Agricultural Journal 2 (5): 613-616, 2007

Studies on Variation in Physical Characters and Chemical Components of Cassava (*Manihot esculenta* Crantz) Tubers

Zira Sunday Peter
Department of Chemistry, Adamawa State University, P.M.B. 25 Mubi, Nigeria

Abstract: Field evaluation and laboratory analysis of the physical and chemical components of cassava tubers was carried out. Significant differences ($p<0.05$) were recorded among the cassava clones for number of tuber/plant, percent dry matter, percent starch, root width, root length and percent ash. This suggests the magnitude of inherent variation among the cassava clones. The number tuber/plant and tuber yield were high in 92/0067. Percent ash content of the cassava tubers was maximum (2.41) (92/0067, 92/0057) A positive correlation coefficient between percent dry matter and dry matter yield, percent starch and percent ash suggests a complementation among there characters, Conversely a negative correlation coefficient in the association between percent dry matter, tuber/plants, tuber yield/plant and percent fibre may suggest an independent association among these characters in selection process is expected. The first four principal axis recorded eigen values greater than 1.00. They altogether summarized 65% of observed variation. Characters of importance in principal axis 1 are percent starch, percent dry matter and dry matter yield. Principal axis 2 was described by chemical components of the tubers. While principal axis 2 was described by the physical attributes of cassava tubers. The stepwise multiple regression analysis for tuber yield/plant returned tuber/plant as most important for dry matter yield. The study highlighted the magnitude of variation among cassava tubers for physical and chemical components, irrespective of the time of sampling (6 months or 9 months after planting).

Key words: Cassava tubers, percent ash, percent fibre, step wise multiple regression, variation

INTRODUCTION

Cassava (*Manihot esculenta Crantz*) is a major staple food in the sub-Saharan African (Nweke, 1996). Cassava is grown in the area between the latitudes 30°N and 30°S (IITA, 2001). Cassava tolerates hot climate, but a critical point exist between a daily average temperature of 18 and 20°C, below which the plants do not grow normally and the yields decrease rapidly (IITA, 2001). Nigeria produces 39 million tonnes annually (CBN, 2003). The potential of this crop has been emphasized in literatures. Studies on the adaptability of cassava clones to varying climatic conditions had been noted. However, when the mean temperature is less than 20°C, no data had been presented on the reaction of different clones to reduced temperature. The cassava tubers form one of the major staple foods in the world and its cultivation is on the rise in most parts of tropical Africa (FAO, 2005). Cassava will continue to assume greater importance with time as a major source of carbohydrate for human consumption in the tropics and subtropics, where the low per capital income will not permit a change in dietary habits (Akparobi *et al*., 2006).

Two broad consumption patterns for cassava are either in the fresh form or dry form (Sanni, 1994; Odogola, 1994). In the fresh form, cassava may be eaten raw in small quantities as snack and may be boiled, roasted or fried with a variety of sauces. The dry form involves peeling of the roots, chipping, slicing, pounding, drying and grinding to obtain cassava meal. Human being exhibit distinct patterns in selection of cassava's food, colour of tuberous root is economically important for cassava variety which the people will like (Akparobi *et al*., 2006). Most traits such as colour is necessary to be evaluated using subjective estimates (Akparobi *et al*., 2006). There is little documented evidence to indicate changes in biochemical parameters (colour, ash, fibre) of improved IITA genotypes and local landraces of cassava to contracting agro-ecological zones of Nigeria.

The cultivation of cassava in Adamawa State, Nigeria is limited (Adeniji and Odo, 2006). Farmers plant local clones in small scale and background farms. However large scale production is limited. This development is due to a non availability of improved cassava clones, most farmers are not aware of management practices, cultivation, processing and utilization techniques. Information on the physical characteristics and chemical components of cassava roots grown in this environment is limited. The availability of which will assist in improving the nutritional status of the communities and provide information necessary for research and development in this environment.

