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GROWTH, YIELD AND DISEASE RESPONSES OF 12 CASSAVA GENOTYPES EVALUATED FOR TWO CROPPING SEASONS IN A DERIVED SAVANNAH ZONE OF SOUTH-EASTERN NIGERIA.

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ABSTRACT

Ten new cassava genotypes selected for high yield and tolerance to some biotic stresses were evaluated alongside the local best, Otupam and 'TMS 30572' (a widely cultivated hybrid genotype, as an improved check) for two cropping seasons with a view to obtaining suitable genotype(s) that could be recommended for release to farmers. The results revealed that only TMS-96/0304, TMS-96/1672 and NR-930255 had above 90% sprout survival at 12 months after planting. Severity of cassava mosaic disease (CMD), cassava anthracnose disease (CAD) and cassava bacterial blight (CBB) varied among genotypes, plant age, and the cropping year. Symptom expressions of CMD and CBB were generally higher on the local best, Otupam and NR-930255. The severity of cassava green mite was moderate and statistically similar on all the genotypes while severity of cassava mealybug was mild. Hybrids NR930255, TMS96/1672 and TMS96/0304 produced the highest number of tubers. These genotypes also significantly ($P< 0.05$) produced the highest harvested tuber yield per hectare: NR 930255 (31.0 t/ha), TMS 96/1672 (28.0 t/ha) and TMS 96/0304 (29.4 t/ha). The three genotypes had the least percent yield difference between the potential and the actual yield. Mean rank-sum for all traits measured suggested that the most adaptable genotypes to Nsukka agro-ecology after two years of evaluation were NR-930255, TMS 96/0304 and TMS96/1672, but the poor disease ratings for NR-930255 and TMS 96/0304 precluded their recommendation for release while TMS 96/1672 could be recommended for release to farmers.

Key words: Adaptation, Cassava, Derived Savannab Agro-ecology, Disease and Pest Resistance, Yield

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a staple food crop in south-eastern Nigeria and it contributes about 15% of the daily dietary energy intake of most Nigerians. Cassava supplies about 70% of the total calories intake of about 60 million people in Nigeria (Ezulike *et al.*, 2006). The crop is one of the most dominant and main crop components in crop mixtures in south-eastern Nigeria (Ikeorgu and Iloka, 1994) and it is gradually gaining importance as an industrial crop (Muoneke and Mbah, 2007).

Pests and diseases are among the major production constraints of cassava in Africa (Theiberge, 1985). Most important among these are Cassava mosaic disease (CMD), Cassava anthracnose disease (CAD), Cassava bacterial blight (CBB), Cassava green mite (CGM) and Cassava mealybug (CM). Among these biotic stresses, CMD, CBB and CGM are considered very important (Yaninek, 1994) but CMD is the most devastating cassava disease with a possible yield loss ranging between 20 – 90% (Thresh and Otim-Nape, 1980). The most reliable and easy-to-adopt method of controlling these biotic stresses is the cultivation of resistant cassava genotypes (Ogbe *et al.*, 2003). Thus, the availability of high yielding and disease/pest resistant varieties to farmers may be the most cost effective long-term measure for sustainable production of the crop (Kueneman 2002).

Multilocational evaluation trials are often conducted to ensure that selections made have a reliable and a predictable performance in the farmers' field. The primary goal is usually to identify superior cultivars for a target region (Yan *et al.*, 2001). Generally, good adaptive capacity means somewhat superior productivity (relative to all strains being tested) of a genotype or population over several environments (Cooper and Byth, 1996).

Both spatial and temporal environments of crop evaluation influence phenotypic expression. Thus, the concept of genotype-by-environment (G x E) interaction; G x E interaction is defined as the differential genotypic expression across environments. Measuring G x E interaction is important for the determination of an optimum breeding strategy for releasing genotypes with adequate adaptation to target environments.

The actual yield and the consistency of yield of an adapted cultivar in a particular environment is its ultimate index of adaptation, but yield is an outcome of several processes at all stages in the growth and development of the crop. Therefore, assessment of adaptation should include evaluation of responses to biotic stresses, phenological and physiological-genetic performances of genotypes been evaluated.

In this paper, therefore, the responses of 12 cassava genotypes to natural pest and disease pressures, their growth and yield performances under a derived savannah environment were evaluated for two cropping years (2004 – 2006) with a view to identifying most adapted genotype(s).

