PLANT BREEDERS ASSOCIATION OF NIGERIA
HYBRID ANNUAL CONFERENCE, MAKURDI 2023

(ISSN: 3027-088X)

STORAGE ROOT YIELD AND RESPONSE TO MOSAIC VIRUS OF YELLOW CASSAVA VARIETIES SELECTED USING MOLECULAR MARKERS

Udemba I. O.
Institute of Agricultural Research and Training, Obafemi Awolowo University,
Moor Plantation, Ibadan, Nigeria.

Olasanmi B.
Department of Crop and Horticultural Sciences, University of Ibadan, Nigeria.

Correspondence: idowuibukunolu2012@yahoo.com

Abstract
As a contribution towards mitigation of malnutrition and food insecurity in Nigeria, some yellow root cassava varieties (YRCVs) are being developed at the University of Ibadan (UI), Nigeria. The new genotypes have been evaluated at early breeding stage to select the promising ones for evaluation at advanced stage. Hence, this study was carried out to evaluate selected UI Cassava (UIC) genotypes in two growing seasons for survival rate, response to Cassava Mosaic Disease (CMD), and yield performance. Fourteen UIC genotypes and a national check variety (TMS07/0593) were planted in two replications using spacing of 1m × 1 m. One month after planting (MAP) data were collected on survival rate while the plants were scored for response to CMD at 1, 3 and 5 MAP using a scale of 1-5 where 1 is resistant and 5 highly susceptible. Shortly before harvest, the genotypes were scored for plant architecture (Arch) using a scale of 1 to 5 where 1 represents no branching and 5 highly branching. At harvest (12 MAP), data were collected on number of roots per plant (Rt/plt), fresh storage root weight, above-ground biomass root quality (Rtqlt) and dry matter content. The raw data were used to estimate fresh storage root yield (FSRY), dry storage root yield (DSRY) and harvest index (HI) for each genotype. Data were subjected to descriptive statistics and analysis of variance at 5% level of probability. The percentage survival recorded ranged between 57.5 (TMS07/0593) and 100 (UIC-17-90 and UIC-17-750). Genotypes UIC-17-5, UIC-17-26, UIC-17-174, UIC-17-220, UIC-17-491, UIC-17-646, UIC-17-750 and UIC-17-1842 were resistant to CMD with severity score of 1. Significant genotypic effect was observed only for Arch, HI and DSRY. The scores for the cassava architecture ranged between 3 (UIC-17-90 and UIC-17-7) and 5 (TMS07/0593, UIC-17-265 and UIC-17-220). Meanwhile the least HI (0.43) and DSRY (2.9) were recorded in TMS07/0593 and UIC-17-2074, respectively while UIC-17-5 had the highest values for both parameters. Seasonal variation was only significant for HI and Rt/plt. The FSRY correlated positively with DSRY, HI and Rt/plt. However, CMD had a negative relationship with all the evaluated traits except survival rate and Rtqlt. The fresh storage root yield potential and root quality are comparable to the check variety. The UIC-17-90 and UIC-17-7 with moderate branching are recommended for intercropping while UIC-17-5 with highest DSRY will give higher product yield. These two traits are farmers' preferred traits and might therefore enhance their adoption coupled with their nutritional advantage.

Keywords: Cassava mosaic disease, University of Ibadan cassava, Varietal Development, Yellow root cassava varieties, Yield performance

Introduction
Cassava was first discovered in America, where native Indians cultivated it for roughly 4,000 years (Olsen and Schaal 2001). It propagation now spans throughout the tropics. Cassava starchy storage roots are highly valued for versatile food and industrial products production (Udemba *et*

al., 2023). However, yield of cassava have been limited by the incidence of cassava mosaic disease, with resulting yield loss of up to 100% in some instances (Thresh and Cooter, 2005; Owor *et al*., 2014). Thus, early research on cassava improvement focused on yield related traits and disease resistance which were of utmost interest to farmers (Njoku *et al*. 2011). In recent times, the prevalence of malnutrition and hidden hunger among cassava consumers (especially rural dwellers) sequel to its poor micronutrient content prompted research into cassava nutritional improvement through bio-fortification.

