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Yield Performance and Agronomic Evaluation of Selected Yellow Cassava Genotypes in Nigeria

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Abstract
Vitamin A deficiency (VAD) is a major public health concern for communities that depend mainly on cassava for their daily carbohydrate requirements. About 50% of Nigerians eat cassava at least once a day in various forms while 60% of children under the age of five and 20% of pregnant women in the country are faced with VAD. Therefore, breeding for enhanced pro-vitamin A in cassava to address both food and nutrition security is an important goal. This study was carried out to evaluate selected yellow root (YRC) cassava genotypes to dry matter content (DMC), fresh root yield (FRY) and, response to important cassava diseases at three agro-ecologies in Nigeria. Ten YRC genotypes and two check varieties (TMS30572 and TMS011368) were evaluated in a randomized complete block design with three replications. There were significant differences among the genotypes for cassava bacteria blight (CBB) and cassava anthracnose disease (CAD) and across location (L), genotypes (G) and genotype by environment (G x E) interaction for cassava mosaic disease (CMD) at P<0.001. There were also significant differences among the genotypes for FRY, DMC and dry root yield (DRY) at P<0.001. The FRY ranged from 4.37 to 31.42 with a mean of 11.79 t/ha; 1.71 to 21.41 with a mean of 7.45; and 3.54 to 35.83 with a mean of 24.51t/ha at Umudike, Otobi and Igbariam, respectively. Dry matter content ranged from 25.9 to 31.4 with a mean of 28.5; 20.1 to 36.1% with a mean of 30.48; and 23.8 to 37.3% with a mean of 33.2% at Umudike, Otobi and Igbariam, respectively. A significant correlation was observed among the parameters evaluated.
Keywords: Biofortification, cassava, genotypes, multilocational trial, and yellow root

Introduction

Cassava (*Manihot esculenta* Crantz) is a major staple for about half of the Nigerian population (the world's largest producer of cassava), and nearly 55 million tons of fresh cassava are produced annually in the country (FAOSTAT 2014). This quantity (about 70% of the production in West Africa) is enough to meet the calorie requirement of 50 million people at about 200 calories per day. Cassava has great potential as a dietary energy source for man and livestock and is likely to produce more food calories per unit area than any other lowland crop grown in Nigeria. This is because of its high-yielding potential and ability to survive about four months of the dry season with zero rainfall but recover normally with the onset of the rains (Ospina *et al*., 2007), thereby producing some food where many other food crops would fail.

Vitamin A deficiency (VAD) is a major public health concern for communities that depend mainly on cassava for their daily carbohydrate requirements. About 60% of children under the age of five and 20% of pregnant women in Nigeria are faced with VAD. Therefore, breeding for enhanced provitamin A in cassava to address both food and nutrition security is an important goal in Africa. Cassava is important as a subsistence or food security crop and as a source of income for the farmers. It supplies 70% of the total calorie intake of about half of the Nigerian population (Ezulike *et al*., 2006), and it is gradually gaining importance as an industrial crop as well. Apart from being the major source of carbohydrates for most Nigerians, it has other diverse uses in the pharmaceutical, confectionery, and livestock industries in Nigeria (Eke-Okoro and Dixon, 2000). Its production and processing provide employment and income for the rural poor, especially women and children (Sarma and Kunchai, 1989). Cassava leaves are used as a nutritious vegetable; the leaves and storage roots can be used as animal feed, and the stems can be sold as planting material (IITA, 2000). The storage roots can be processed into various food products and starch for domestic consumption, and local and/or foreign markets. The roots are used to make flour, bread, tapioca, sugar, laundry starch, and even an alcoholic drink. Full realization of the potential depends on obtaining more detailed information by researchers,

most especially extension workers about cassava-growing conditions, production system, processing methods, market prospects, end-user preferences and urban consumption patterns (Nweke *et al*., 2002). Cassava, however, shows a strong and significant genotype × environment interaction (G × E) effect (Fukuda, 1996; Kvitschal *et al*., 2007) due to its diverse cropping condition, thus making selection difficult. Breeding cassava for superior cultivars should be carried out considering the G×E effect. A detailed assessment of the magnitude and significance of G × E is important to ensure greater precision in the selection and release of high-yielding and stable clones (Kvitschal *et al*., 2009). The assessment and selection of cultivars with high yield and stability are very important in any breeding program to indicate superior materials for commercial use (Carneiro, 1998). The objective of this study was to evaluate selected YRC blight (CBB), cassava anthracnose disease (CAD) and cassava green mite (CGM) in three locations.