MATERIALS AND METHOD

The experiment was conducted in the research farm land of the Department of Crop Science, University of Nigeria, Nsukka, Nigeria. Nsukka is in the derived Savannah agro-ecology. The vegetation is predominantly grass with interspersed trees. It is located on latitude 06° 52'N, longitude 07°24'E and 447m altitude. Rainfall is bimodal with an annual total of about 1500 mm. Rains stabilise in May and often stop in October. Relative humidity ranges between 70% and 80% while the ambient temperature ranges between 20°C and 30°C, during the rainy months of the year. The soil was acidic and it is classified as a sandy loam Oxisol of Nkpologu series (Ndubizu, 1981).

Ten new cassava genotypes selected for high yield and tolerance to some biotic stresses were evaluated alongside the local best Otupam (as a local check) and 'TMS 30572' (a widely cultivated hybrid genotype, as an improved check). The ten new genotypes comprised five NR-series and five TMS-series, which included 'NR930061', 'NR930127', 'NR930162', 'NR930199', 'NR930255', 'TMS96/0160', 'TMS96/0304', 'TMS96/1087', 'TMS96/1432' and 'TMS96/1672'. The 12 genotypes were planted for two consecutive cropping seasons, that is, 2004/2005 and 2005/2006.

The land was ploughed, harrowed and ridged. The field layout was randomised complete block design replicated three times. Each plot size was 30 m^2 comprising five ridges, each measuring six meters long and at 1 m intervals. Planting distance was 1 x 1 m on the crest of the ridges. Thus, thirty cuttings per genotype in a plot per replication were planted. Weeds were controlled manually as at when due and NPK 15-15-15 was applied at the rate of 400 kg/ha. Data on sprout survival counts 4, 6, 8 and 48 weeks after planting, (WAP), and plant height 3 and 12 months after planting (MAP) were collected. Cassava mosaic disease (CMD) severity scores were recorded 1, 3 and 5 MAP on a 5-point scale (1 no symptom and 5 being severe mosaic and distortion of entire leaf) (Terry 1975). As symptoms were not uniform on the leaves, symptom score was on whole plant (Ogbe *et al.*, 1993). Cassava bacterial blight (CBB) and Cassava anthracnose disease (CAD) severity scores were recorded 3, 6, and 9 MAP also on a 5-point scale (Wydra, 1994). Cassava green/red mites (CGM) symptom severity was assessed in December 2005, January and February 2006 on a 5-point scale: 1 no symptom; 2 few chlorotic specks on the leaf surface, presence of few reddish brown leaves, presence of mites; 3 numerous chlorotic specks on leaf surfaces, numerous reddish brown leaves, slight distortion of leaf shape and slight reduction of leaf sizes; 4 severe reduction of leaf sizes particularly of young leaves/top leaves of branched stems, webs of green/red mites evidence; 5 defoliation of top leaves, webs of green/red mites evidence. Cassava mealybug (CM) symptom severity was also assessed at the same time with CGM on the following 5-point scale: 1 no symptom; 2 slightly shorten leaf petioles and internodes, presence of mealybugs whitish in colour; 3 moderately shorten leaf petioles and internodes, obvious bunchy top, presence of numerous mealybugs; 4 severe bunchy top, plant becomes stunted; 5 severe bunchy top, stunted growth, induced shoots branches that are stunted, occasional death of plant top.

The following data on yield components were measured: number of cuttings per plant, number of tubers per plant and per hectare, tuber yield (kg) per plant, potential tuber yield (t/ha) (PY) estimated as yield per plant multiply by 10,000 (the expected plant population per hectare), actual tuber yield (t/ha) (AY) estimated as tuber yield per plant multiply by actual plant population obtained at the time of harvest, and percent yield difference determined as (PY-AY/PY)*100. All the data were subjected to analysis of variance (ANOVA) using GENSTAT 1-Discovery edition (GENSTAT. 2003). Tests of significance of variances of traits were performed and mean values of traits measured were ranked, and mean rank-sum for group of physiologically related traits were calculated. Ranking was conducted to assess the relative performances of genotypes during the two cropping seasons.

Table 1. The main effects of genotypes and cropping year on survival counts and plant height of 12 cassava genotypes evaluated at Nsukka for two cropping seasons, 2004 - 2006.

	% survival counts (WAP)				Plant height, cm (MAP)	
GENOTYPE	4	6	8	48	3	12
Local Best	87.9	87.4	87.4	79.7	118.2	282.3
NR930061	96.9	96.3	95.3	85.9	77.5	183.5
NR930127	90.7	90.3	90.2	86.5	63.2	170.2
NR930162	87.3	87.3	87.3	82.0	91.0	232.0
NR930199	86.8	87.4	87.4	84.2	94.5	252.7
NR930255	97.8	95.6	95.6	92.9	128.7	299.2
TMS30572	75.3	74.2	72.0	63.6	92.7	220.0
TMS96/0160	91.8	89.6	89.1	82.0	84.0	218.5
TMS96/0304	99.4	99.4	99.4	98.9	80.0	235.8
TMS96/1087	79.6	77.9	75.7	68.7	105.5	313.2
TMS96/1432	87.8	85.6	86.7	77.6	105.0	208.8
TMS96/1672	97.8	95.0	94.4	93.9	110.7	300.5
LSD(0.05)	5.9	7.0	7.6	11.8	31.0	43.8
Year						
2004	83.1	80.9	80.6	74.6	73.7	255.2
2005	96.8	96.8	96.2	91.3	118.1	230.9
LSD(0.05)	2.4	2.9	3.1	4.8	12.7	17.9