The successful bio-fortication of cassava in Nigeria resulted to the development and release of six yellow roots cassava varieties in 2011 and 2014 (IITA 2011 and 2014). These bio-fortified cassava varieties have enhanced total carotenoids contents (ranging between 6 and 10 µ/ g) which can combat vitamin A deficiency when consumed (Ayetigbo *et al*., 2018). The utmost target of cassava bio-fortification was to develop varieties with β-carotene content of about 15 µg/ g of fresh storage roots (CGIAR, 2013). This necessitated further research on improvement of cassava carotenoid content. Presently at the University of Ibadan (U.I.), some yellow root cassava varieties are being developed. Sequel to the fact that yield and disease resistance are key driver for cassava adoption by farmers and bio-fortification might have boomerang effect on yield potential and quality of cassava, evaluation of the new U.I. cassava (UIC) genotypes for the afore-mentioned farmers' premium traits is paramount. Some of the promising UIC genotypes were selected at the early breeding stage for fresh storage root yield, root colour, plant architecture and root quality. Molecular markers were also used to screen them for cassava mosaic disease and beta carotene. Therefore, this study was conducted to evaluate the yield performance and response to cassava mosaic disease of the selected UIC genotypes in two growing seasons at advanced breeding stage.

Materials and Methods

Fourteen UIC genotypes and a national bio-fortified variety (TMS07/0593) as check were planted at the Teaching and Research farm of the Department of Crop and Horticultural Science in 2021 and 2022 using a spacing of 1 m × 1 m**.** The experiment was laid using randomized complete block design and replicated twice. One month after planting (MAP) survival rate of the genotypes were estimated by expressing the number of sprouted stem cutting per plot as a percentage of the total number of planted cuttings per plot. Response of the plants to cassava mosaic disease were scored at 1, 3 and 5 MAP using a scale of 1-5 where 1 and 5 depicted highly resistant and highly susceptible, respectively. Prior to harvesting, the genotypes were scored for plant architecture (Arch) using a scale of 1 to 5 where 1 represents no branching and 5 highly branching. At harvest (12 MAP), data were collected on number of roots per plant (Rt/plt), fresh storage root weight, dry matter content, above-ground biomass and root quality (Rtqlt) on a scale of 1 to 5 where 1 represented genotypes with storage roots that were smooth, high uniformity in size, good form; and 5 storage roots that were wrinkled, curved, highly fibrous or woody part and high disparity in size. Subsequently, fresh storage root yield (FSRY), dry storage root yield (DSRY) and harvest index (HI) of each genotype was estimated using the raw data. Data were subjected to descriptive statistics and analysis of variance using SAS (9.0 version). Significant means were separated using Duncan Multiple Range Test at 5% level of probability.

Results and Discussion

Comparative evaluation of performance of developed genotypes in relation with existing varieties might reveal some advantages of the former over the later which can enhance subsequent adoption when released. The survival rate of the cassava varied with genotypes UIC-17-90 and UIC-17-750 recording highest percentage of 100 while the check variety (TMS07/0593) had least value of 57.5% (Figure 1).