Materials and Methods

A set of 12 YRC genotypes developed at NRCRI, Umudike, Nigeria and two check varieties (TMS 30572 and TMS 01/1368) were evaluated across three agro-ecological zones: Umudike (humid rainforest) with latitude 05^{0}29$^{'}$N and longitude 07^{0}33$^{'}$E at about 122 m altitude above sea level and has an annual rainfall of 2200mm, temperature of 22-32^{0}c, 50 95% relative humidity with dystric luvisol soil; Igbariam(6.4°N, 6.93333°E) in the Derived Savanna, rainfall pattern is bimodal between April and October, with a mean annual rainfall of 1268.4mm. The dry season falls between November and March. The relative humidity (RH) of the study area is moderately high all year round with the highest RH of 85% during the wet season and the lowest 64% occurring during the dry season. The temperature range is between 21°C - 35°C. The soil is of the sandy loam textural class and poorly drained; classified as Ultisol; Otobi (derived savanna) with latitude 07^{0}20$^{'}$N and longitude 08^{0}41$^{'}$E at about 319 m altitude above sea level, annual rainfall 1500mm, temperature of 24-35^{0}c and ferric luvisol soil in Nigeria. The trial was established at each location using a randomized complete block design replicated three times. Thirty-six cuttings of each genotype were planted in a plot (6m x 6m) at a spacing of 1m x 1m. Weeding of the plots at each location was carried out as required using cutlasses and hoe. The plants were scored for resistance to major cassava pests and diseases at 1, 3, 6, 9 and 12 MAP using a scale of 1 to 5 (1 = no symptom; 5 = severe symptom) according to established protocol (1990). At harvest (12 MAP), the cassava genotypes were evaluated for FRY, DMC, and DRY using the 16 inner plants in each plot. The DMC of each genotype was determined using the specific gravity method. The data collected were collated and subjected to analysis of variance using SAS software (2002).

Results and Discussion

Fresh root yield ranged from 4.37 to 31.42 with a mean of 11.79 t/ha at Umudike; from 1.71 to 21.41 with a mean of 7.45 t/ha at Otobi; and from 3.54 to 35.83 with a mean of 24.51 t/ha at Igbariam. Dry matter content ranged from 25.9 to 31.4 with a mean of 28.5% at Umudike, from 20.1 to 36.1 with a mean of 30.48% at Otobi and from 23.8 to 37.3 with a mean of 33.2% at Igbariam (Table 1). The highest mean for DMC and FRY and the lowest score for cassava mosaic disease severity were recorded at Igbariam (Table 1).

At Umudike, nine genotypes with 7.67 t/ha and above FRY had a DMC of 25.9% and above. Genotype NR070136 had the highest DMC of 31.4%. At Otobi, five genotypes with FRY above 7.5 t/ha have DMC of 28.9% and above while genotype NR1S1023 had the highest DMC of 36.1%. At Igbariam, eleven genotypes with 17.83 t/ha and above FRY had DMC of 31.9% and above, with genotype NR070391 recording the highest DMC of 37.3% (Table 1). Similarly, significant differences were also observed across locations, among genotypes and significant genotype x environment interaction for cassava mosaic disease severity (CMDS); across locations for cassava bacteria blight severity (CBBS) and cassava anthracnose disease severity (CADS) at P<0.01 (Table 2). Significant correlation was observed between harvest index, FRY and DRY, FRY and DRY, DMC and DRY at P<0.001 (Table 3). There were significant differences among the genotypes for FRY, DMC and DRY at P<.001 (Table 4).

The overall objective of this study was to assess the performance of selected cassava genotypes for FRY, DMC, and DRY in three locations in Nigeria. The significant variation for FRY, DMC and DRY among these genotypes presents an important opportunity to improve cassava for the traits in breeding programmes in Nigeria. This variability could form the basis for making good progress in the genetic improvement of cassava for these traits through hybridization and selection. Genotype and Location were highly significant (p<0.01) for FRY, DMC and DRY (Table 4) indicating genetic variability among the genotypes by changing environment. Effects from genotype and environment that showed highly significant mean square reflect genotypic differences and adaptability to different environments, thus, this suggests that genotypes may be selected for adaptation to specific environments (Aina *et al*., 2009). Cassava, however, shows a strong and significant genotype x environment interaction (GxE) effect (Fukuda, 1996; Kvitschal *et al*., 2007) due to its diverse cropping condition, thus making selection difficult. Breeding cassava for superior cultivars should be performed considering the GxE effect. Breeders face the GEI challenge by evaluating genotypes in several environments to ensure that they select genotypes with high and stable performance (Ssemakula and Dixon, 2007). Similarly, genotypes (G), Location (L) and G x E were significant for cassava mosaic disease (CMD) while Location was significant for both cassava bacteria blight (CBB) and cassava anthracnose disease (CAD) at P<0.01 but not significant for cassava greenmite (CGM). This suggests that CMDS, CBBS and CADS were influenced by Location,

genotypes and GxE but CGMS is not influenced by any of the sources of variation (Table 1). The high genotype effects on cassava mosaic disease have also been reported by Maroya *et al*. (2012) in a study on G×E interaction for mosaic disease, storage root yield and total carotene content of yellow-fleshed cassava genotypes in Nigeria. Nevertheless, the best-performing genotypes identified in this study could form part of the materials for such genetic improvement through hybridization.