Table 2. The main effects of genotypes and cropping year on severity scores of Cassava mosaic disease (CMD), Cassava anthracnose disease (CAD) and Cassava bacterial blight on 12 cassava genotypes evaluated at Nsukka for two cropping seasons, 2004 - 2006.

	CMD			CAD			CBB		
GENOTYPE	1MAP	3MAP	5MAP	3MAP	6MAP	9MAP	3MAP	6MAP	9MAP
Local Best	2.2[§]	4.0	3.0	1.3	1.7	1.5	2.7	3.0	3.2
NR930061	1.7	3.7	3.0	1.2	1.2	1.3	1.8	2.3	3.0
NR930127	2.0	3.7	2.5	1.0	1.0	1.0	1.8	2.0	2.5
NR930162	2.5	3.0	2.7	1.3	1.5	1.3	2.2	2.7	3.2
NR930199	2.2	1.0	1.3	1.3	1.7	1.5	2.0	2.2	2.8
NR930255	3.5	2.0	2.7	1.7	2.3	2.2	2.5	2.8	3.0
TMS30572	1.7	2.5	2.2	1.0	1.3	1.3	2.0	2.7	3.7
TMS96/0160	2.2	1.3	1.3	1.3	1.5	1.2	2.2	2.2	2.8
TMS96/0304	2.8	2.2	2.0	1.8	2.7	2.7	2.7	2.3	2.3
TMS96/1087	2.0	2.0	1.5	1.0	1.2	1.2	2.3	2.8	3.7
TMS96/1432	1.7	1.0	1.3	1.2	1.3	1.2	2.2	2.7	3.7
TMS96/1672	2.2	1.5	1.5	1.3	1.8	1.8	2.7	2.5	2.5
LSD(0.05)	-	0.7	0.8	0.4	0.5	0.6	0.5	0.6	0.6
Year									
2004	2.0	2.2	2.4	1.6	1.8	1.6	2.2	2.4	3.5
2005	2.4	2.4	1.8	1.0	1.4	1.4	2.3	2.6	2.6
LSD(0.05)	-	-	0.3	0.2	0.2	0.2	-	-	0.2

MAP: Month after planting; [§]Severity indices: 1 = no symptom; 2 = mild; 3 = moderate; 4 = severe; 5 = more severe.

Table 3. The main effects of genotypes on severity scores of Cassava green mite (CGM) and Cassava mealybug (CM) on 12 cassava genotypes evaluated at Nsukka for two cropping seasons, 2004 - 2006.

	2004/2005		2005/2006					
			CGM			CM		
GENOTYPE	CGM	CM	DEC.	JAN.	FEB.	DEC.	JAN.	FEB.
Local Best	3.0[§]	1.7	1.0	2.3	2.3	1.0	2.7	2.7
NR930061	3.0	1.3	1.0	2.7	2.7	1.3	2.3	2.3
NR930127	3.7	1.0	1.0	2.3	2.3	1.0	2.3	2.7
NR930162	3.3	1.7	1.0	3.0	3.0	1.7	3.0	3.3
NR930199	3.0	1.0	1.0	3.3	3.3	1.3	2.0	2.0
NR930255	3.0	1.7	1.0	2.3	2.3	1.0	2.0	2.0
TMS30572	3.7	1.7	1.0	3.7	3.7	1.0	2.0	2.0
TMS96/0160	4.0	1.3	1.0	3.3	3.3	1.0	1.3	1.3
TMS96/0304	3.3	1.0	1.0	2.3	2.3	1.3	1.3	1.3
TMS96/1087	3.7	1.7	1.3	3.0	3.0	1.0	1.7	1.7
TMS96/1432	3.3	1.0	1.0	4.0	4.0	1.7	1.0	1.0
TMS96/1672	2.3	1.7	1.0	2.3	2.3	1.0	1.0	1.0
LSD(0.05)	-	-	-	-	-	-	1.0	1.1

[§]Severity indices: 1 = no symptom; 2 = mild; 3 = moderate; 4 = severe; 5 = more severe

Table 4. The main effects of genotypes and cropping year on yield and its components of 12 cassava genotypes evaluated at Nsukka for two cropping seasons, 2004 - 2006.