Objectives of this study are:

- To evaluate the magnitude of variation among physical characters and chemical components of cassava roots.
- To determine association among physical characters and chemical components of cassava roots.
- To discriminate among cassava clones using physical characters and chemical components of the roots.

MATERIALS AND METHODS

Twelve cassava clones and one local variety (Table 1) were sourced from the germplasm collection of International Institute of Tropical Agriculture, Ibadan and farmers collection, respectively. The clones for IITA have been developed for high root yield, tolerant to pests and diseases. The twelve clones were planted for evaluation at the Teaching and Research Farm located in Mayo Bani, ((Lon. 13°E, Lat. 10.1°N 879 m above sea level) in 2006 planting season

Field experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each plot consists of 6 ridges of 6 meters long and spaced 1 meter apart. Cassava cuttings of 25cm long were planted in a slanting position at 1 meter apart. A total of 36 stands were established per plot. Agronomic activities as weeding and earthing-up were carried out as at when due. At 6 and 9 months after planting, cassava clones were harvested, root characters and quality characters were evaluated. The number of tuber yield/plant was determined by counting the number of tubers produced by each plant of 6 months and 9 months after planting. Thereafter the root yield/plant was computed. Root length and width were measured on the longest and widest points on the roots. The laboratory determination of dry matter content was done by taking 200 g sample of freshly harvested cassava roots, which were oven dried at 60°C, until a constant weight was obtained (after 48 h).

Table 1 List of cassava clones evaluated

Serial number	Clones	Place of collection
1	4(2)1425	IITA
2	97/4763	,,
3	92/0057	,,
4	91/02324	,,
5	Tms 30572	,,
6	TME 419	,,
7	96/1632	,,
8	98/0510	,,
9	92/0067	,,
10	92/0326	,,
11	95/0289	,,
12	97/2205	,,
13	Local	Local farmers

For determination of colour, fresh roots were taken to the laboratory. Samples were assigned label using metal plate for easy identification and later put in cloth bags and cooked for 2 h at 100°C. The colour was determined using 1-3 scale, where 1 = white or creamy; 2 = slightly yellow, 3 = deep yellow. The cassava tubers were analyzed for proximate composition according to AOAC (2000). The percent starch was computed using IITA, formula

$$Y = - 2.8082 + 0.8679X$$

Where Y = starch

X = % dry matter.

Also the dry matter yield for each clone was determined as the ratio of fresh weight/dry weight multiply by 100.

Data collected were summarized and subjected to statistical analysis using SAS software (SAS, 1998) for generalized linear model (PROCGLM). The association analysis and principal component analysis for multivariate evaluation were done. While the contribution of characters to tuber yield/plant and dry matter yield were analyzed using the multiple regression analysis.

RESULTS AND DISCUSSION

As shown in Table 2, significant differences ($p<0.05$) was recorded among the cassava clones for number of tuber/plant, percent dry matter, percent starch, root width, root length and percent ash. This suggests the magnitude of inherent variation among the cassava clones evaluated, thus providing basis for selection and genetic improvement for this environment. A non-significant difference recorded for percent crude fibre is a clear indication of little or no variation among the cassava clones evaluated. Significant difference ($p<0.05$) for the sampling periods (6 and 9 months) as observed for number of tubers/plant suggest a variation in the tuber number among the months of evaluation. However, the number of tubers might have increased or reduced among the sampling periods. The dry matter yield and tuber yield/plant are the most variable characters among others evaluated. Variation was least for percent ash content. This provides that exploiting the magnitude variation as found for tuber yield/plant and dry matter yield could assist in development of improved varieties.