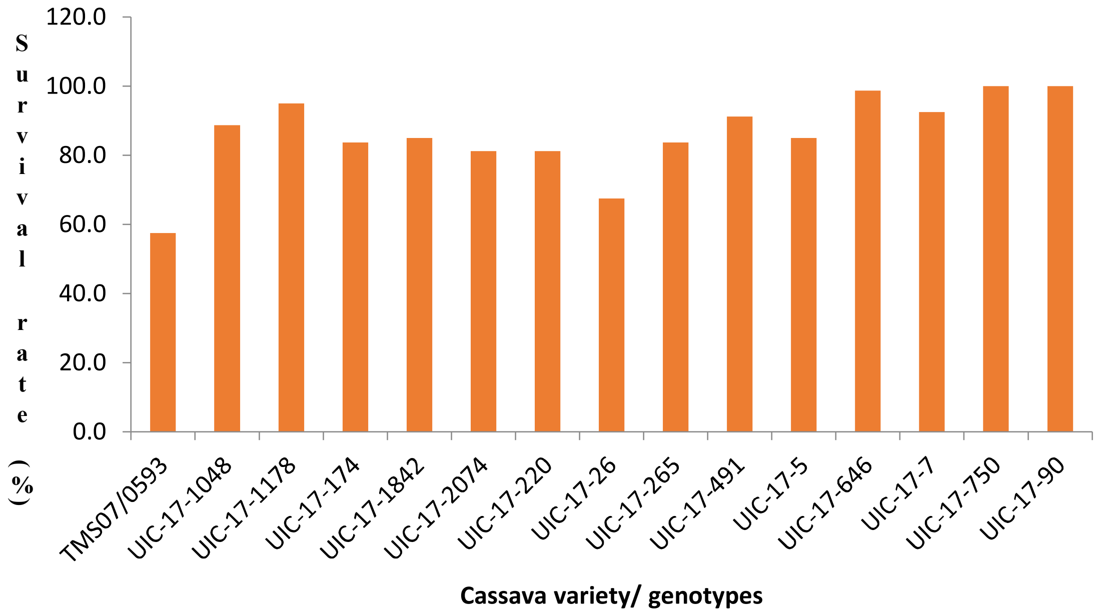

Figure 1: Survival rate (%) of some University of Ibadan cassava genotypes evaluated at the advanced breeding stage

This observation suggests that the cassava genotypes had different genetic capacities to withstand field stress which is consistent with the finding of Udemba (2023) while working on different cassava varieties including bio-fortified cassava varieties. Notably the rate of survival of all UIC was > 80% (with the exception of UIC-17- 26 which had 67.5%) and higher than percentage recorded for the check variety. This shows that the UIC genotypes had better vigour and were more adapted to the study area than the check variety. This result also highlights possibilities of their superior resilience to effect of climate change. The economic impact of CMD on cassava productivity has increased the interest in developing cassava varieties that are resistant to the disease in Nigeria (Owor *et al.*, 2014; Udemba, 2023). The result showing the response of the cassava genotypes to cassava mosaic disease is presented in Figure 2. Genotypes UIC-17-5, UIC-17-26, UIC-17-174, UIC-17-220, UIC-17-491, UIC-17-646, UIC-17-750 and UIC-17-1842 had severity score of 1 and were highly resistant to CMD. Meanwhile, score of 2 was recorded for UIC-17-265, depicting moderate resistant to CMD. The response of these 9 UIC genotypes to CMD was better than the check variety which had score of 3 and tolerant to the disease. Conversely, genotypes UIC-17-1178, UIC-17-2074 and UIC-17-7 with scores of 5 were highly susceptible to the disease. The cassava genotypes differed significantly only for Architecture, harvest index and dry storage root yield while seasonal variation was not significant for all evaluated traits except harvest index and number of roots per plant (Table 1).