GENOTYPE	PC/plt	Tuber/plt	Tuber/ha ('000)	Yield/plt	Potential yield/ha	Harvested yield/ha	% Yield difference
Local Best	11.4	4.7	39.2	2.2	22.1	16.9	20.3
NR930061	7.3	5.5	46.9	2.4	24.4	20.7	14.1
NR930127	6.8	5.1	45.0	1.9	18.9	16.4	13.5
NR930162	9.3	4.7	40.1	2.5	25.1	20.2	18.0
NR930199	10.3	5.7	48.8	3.1	30.9	25.5	15.8
NR930255	11.9	6.5	62.2	3.3	32.9	31.0	7.1
TMS30572	8.7	6.1	41.9	3.1	30.7	19.0	36.4
TMS96/0160	8.8	6.6	55.3	3.4	34.3	28.2	18.0
TMS96/0304	9.5	8.2	80.7	3.0	29.9	29.4	1.1
TMS96/1087	12.6	6.8	48.7	3.4	33.8	21.4	31.3
TMS96/1432	8.2	6.7	55.2	3.3	33.4	25.5	22.5
TMS96/1672	11.4	7.5	71.9	3.0	29.7	28.0	6.1
LSD(0.05)	1.7	-	23.9	-	-	-	11.8
Year							
2004	10.1	4.9	37.3	3.5	35.2	26.0	25.4
2005	9.2	7.4	68.7	2.3	22.5	21.0	8.7
LSD(0.05)	0.7	1.0	9.8	0.6	4.8	-	4.8

PC/plt: Number of plantable cuttings per plant; Tuber/plt: Number of tubers per plant; Tuber/ha: Number of tubers per hectare; Yield/plt: Tuber yield (kg) per plant; Potential yield/ha: Estimated yield (tons) based on full plant population per hectare, Actual yield/ha: Yield (tons) per hectare based on actual plant population surviving till harvest; Yield difference: Differences between estimated and actual yield in percent.

Table 5. Mean rank-sum* of physiologically related traits showing performance ranking summary of 12 cassava genotypes evaluated at Nsukka for two cropping seasons, 2004 - 2006.

GENOTYPE	Survival/Growth	Diseases	Pests	Yield Components	Mean
Local Best	6	5	3	9	6
NR930061	6	3	3	8	5
NR930127	7	2	3	9	5
NR930162	8	4	4	8	6
NR930199	7	3	3	5	4
NR930255	2	5	2	3	3
TMS30572	10	3	3	8	6
TMS96/0160	7	3	3	4	4
TMS96/0304	3	5	2	3	3
TMS96/1087	8	3	3	4	4
TMS96/1432	8	3	3	5	5
TMS96/1672	3	4	1	4	3

1 = Most desirable, 10 = Poorest performance

***Genotype that recorded the lowest mean rank-sum value is the best for the specific physiological traits**

RESULTS

The analysis of variance tests performed revealed significant genotype (g), year (y) and g x y effects, especially on growth and disease response traits. The effect of genotypes on the components of yield was in most cases statistically non-significant, however, year (cropping season) effect elicited significant ($P < 0.05$) variability (data not shown).

Sprout survival counts across genotypes were above 80% in the first 8 weeks of planting except for TMS-96/30572 that recorded 72%. Hybrid TMS-96/0304 had a consistent sprout count of 99.4% during the first 8 weeks of planting, which only dropped to 98.9% at 12 months after planting (MAP). Two other genotypes that recorded more than 90% survival at 12 MAP were TMS-96/1672 and NR-930255 (Table 1). NR-930255 produced the tallest plants 3 MAP but only TMS-96/1087 and TMS-96/1676 produced plants that were taller than 3 m 12 MAP. Survival counts were generally higher in the second season planting (2005/2006) but plants were taller in 2004/2005 cropping season (Table 1).

Severity of CMD, CAD and CBB varied among genotypes, plant age, and the cropping year (Table 2). Symptom expression of CMD and CBB was generally higher with the local best, Otupam and NR-930255. Except for TMS96/0304 and NR-930255, the expression of CAD was generally very mild. CBB was moderately severe on TMS30572, TMS96/1087 and TMS96/1432 9 MAP but the severity of CMD and CAD was lowest on TMS96/0160 and TMS96/1432 (Table 2). It was noteworthy that during the two cropping seasons of evaluation NR-930127 did not express CAD symptom. G x Y interaction on severity of CMD, CAD, and CBB (data not shown) revealed that symptom expression varied across cropping years for any specific genotype at a similar plant age. The most severe case of CMD was recorded on the local best, Otupam, at 3 MAP in 2005. Similarly, the highest severity of CAD was on 6 and 9 months old TMS96/0304 in 2004. Also, CBB severity was highest on most of the genotypes in 2004 when the plants were 9 months old.