The mean values characters that described the cassava roots (Table 3) showed that the number tuber per plant presented a variation between 5. 00 tubers in the local variety and 14 tubers/plant in 92/0067. Similarly the tuber yield (kg) was maximum in 92/0067. The percent ash content of the roots presented a range between 28.19 (92/0067) and 38.07 (Danwari). The root width as

Table 2: Mean square values of the physical attributes and chemical components of cassava roots

	df	Tub/plant	Percent dm	Dmyld	P Starch	Root W	Pcfb	Rtl	Pcash	Rtl
Genotype	11	41.58**	79.14**	1653.52**	74.82**	57.43**	0.0002^{ns}	556.23**	0.0009**	
Months	1	22.22**	4.72^{ns}	19.11^{m}	3.5^{m}	68.08	0.0001^{m}	0.001	0.0001	
Replication	2	2.00	3.62^{m}	131.7	4.37^{m}	0.0001	0.0001^{m}	91.72**	0.0006**	
Mean		10.00	43.98	46.07	34.37	9.86	0.41	29.53	2.41	
R^2		0.53	0.39	0.36	0.44	0.51	0.20	0.85	0.52	
CV		27.68	11.23	52.40	12.51	37.22	3.65	14.86	0.24	

Tub/plant= Tuber yield/plant, Percent dm= percent dry matter, Dmyld= Dry matter yield, P Starch = Percent starch, Root W = Root Width, Pcf =Percent, Pcfb= Percent fibre content, Rtl = Root length, Pc ash = Percent ash

Table 3: Mean values for physical attributes and chemical component of cassava tubers

Genotypes	Tub/plant	Tub/kg	Rt Cobfk	Rt Cola Ck	Pdm	dmyld	Pcstarch	Rtw	Rtl	Pcfibre	Pc ash
67	14^{a}	2.7^{a}	571.00^{a}	1.0^{b}	37.84^{d}	37.57^{bcd}	28.19^{d}	11.67	29.0^{cde}	0.43^{a}	2.40^{ab}
1632	12.5^{ab}	1.60^{b}	1.0^{a}	1.0^{b}	33.34^{d}	$73.3a^{a}$	36.64^{abc}	9.67	45.33^{a}	0.41^{ab}	2.40^{b}
57	12.0^{ab}	1.51^{b}	1.0^{a}	1.0^{b}	37.84^{d}	57.00^{abc}	32.21^{cde}	16.97	34.17^{cb}	0.41^{ab}	2.41^{a}
1425	11.83^{abc}	1.34^{bc}	1.0	1.0^{b}	46.06^{abc}	$57.6c^{abc}$	36.87^{abc}	9.55	30.34^{cd}	0.41^{ab}	2.40^{b}
4763	11.16^{abc}	1.33^{bc}	1.0	2.00^{a}	39^{dc}	47.66^{abc}	28.32^{d}	7.96	26.33^{def}	0.41^{ab}	2.40^{b}
2394	10.67^{abcd}	1.21^{bc}	1.0	1.0^{b}	33.8^{dc}	33.18^{bcd}	31.38^{cd}	11.38	57^{b}	0.42^{ab}	2.40^{ab}
289	10.17^{bcd}	1.05^{cd}	1.0	1.0^{b}	46.61^{ab}	13.91^{a}	37.47^{ab}	10.50	30.67^{cd}	0.4^{ab}	2.40^{ab}
2205	9.89^{bcd}	1.04^{cd}	1.0	1.0^{a}	45.99^{abc}	55.61^{abc}	36.04^{abc}	7.40	24.33^{ef}	0.39^{b}	2.40^{ab}
30572	8.5^{cde}	0.98^{cde}	1.0	1.0^{a}	45.05^{abc}	38.65^{bcd}	36.03^{abc}	10.70	32.0^{bc}	0.41^{ab}	2.40^{ab}
419	8.0^{def}	0.81^{def}	1.0	1.0^{a}	49.99^{a}	54.49^{abc}	37.29^{ab}	17.13^{a}	33.0^{bc}	0.41^{ab}	2.41^{a}
510	6.3^{de}	0.63^{ef}	1.0	1.0^{a}	42.70^{bcd}	61.06^{ab}	34.01^{abc}	8.83	34^{cb}	0.42^{a}	2.40^{ab}
Local	5.0^{f}	0.56^{f}	10	1.0^{a}	47.02^{ab}	13.91^{d}	38.07^{a}	2.57	6.33^{g}	0.41^{ab}	2.41^{a}