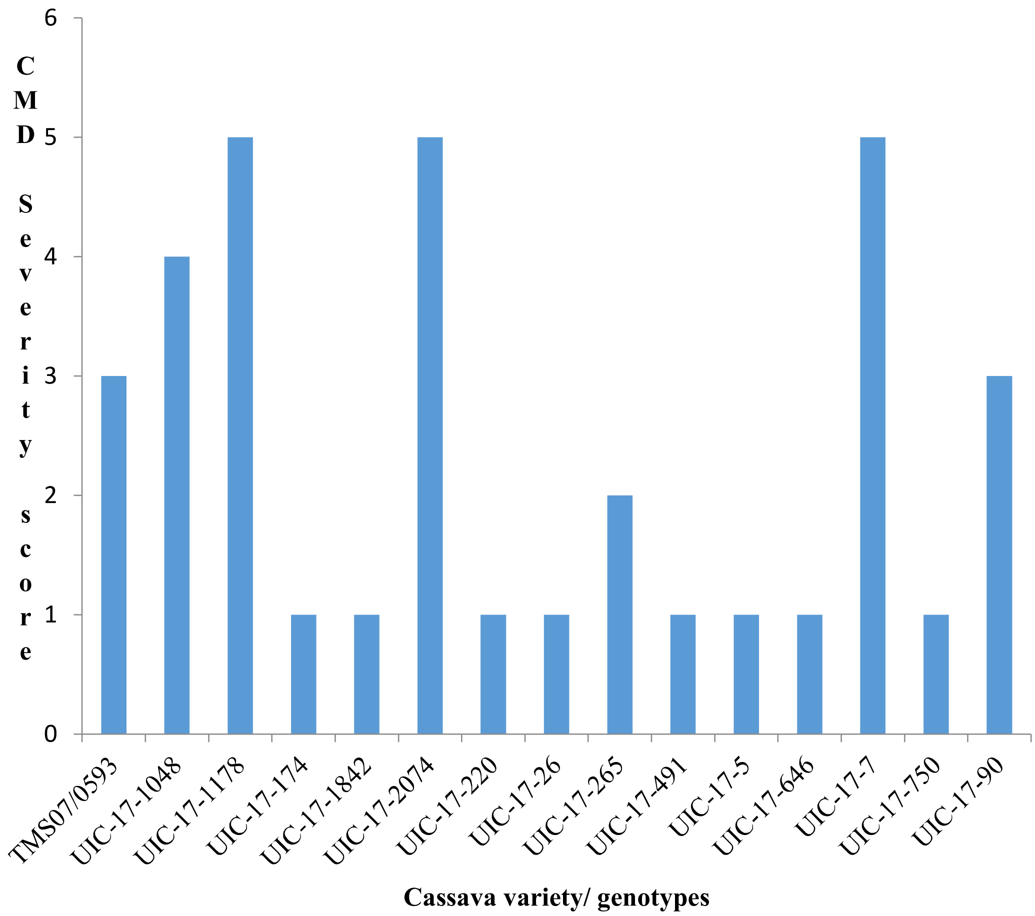

Figure 2: Cassava mosaic disease severity scores for some University of Ibadan cassava genotypes evaluated at the advanced breeding stage

Genotypes UIC-17- 7 and UIC-17-90 produced few branches and had the least score of 3 for plant architecture which was only significantly comparable with score of 3.74 recorded for UIC-17-2074 (Table 2). These UIC genotypes with moderate branching system will support intercrop, which is the dominant farming system in south-west of Nigeria (Amujoyegbe and Alabi, 2012). However, genotypes UIC-17-220 and UIC-17-265; and the check variety branched profusely and had score of 5. The score of 5 was statistically at par with scores obtained from other genotypes with the exception of UIC-17-491 (4), UIC-17-1178 (4), UIC-17-7 (3), UIC-17-90 (3) and UIC-17-2074 (3) (Table 2). The wider canopy coverage produced by the highly branching genotypes can reduce weed growth and consequently cost incurred for its management (IITA,1990). Notably, the significantly comparable root quality, fresh storage root yield and number of roots of the UIC genotypes with the national check (Table 2) implies good yield

Table1: Combined analysis of variance for yield and yield related traits of some University of Ibadan cassava genotypes evaluated at the advanced breeding stage

Sources of variation	Degree of freedom	Root quality		Plant architecture		Fresh storage root yield		Harvest index		Roots/ plant		Dry storage root yield	
		SS	MS	SS	MS	SS	MS	SS	MS	SS	MS	SS	MS
Replication	1	0.77	0.78	0.05	0.05	117.88	117.88	0.00	0.00	2.59	2.59	10.35	10.35
Genotype	14	5.61	0.40	19.15	1.37**	938.04	67.00	0.12	0.01*	35.35	2.53	110.21	7.87*
Season	1	0.78	0.78	0.07	0.07	0.31	0.31	0.31	0.31***	22.35	22.35*	1.24	1.24
Genotype ×Season	14	3.57	0.26	4.43	0.32	919.29	65.66	0.05	0.00	25.74	1.84	70.98	5.07

SS: Sum of squares; MS: Mean square; "*, ** and ***" implies significant at 0.05, 0.01 and 0.001 levels of probability, respectively.