The severity of cassava green mite (CGM) was statistically ($P > 0.05$) similar on all the genotypes for the two cropping years (Table 3). Cassava mealybug (CM) severity was generally mild in 2004 and in December 2005. By February 2005 the population of CM on the local best, Otupam, and NR-930162 was mild to moderate. During the same period, CM was not found on TMS 96/1672 (Table 3).

The number of tubers per plant and per hectare varied with genotypes. Genotypes NR930255, TMS96/1672 and TMS96/0304 produced the highest number of tubers which, translated to the highest quantity of actual tuber yield per hectare. These genotypes had the least percent yield difference between the potential and the harvested tuber yield (Table 4). Although number of tubers harvested was higher in 2005 planting, yield per plant and per unit area was higher in 2004 planting. It was notable, however, that yield difference was relatively low in 2005 (Table 4). This low yield difference in 2005 was associated with high sprout survival (Fig. 1). It was evident from Figure 1 that there was a higher sprout survival for all genotypes in 2005. In spite of the higher sprout survival in 2005, actual tuber yield per hectare was higher in 2004 in nine genotypes. Genotypes NR930199, TMS96/1087 and TMS96/1672 had the most consistent tuber yield across the two cropping years (Fig. 2).

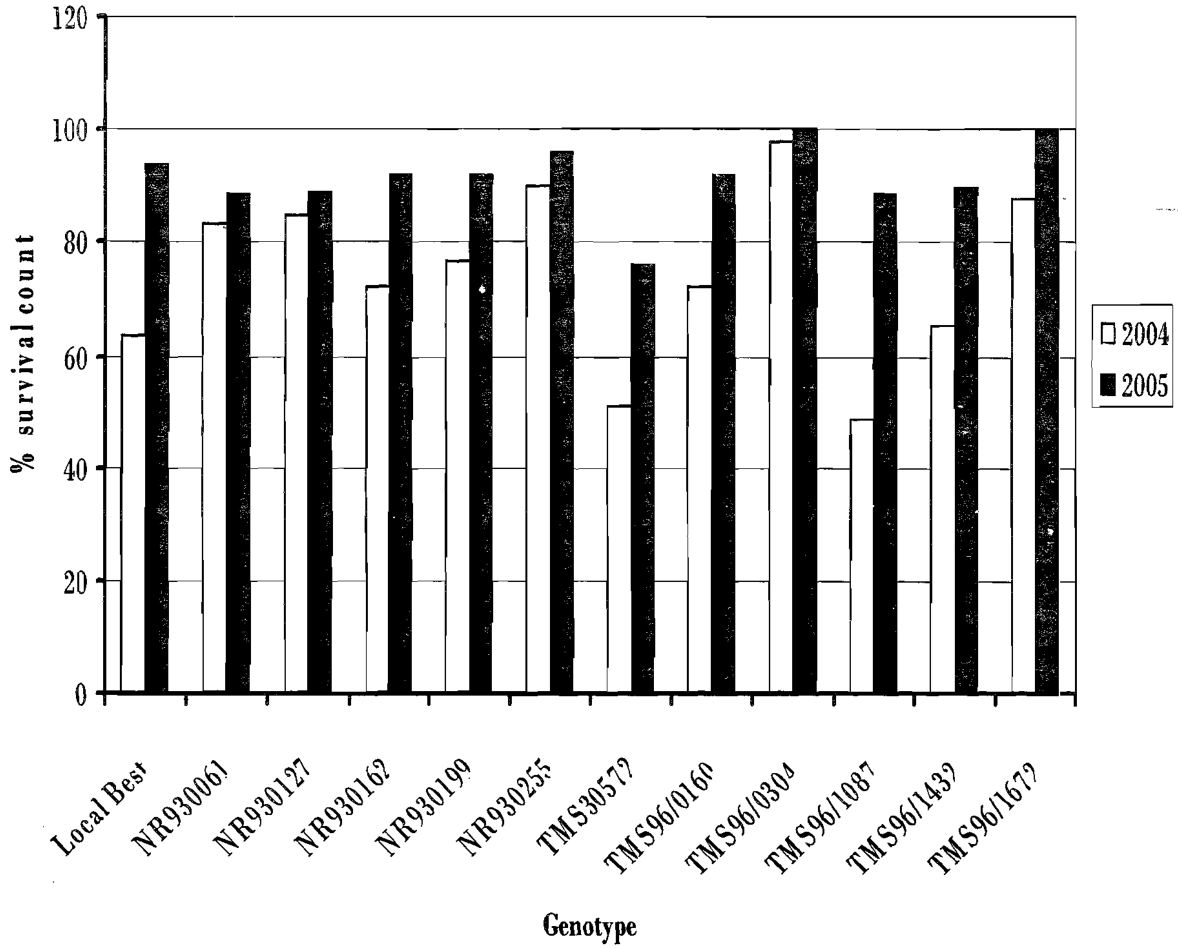

Fig. 1. The effect of genotype and cropping year on percent survival of sprouts of 12 cassava genotypes at 12 months after planting under Nsukka environment.