Rt Cobfk= Root colour before cooking, Rt Cola Ck=Root colour after cooking, Tub/plant= Tuber yield/plant, Percent dm= percent dry matter, Dmyld= Dry matter yield, P Starch = Percent starch, Root W = Root Width, Pcf =Percent, Pcfb= Percent fibre content, Rtl = Root length, Pcash = Percent ash

Table 4. Correlation coefficients among physical attributes and chemical compositions of cassava tubers

	Tub_pl	TubYkg	Rt coafck	Pdm	dmyld	Pstarch	RtW	RtL	Pcfib	Pc ash
Tub/pl	1.00									
TubYkg	0.27	1.00								
Rtcoafck	0.13	-0.28	1.00							
Pdm	-0.13	-0.10	-0.20	1.00						
Dmyld	-0.05	-0.26	0.008	0.31	1.00					
Pstarch	-0.17	-0.05	-0.36	0.92	0.27	1.00				
RtW	0.08	0.05	-0.15	0.07	-0.09	-0.001	1.00			
RtL	0.03	0.16	-0.13	0.03	0.01	0.09	0.33	1.0000		
Pcfib	0.19	0.007	0.01	-0.17	-0.31	-.017	-0.06	-0.0827	1.00	
Ash	-0.13	0.03	-0.16	0.10	0.005	0.08	0.07	-0.1286	-0.24	1.00

Rt Cola Ck=Root colour after cooking, Tub/plant= Tuber yield/plant, Percent dm= percent dry matter, Dmyld= Dry matter yield, P Starch = Percent starch, Root W = Root width, Pcf =Percent, Pcfb= Percent fibre content, Rtl = Root length, Pcash = Percent ash

evaluated among the cassava clones high in 92/0067, 92/0057 and TME 419. While 91/02324 recorded the longest roots among the cassava clones evaluated. The percent ash content of the cassava roots ranged between 2.41 (92/0067, 92/0057) and 2.40 (in the remaining clones). The laboratory analysis of percent fibre content of the tubers was 41% in seven clones, 42% in 91/02324 and 98/0510; 43% in 92/0067. The close estimates of these mean values must have accounted for a non significant difference recorded for percent ash and fibre content.

Association analysis among the physical characters and chemical components of cassava tubers (Table 4) showed a positive correlation coefficient between percent dry matter and dry matter yield, percent starch and percent ash. This suggests a complementation among there characters, whenever improvement is desirable for dry matter yield and ash. Similarly, the dry matter yield correlated positively with percent starch. Conversely a negative correlation coefficient recorded in the association between percent dry matter, tuber/plants, tuber yield/plant and percent fibre may suggest an independent association among these characters is expected in selection process. In addition percent fibre content of the tuber recorded a negative correlation coefficient with percent starch, root width, root length and percent ash. The foregoing provides that whenever improvement is desirable for fibre content of the tubers, expectedly the percent starch, root width, root length and percent ash content may decrease. The analyses revealed that long and wider cassava roots is not a necessary condition for high starch and ash content in the tubers. A short cassava tuber may contain a high percentage of starch and ash as compared with longer roots. This is sequel to a negative correlation coefficient among these variables.

The Principal Component Analysis (PCA) performed on the data, generated eleven principal axis with eigen values that varied between 0.01 and 2.43 (Table 5). The first four principal axis recorded eigen values greater

Table 5: Eigen values and percentages of total variation accounted for by the first principal component axis of administration of Cassava roots

Principal axis	Latent root	Total variation Accounted (%)	Cumulative (%)
1	2.43	24	24
2	1.67	17	40
3	1.23	12	53
4	1.18	11	65
		Eigen vectors	
	Prin 1	Prin 2	Prin 3
Tub/pl	-0.22	0.23	0.36
Tub/kg	-0.09	0.53	-0.12
Rtcoafk	-0.27	-0.42	0.19
Pdm	0.56	0.01	0.25
dmyld	0.31	-0.29	0.19
Pcstarch	0.58	0.06	0.22
Rtw	0.06	0.43	-0.01
Rtl	0.08	0.43	0.23
Pcfibre	-0.28	0.07	0.36
Pcash	0.17	0.00	-0.69