The higher mean FRY recorded at Igbariam than Umudike and Otobi for the yellow root cassava genotypes is contrary to the earlier reports that cassava genotypes yield more at Otobi, a good site for identifying high-yielding (Olasanmi, 2010; Olasanmi *et al*., 2014) cassava genotypes. However, the variation for yield increase observed at Umudike was very close to what was observed across the three locations, an indication that Umudike is more representative of the three locations and may therefore be a good site for early selection in a breeding program before carrying out a multilocational trial.

Conclusion

This study was carried out to evaluate selected yellow root cassava genotypes' response to storage root yield, dry matter content, dry root yield pest and disease. In terms of FRY genotypes NR070136 and NR1S1059 perform better while for DMC, NR070136, NR1S1023 and NR070391 did well which implies that such genotypes could eventually be released to farmers or used as progenitors in other breeding programmes.

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Table 1: Agronomic and quality traits of selected yellow root cassava genotypes and 2 checks evaluated in 3 agro-ecological zones

	Umudike			Otobi			Igbariam		
Genotypes	**HI**	**FRY (t/ha)**	**DMC (%)**	**HI**	**FRY (t/ha)**	**DMC (%)**	**HI**	**FRY (t/ha)**	**DMC (%)**
NR070136	0.57	31.42	31.4	0.66	21.41	32.2	0.63	25.75	31.9
NR070282	0.42	4.37	28.4	0.43	3.54	23.8	0.44	3.54	23.8
NR070391	0.39	10.71	30.2	0.41	1.71	20.1	0.54	20.88	37.3
NR070484	0.32	4.71	26.9	0.45	5.25	31.9	0.62	21.46	32.7
NR1S1023	0.58	12.41	29.4	0.45	6.29	36.1	0.66	23.00	32.2
NR1S1059	0.55	7.88	26.2	0.52	6.50	28.9	0.76	35.83	34.2
NR1S1096	0.59	8.58	25.9	0.5	7.50	30.4	0.68	28.46	36.8
NR1S1131	0.48	7.67	27.2	0.61	5.04	32.5	0.47	18.63	34.1
NR1S1200	0.35	8.21	29.5	0.31	4.29	30.3	0.64	17.83	36.2
NR1S1205	0.38	9.63	30.2	0.38	9.63	30.2	0.61	31.50	31.8
TMS 30572	0.64	24.46	30.5	0.63	10.54	35.8	0.65	26.50	36.7
TMS011368	0.65	11.58	26.9	0.73	9.50	33.5	0.73	28.77	30.6
MIN	0.32	4.37	25.9	0.31	1.71	20.1	0.44	3.54	23.8
MAX	0.65	31.42	31.4	0.73	21.41	36.1	0.76	35.83	37.3
MEAN	0.49	11.79	28.5	0.51	7.45	30.48	0.62	24.51	33.2
STDEV	0.11	7.71	1.79	0.12	4.87	4.39	0.09	9.16	3.55
CV (%)	22.4	6.54	6.27	23.53	64.08	14.4	14.5	37.37	10.69

HI = Harvest index; FRY = Fresh root yield; DMC = Dry matter content

Table 2: Mean square of cassava mosaic disease, cassava bacterial blight, cassava anthracnose disease, and cassava greenmite

Source	**df**	**CMDS**	**CBBS**	**CADS**	**CGMS**
Location	2	5.9537**	13.3981**	13.4537**	0.2870^{ns}
Genotypes	11	0.8552**	0.2315^{ns}	0.3931^{ns}	0.4613^{ns}
Genotype x Location	22	0.6002**	0.3880^{ns}	0.1911^{ns}	0.5194^{ns}
Error	72	0.1204	0.2407	0.2222	0.5000

****(P<0.05), ** (P<0.01), *** (P<0.001), CMDS = cassava mosaic disease severity; CBBS = cassava bacterial blight severity, CADS = cassava anthracnose disease severity, CGMS = cassava green mite severity; ns = not significant***

Table 3: Correlation among yield, yield-related traits and carotene content of selected yellow root cassava genotypes evaluated in three locations in Nigeria

Source	**Harvest index**	**Fresh root yield (t/ha)**	**Dry matter content (%)**	**Dry root yield (t/ha)**
Harvest index	----	0.56952***	0.27573ns	0.55761***
Fresh root yield		-----	0.36064ns	0.47232***
Dry matter content			-----	0.50993***
Dry root yield				-----

****(P<0.05), ** (P<0.01), *** (P<0.001), ns= not significant***

Table 4: Combine Analysis of variance (ANOVA) for fresh root yield, dry matter content, and dry root yield of selected yellow root cassava genotypes and 2 checks evaluated across three agro-ecologies in Nigeria

Source	**df**	**Fresh root yield (t/ha)**	**Dry matter content (%)**	**Dry root yield (t/ha)**
Location	2	3478.63**	285.99**	441.981**
Genotypes	11	241.20**	21.44^{ns}	24.389**
Genotypes x Location	22	88.53^{ns}	34.49^{ns}	9.650^{ns}
Error	72	46.06	30.63	7.301

****(P<0.05), ** (P<0.01), *** (P<0.001), ns- not significant***