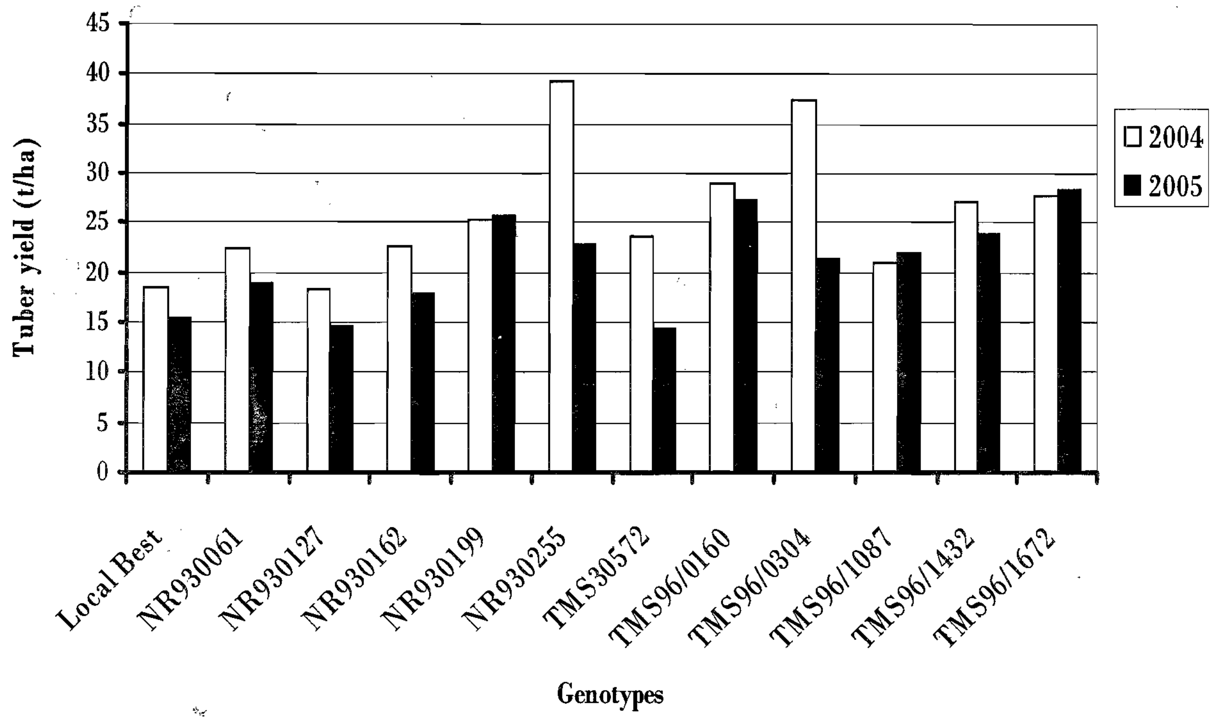

Fig. 2. The effect of genotype and cropping year on harvested fresh tuber yield under Nsukka environment.

Performance ranking revealed variable genetic expressivity. From the two-year mean severity scores, NR930127 had the lowest mean rank-sum for diseases and TMS96/1672 for pest. Hybrids NR-930255 and TMS 96/0304 which had the best ranking scores for sprout survival, pests and yield components had poor disease ranking (Table 5). Both the negative (Local Best) and the positive (TMS30572) controls had similar and the poorest overall performance ranking. NR93/0255, TMS96/0304 and TMS96/1672 were similar and the best in terms of growth parameters evaluated. It was notable that the same three genotypes NR93/0255, TMS96/0304 and TMS96/1672 also, had the best yield and yield components traits ranking. However, selection criteria for genotype recommendable for release are hinged mostly on yield parameters, resistance to the biotic and abiotic stresses, yield and then postharvest quality traits.