Table 6: Stepwise multiple regression analysis indicating the contributions of some characters to dry matter yield and Tuber/plant

Variable	No. In	Partial R^2	Cumulative (%)
	Tuber yield/plant		
Tuber/plant	1	0.10**	10
Root colour after cooking	2	0.08**	18
Dry matter yield	3	0.07**	25
	Dry matter yield		
Percent dry matter	1	0.10**	10
Percent fibre	2	0.07**	17
Tuber yield (kg)	3	0.06**	23

than 1.00. They altogether summarized 65% of observed variation. Principal axis 1 accounted for 24% of variation, while principal axis 2 summarized 17% of variation. Principal component axis 1 had the highest total variance and had almost all the characters correlated positively with it. Characters of importance in principal axis 1 are percent starch, percent dry matter and dry matter yield. Principal axis 2 was loaded largely by tuber yield (kg), root length and root width. This is a clear indication that principal axis was described by chemical components of the tubers. While principal axis 2 was loaded by characters describing the physical attributes of cassava tubers.

The stepwise multiple regression analysis for tuber yield/plant returned tuber/plant (10%), dry matter yield (6%) and root colour after cooking (8%) to have altogether summarized 25% of observed variation in tuber yield. Using the dry matter yield as dependent variable (Y), characters of importance are percent dry matter (10%), percent fibre (7%) and tuber yield (6%).

The study highlighted the magnitude of variation among cassava tubers for physical and chemical components. Irrespective of the time of sampling (6 or 9 months after planting), percent ash, fibre, starch, percent dry matter and dry matter yield had similar response. High mean values for tuber yield, percent dry matter, dry matter yield necessitate the desirability for further studies. The tuber yield/plant is of significant importance whenever selection is desirable for tuber yield. The study revealed that dry matter yield can be improved by selecting cassava roots with high percent dry matter.

ACKNOWLEDGEMENT

The author acknowledges with thanks Mr Adeniji, O.T., Department of Crop Science for providing samples and relevant information for this research.

REFERENCES

Adeniji, O.T. and P.E. Odo, 2006. Preliminary evaluation of variability for yield and yield components among cassava clones (*Manihot esculenta crantz*) in Adamawa State, Nigeria. In: Proceedings of the 31st Annual conference of the Genetics Society of Nigeria, pp: 11-16.

Akparobi, S.O., P.G. Eruetor and E.C. Enujeke, 2006. Screening cassava clones in two agro-ecological zones of Nigeria for tuberous root colour. Preceedings of the 31st Annual Conference of the Genetics Society of Nigeria, pp: 86-90.

AOAC, 2000. Association of Analytical Chemist. Official method of analysis. (17th Edn.), AOCA Inc. Arlingon, Virginia, USA.

CBN, 2003.Central Bank of Nigeria Annual Report and Statement of Accounts.

FAO, 2005. FAO Food Outlook, pp: 19-22.

IITA, 2001. Cassava IITA Crops. W://www.iita.org/crop/cassava

Nweke, F.I., 1996. Cassava Processing in Sub-Saharan Africa. Implication for expanding cassava production. IITA. Res., pp: 7-14.

Odogbola, W.R., 1994. A comparative study of solon and open sundrying of cassava chips in Uganda in proceeding of the ninth Tropical root and crops, Accra, Ghana, pp: 274-282.

Sanni, M.O., 1994. Gawl processing in Ibadan metropolis, factors controlling quality at the small scale level in proceedings of the ninth symposium of the international success by for tropical root and cops. Accra, Ghana, pp: 256-260.

SAS Institute, Inc., 1998. SAS user's guide statistics version 6, SAS institute Int. Raleigh, N.C. USA, pp: 956.