Table 2: Yield and yield related traits of some University of Ibadan cassava genotypes evaluated at the advanced breeding stage

Genotypes/ yield components	Root quality	Plant architecture	Fresh storage root yield (t/ha)	Harvest index	Dry storage root yield (t/ha)	Roots/ plant
UIC-17-1842	2.75a	4.75a	26.79a	0.46bc	5.04ab	6.30a
UIC-17-2074	2.75a	3.75dc	13.92a	0.45bc	2.87b	4.94a
UIC-17-174	2.75a	4.25abc	19.29a	0.49bc	5.24ab	5.67a
UIC-17-750	2.50a	4.25abc	24.75a	0.53abc	6.39ab	6.92a
UIC-17-5	2.50a	4.50abc	29.73a	0.59a	8.15a	6.14a
UIC-17-7	2.33a	3.00d	26.75a	0.44bc	7.99a	6.78a
UIC-17-26	2.25a	4.25abc	26.33a	0.54abc	6.42ab	5.46a
UIC-17-90	2.25a	3.00d	23.44a	0.53abc	6.20ab	6.00a
TMS070593	2.25a	5.00a	24.06a	0.43c	5.43ab	4.85a
UIC-17-491	2.25a	4.00bc	17.69a	0.55ab	4.43ab	4.15a
UIC-17-1178	2.25a	4.00bc	23.41a	0.54abc	5.99ab	6.81a
UIC-17-265	2.25a	5.00a	26.33a	0.53abc	7.81a	5.80a
UIC-17-1048	2.00a	4.50abc	23.9a	0.51abc	5.68ab	6.65a
UIC-17-220	2.00a	5.00a	24.55a	0.51abc	6.16ab	5.63a
UIC-17-646	1.75a	4.25abc	20.33a	0.46bc	5.04ab	5.95a

Means in a column with different letters are significantly different potential of the new genotypes. Genotype UIC-17-5 had the highest harvest index of 0.59, which differed statistically from harvest index values of only UIC-17- 1842 (0.46), UIC-17-2074 (0.45), UIC-17-7 (0.44), TMS070593 (0.43) and UIC-17-646 (0.46) (Table 2). The record of least harvest index from the check variety shows that the UIC genotypes were more efficient in partitioning photosynthetic assimilate from the source (leaves) to the sink (fresh storage roots) than the national check variety. Meanwhile, the highest dry storage root yield (8.51 t/ha) was obtained from UIC-17-5 which compared favourably with values recorded for 07/0593 and other UIC genotypes except UIC-17-2074 (2.87 t/ha) (Table 2). Summarised in Table 3 is the result showing the Pearson correlation coefficients for the evaluated traits.

Table 3: Pearson correlation coefficients for survival rate, severity of mosaic disease and yield components for some University of Ibadan cassava genotypes evaluated at the advanced breeding stage

Traits	Rtqlt	CMD	_Surv	FRY	HI	DRY	Rt_plt
Arch	-0.0665	-0.4033	-0.3456	0.2335	0.0497	0.1117	-0.0627
	0.6139	0.0014	0.0068	0.0726	0.7061	0.3954	0.6340
Rtqlt		0.0144	-0.0775	0.1108	0.1452	0.1621	0.2127
		0.9131	0.5561	0.3992	0.2685	0.2160	0.1028
CMD			0.1271	-0.2171	-0.1992	-0.1720	0.0728
			0.3332	0.0957	0.1270	0.1887	0.5806
Surv				-0.1503	0.1104	-0.0205	0.0440
				0.2518	0.4009	0.8762	0.7386
FRY					0.0719	0.8984	0.6405
					0.5853	<.0001	<.0001
HI						0.0613	0.2675
						0.6418	0.0388
DRY							0.6106
							<.0001

The fresh storage root yield of the cassava correlated positively with dry storage root yield, harvest index, plant architecture and number of root per plant. This suggests that the former trait increases with corresponding increase in the later traits. Conversely, severity of cassava mosaic disease maintained a negative relationship with all evaluated traits except survival rate and root quality (Table 3). This highlights the detrimental effect of the disease on yield related trait of cassava and the consequential associated yield loss as reiterated by Thresh *et al*. (1997).