DISCUSSION

The significant variability in genotypic performances in most of the traits evaluated suggested genetic dissimilarity among the population evaluated, meaning that selection was feasible. A significant variation in sprout survival counts was probably genetic but modulated by the cropping environment. Standard cuttings (25 cm) from healthy plants were planted, and so, variable sprout counts at 4 WAP and 48 WAP suggested differential genetic capacity to withstand field stress. The possible interplay of the cropping environment was suggested by the differences in percent survival during the two cropping seasons (Fig 4). Variability in quantity and quality of cassava sprouts due to genotypes and growth media has been reported by Okpara and Baiyeri (2006). Similarly, but on a different crop, Baiyeri and Aba (2005) reported significant genotypes and media effects on sucker production in *Musa* germplasm

Sprout survival determines the eventual plant population per unit area, thus, survival counts has significant agronomic and economic implications, this is because the eventual plant population obtained per genotype will influence land use efficiency via its effect on resource utilization and the harvestable yield obtained; this ultimately determines profitability of investment per unit area. The consequence is that genotype exhibiting low sprout survival will suffer poor adoption due to either added cost of supplying of missing stands or where missing stands are not supplied due to low yield per unit area.

CMD, CAD and CBB are considered the most important cassava diseases in Africa (Zhou *et al.*, 1997) capable of causing an estimated 50% root yield reduction (Akparobi *et al.*, 1998). Thus selection of genotypes possessing durable genes for resistance to these diseases portends sustainable way of enhancing cassava productivity. The variability in the severity of the diseases and pests studied suggested the possibility of selecting varieties possessing durable/stable genes for resistance from among the genotypes evaluated; earlier work of Owolade *et al.*, (2005) identified some cassava lines resistant to CAD. Under the local evaluation conditions at Nsukka, NR-930127 had no symptom expression for CAD but was susceptible to CMD and CBB, thus, this genotype needs further introgression of durable genes for resistance to CMD and CBB. However, it could be utilized in future breeding schemes as a source of genes for resistance to CAD.

Variability in severity of the diseases and pests across plant age and cropping years was probably associated with disease pressure and prevailing abiotic stresses (especially moisture stress). Akparobi *et al.*, (1998) working on similar diseases and pests, although different cassava genotypes, reported significant variability in disease severity due to altitude (lowland versus highland) and prevailing relative humidity. Similarly, Okogbenin *et al.*, (1999) reported genotypic differences in cassava adaptation and responses to moisture stress. Thus, the finding in this study was in consonance with earlier reports.

It is a fundamental knowledge in crop science that crop growth has positive and significant relationship with yield (Evans, 1993), thus, some similarity in growth and yield trends was expected; however, trend in disease severity and tuber yield differed. Genotypes such as NR-930255 and TMS 96/0304 recorded high harvestable tuber yield per hectare and relatively low differences between the potential and the actual harvested yield. However, their disease severity scores were relatively high suggesting that these genotypes could be tolerant to the diseases. It also implies that the genotypes could be cultivated successfully in locations where these diseases are not endemic. NR-930199 and TMS 96/1087 had consistent high yield but were only less susceptible to CMD, thus these genotypes were only recommendable for locations where CAD and CBB were not prevalent.

It was interesting to note, however, that hybrid TMS 96/1672 combined high yield (28 t/ha) with low diseases and pests severity ratings, suggesting that the genotype was the most adaptable to the evaluation agro-ecology. This genotype demonstrated stable yield during the two cropping years, making its performance predictable or reliable.

Based on the overall mean rank-sum, the most adaptable genotypes to Nsukka agro-ecology after two years of evaluation were NR- 930255, TMS 96/0304 and TMS96/1672 but the poor disease ratings for NR-930255 and TMS 96/0304 preclude their recommendation for release. Genotype TMS 96/1672 combined stable high yield with low diseases and pests severity ratings, and had the best combined ranking thus could be recommended for release for this agro-ecology.

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REFERNCES

Akparobi, S. O., Togun, A. O. and Ekanayake, I. J. (1998). Assessment of cassava genotypes for resistance to cassava mosaic disease, cassava bacterial blight and cassava green mite at a lowland and mid-altitude site in Nigeria. *African Crop Science Journal* 6(4): 385 – 396.

Baiyeri, K. P. and Aba, S. C. (2005). Response of *Musa* species to macro-Propagation: I: Genetic and initiation media effects on number, quality and survival of plantlets at prenursery and early nursery stages. *African Journal of Biotechnology*. 4(3): 223 - 228

Cooper, M. and. Byth, D. E. (1996). Understanding plant adaptation to achieve systematic applied crop improvement- A fundamental challenge. In M. Cooper and G. L. Hammer, eds. *Plant Adaptation and Crop Improvement*, pp. 5 – 23. Wallingford, UK, CABI.

Evans, L. T. (1993). *Crop Evolution, Adaptation and Yield*. Cambridge Univ. Press. 500 pp.

