location of planting and variety. The dry matter contents for the three cassava varieties were at the high range of values reported by Chávez *et al*. (2005), who screened roots from 2,457 genotypes, comprising landraces and improved clones, for their nutritional and agronomic traits. Dry matter contents for their research recorded values ranging from 10.7% to 57.2%, with an average of 34.7%. The variety 'John LaMotte', which exhibited the highest tuber weights, had the lowest dry matter content. Both 'Blue Mountain' and 'Cuban White Stick' had significantly lower tuber weights with higher dry matter contents than 'John LaMotte'. Ntawuruhunga *et al*. (2001), and more recently Adeniji *et al*. (2011), reported similar results on the relationship between dry matter content and storage tuber weights. Dry matter content was significantly negatively correlated with storage root weight, suggesting that when the storage root weight is high, the dry matter content tends to be low.

The mineral composition of the three cassava varieties revealed an appreciable amount of potassium and sodium when compared to those of Rojas *et al*. (2007), whose mineral contents of six cassava varieties averaged 623mg/100g for potassium and 30mg/100g for sodium. The percentage ash content, which gives an indication of the total mineral content of the three cassava varieties, is comparable to that of Wheatley *et al.* (1995) who reported ash contents within a range of between 0.5 and 1.5% of dry matter.

General Comments:

Cassava is an ideal crop to integrate into the crop production system of local farmers. This study suggests that the three varieties can effectively compete under the soil and environmental conditions of The Bahamas. A wide range of cassava types will give the farmer the opportunity to choose the cassava best suited to his growing conditions. This study showed that great variability exists among the morphological root and stem characteristics of the three varieties. The morphological characteristics presented in this study will assist farmers in the identification of these varieties. Tuber yield can be improved through selection based upon yield components, in particular, plant height, tuber number and tuber size (Aina *et al*., 2007, Akinwale, *et al.,* 2010). The selection of cassava types with good plant height and good branching habit will facilitate cultivation and harvesting operations, and also provide quality planting material at the end of the harvest.

It has been shown from this study that the mineral and other food compositions are comparable to those found in documented studies. The results reveal that the three cassava varieties, in particular 'John LaMotte', are nutritionally rich in potassium. 'John LaMotte' also had a higher percentage ash content than the other two varieties, suggesting a high mineral content. The cassava can therefore be considered as an important food source along with other foods. Additional analyses, such as crude protein content, were not included in this study as the required equipment at the Food Safety and

Technology Laboratories was not functioning at the time of this study. According to the literature, the protein content varies tremendously from variety to variety. For this reason it is important to do the actual analysis for protein, in addition to the analysis of crude fibre and total carbohydrate contents, for a more definitive interpretation of the performance of the three cassava varieties.

The root characteristics of the cassava play an important role in its acceptability to consumers. When recommending cassava varieties to farmers, the Department of Agriculture's root crops programme must consider not only the tuber yield performance, but must also take into account quality characteristics. Quality characteristics may be more difficult to assess objectively, however, as they relate to features such as appearance, colour, taste and texture.

The results show differences in the responses of the cassava varieties to the parameters measured, an indication that these traits are dependent on the variety. It is therefore critical that cassava varieties are evaluated to assess their potential. Additional research is also necessary, with respect to the feasibility of cassava production. The introduction and evaluation of new cassava varieties can improve the productivity of local farmers through increased tuber and stem yields, with a minimum of financial and labour inputs.

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