Conclusion

The University of Ibadan yellow roots cassava varieties have the potential to address vitamin A defficiency when consumed. Majority of the genotypes had superior or comparable agronomic and yield performance in relation to the national check variety. About 64% of the new cassava genotypes were also resistant to cassava mosaic disease. Genotypes UIC-17-90 and UIC-17-7 with moderate branching will support intercropping with other crops. Conversely UIC-17-5 is highly resistant to cassava mosaic disease and combined this with highest fresh and dry storage root yield; and harvest index. It will therefore give high product yield and is recommended for mono-cropping because of its profuse branching habit.

References

Amujoyegbe, B.J. and Alabi, O.S. 2012. Cropping system analysis of two agro ecological zones of Southwestern Nigeria. *Journal of Agricultural Extension and Rural Development.* 4(14): 396-401

Ayetigbo O., Sajid, L., Abass, A., Muller, J. 2018 Comparing characteristics of Roots, Flour and Starch of Biofortified Yellow Flesh and white flesh cassava variants and sustainability considerations: A review. *Sustainability* 10(8):3089

CGIAR, 2013. Roots, Tubers and Banana: Planting for greater impact. Available at https://www.rtb.cgiar.org. Accessed on 15 March 2020.

IITA. 1990. *Cassava in tropical Africa: A reference manual*. UK: Balding and Mansel International. 173.

IITA. 2011. IITA-led team develops vitamin A cassava to tackle malnutrition in Africa. Available at https://www.iita.org/news-item/iita-led-team-develops-vitamin-cassava-tackle-malnutrition-africa/ Accessed on 22 August 2023.

IITA. 2014. Nigeria releases more cassava with higher pro-vitamin A to fight micronutrient deficiency. Available at https://www.iita.org/news-item/nigeria-releases-cassava-higher-pro-vitamin-fight-micronutrient-deficiency/. Accessed on 22 August 2023.

Njoku, D.N., Vernon, G., Egesi, C.N., Asante, I., Offei, S.K., Okogbenin, E., Kulakow, P., Eke- Okoro, O.N. and Ceballos, H. 2011. Breeding for enhanced ß-Carotene content in cassava: constraints and accomplishments. *Journal of Crop Science* 25: 560-571.

Olsen, K.M. and Schaal, B.A. 2001. Micro satellite variation in cassava *(Manihot esculenta*, Euphorbiaceae) and its wild relatives: further evidence for a Southern Amazonian origin of domestication. *Annals of botany Journal* 88: 131-142.

Owor, B., Legg, J.P., Okao-Okuja, G., Obonjo, R., Kyamanywa, S. and Ogengalatigo, M.W. 2004. Field studies of cross protection with cassava mosaic geminiviruses in Uganda. *Journal of Phytopathology* 152: 243-249.

Thresh, J.M., Otim-Nape, G.W., Legg, J.P. and fargette, D. 1997. African cassava mosaic virus diseases: the magnitude of the problem. *African Journal of Root and Tuber Crops* 2.112: 13-17.

Thresh, J.M. and Cooter, R.J. 2005. Strategies for controlling cassava mosaic virus disease in Africa. *Plant Pathology* 54: 587-614.

Udemba I.O. Variability in storage root yield and *gari* quality of yellow root cassava (*Manihot esculenta* Crantz) varieties. Ph.D. Thesis. University of Ibadan. 2023; 144.

Udemba I.O. Olasanmi B. and Iluebbey P. 2023. Tandem effect of bio-fortification on dry matter content and *gari* yield of some yellow root cassava (*Manihot esculenta* Crantz) varieties. Asian Journal of Advances in Agricultural Research 23 (2): 11-19