Ezulike, T. O., Nwosu, K. I., Udealor, A. and Eke-Okoro, O. N. (2006). *Guide to Cassava Production in Nigeria. Extension Guide No. 16*. National Root Crops Research Institute, Umudike, Nigeria. 10 pp.

GENSTAT. (2003). GENSTAT 5.0 Release 4.23DE, Discovery Edition 1, Lawes Agricultural Trust, Rothamsted Experimental Station.

Ikeorgu, J. E. G. and Iloka, A. W. (1994). On-farm evaluation of the effects of three contrasting maize varieties on the productivity of cassava/maize intercrop in south-eastern Nigeria. pp. 243 - 246 In: *Proceedings of the fifth triennial symposium of the International Society of Tropical Root Crops, Africa Branch,* Kampala, Uganda, 22 – 28 Nov., 1992.

Muoneke, C. O. and Mbah, E. U. (2007). Productivity of cassava/okra intercropping systems as influenced by okra planting density. *African Journal of Agricultural Research* 2(5): 223 – 231.

Kueneman, E. A. (2002). Foreword. In P. Annicchiarico, *Genotyppe x environment interactions-Challenges and opportunities for plant breeding and cultivar recommendations*, p.iii. FAO Plant Production and Protection Papers – 174.

Ndubizu, T. O. C. (1981). Effect of split fertilizer application on growth and yield of falsehorn plantain (*Musa* spp.) in the rain forest belt of Nigeria. *Der Tropenlandwirth, Zeitschrift fur die Landwirtschaft in den Tropen und Subtropen* 82: 153 – 161.

Ogbe, F.O., Ohiri, A.C. and Nnodu, E.C. (1993). Effect of NPK fertilization on symptom severity of African cassava mosaic virus. *International Journal of Pest Management* 39(1): 80–83.

Ogbe, F. O., Thottappilly, G., Dixon, A. G. O., Atiri, G. I. and Mignouna, H. D. (2003). Variants of East African cassava mosaic virus and its distribution in double infections with African mosaic virus in Nigeria. *Plant Disease* 87: 229–232

Okogbenin, E., Ekanayake, I. J. and Porto, M. C. M. (1999). Effect of planting methods and soil moisture on cassava performance in the semi-arid Sudan savanna belt of Nigeria. *African Crop Science Journal* 7(1): 21 – 33.

Okpara, D. A, and Baiyeri, S. O. (2006). Effect of growth media on propagation of four varieties of cassava, pp 16 – 18. In: G. N. Asumugha, A.O. Olojede, J. G. Ikeorgu, A. O Ano, U. Herbert (eds). Proceedings of the 40th Annual conference of the Agricultural Society of Nigeria (ASN) held at National Root Crops Research Institute, Umudike, Abia State, Nigeria; 6-8, October 16th -20th 2006.

Owolade, O. F., Dixon, A. G. O., Adeoti, A. A. and Osunlaja, S. O. (2005). Sources of resistance to cassava anthracnose disease. *African Journal of Biotechnology* 4(6): 570 – 572

Terry, E.R. (1975). Description and evaluation of cassava mosaic disease in Africa. Pages 53–54. In: *The International Exchange and Testing of Cassava Germplasm in Africa.* E.R. Terry and R. MacIntyre, eds. IITA, Ibadan, Nigeria.

Theiberge, R. L. (1985). *Common African Pests and Diseases of Cassava, Yam, Sweet potato and Cocoyam, International Institute of Tropical Agriculture, IITA*, Ibadan, Nigeria. 108 pp.

Thresh, J. M. and Otim-Nape, G. W. (1994). Strategies for controlling African cassava mosaic germinivirus. *Advances in Disease Vector Research* 10: 215 – 236.

Wydra, K. (1994). Training Manual on Cassava Pathology. Draft 2, Plant Health Management Division, IITA, Ibadan, Nigeria.

Yaninek, J. S. (1994). Cassava plant protection in Africa, pp. 26 – 34 In: *Proceedings of the Fifth Triennial Symposium of the International Society of Tropical Root Crops, Africa Branch,* October, 1991, Accra Ghana, Ofori, F. and Hahn, S. K. (eds), IITA, Ibadan, Nigeria

Yan, W; P. L. Cornelius; J. Crossa, and L. H. Hunt. (2001). Two types of GGE biplots for analysing multi-environment trial data. *Crop Sci.* 41: 656 – 663.

Zhou, X., Liu, Y., Calvert, L., Munoz, C., Otim-Nape, G. W., Robinson, D. J. and Harrison, B. D. (1997). Evidence that DNA-A of a germinivirus associated with severe cassava mosaic disease in Uganda has arisen by inter-specific recombination. *Journ. Gen. Virol.* 78: 2101 – 2111.